CHARACTERISTICS OF PROFESSIONAL DEVELOPMENT AND TEACHER INTERACTIONS IN A MOOC DESIGNED FOR THE TEACHING OF STATISTICS

A Dissertation in
Curriculum and Instruction

by
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This study investigates to what extent the characteristics of effective face-to-face professional development hold in a MOOC designed for statistics development of secondary teachers and the nature of teachers’ and others’ interactions with materials and with each other in this online professional development. Social theory of learning and connectivism are used to frame participants’ learning as they establish and experience interactions in the network.

The context of this study is a MOOC for educators offered by a large American university and specifically designed for teachers to learn about statistics teaching and the use of statistical investigations in teaching. Qualitative research methods of content analysis are used to identify and describe the enacted characteristics of the MOOC vis-à-vis documented characteristics of effective face-to-face professional development literature. Inductive coding and social network analysis were used to understand the content of participants’ interactions and the network structure produced by them, respectively.

Findings regarding characteristics of effective professional development show how this MOOC embodied variations on key characteristics of effective face-to-face professional development. Participants’ autonomy is highlighted as a common element that modifies the characteristics suggested in the literature of face-to-face teachers’ professional development.

Findings regarding the nature of participants’ interactions show that MOOC resources were vehicles for participants’ interactivity with some resources engaging more participants than others, and resources being essential for the creation of organic networks. Discussion starters acted as network expanders who amplified interactivity among participants, while the main instructor took the leadership of interactivity and acted as a concierge throughout this MOOC. The study also shows how participants interacted with others in forums, exposing that they shared
not only their perspectives about resources provided by this MOOC but also their qualifications and their insecurities with respect to statistics content and statistics teaching.

Aligning theoretical perspectives from social theory of learning with connectivism, this study helps to create awareness in the field of teacher professional development regarding new characteristics that emerge when professional development is delivered in large-scale, via the Internet, and free of charge. In this sense, outcomes of the study include a suggested set of characteristics that MOOCs should contain to be an environment for effective professional development for teachers.

For the fields of mathematics education and statistics education, this study presents teachers getting acquainted with the pedagogical approach of teaching statistics through data investigations through this MOOC, exposing their perceptions of this approach and their intentions of further implementation, which can contribute to minimize the lack of training in statistics teaching identified in the literature.

Implications for research highlight the importance of the quality of participants’ posts in MOOC forums, their individualist modes of interaction in this online professional development, and the role MOOC resources play in their practice. Further research is suggested in the areas of investigating the impact of forum prompt content on the quantity of posts made by participants, sentiment analysis of the content of participants’ forum posts, and investigation into the role of the main instructor in MOOCs for teachers’ professional development.
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Chapter 1

Rationale

The motivations for this study are the increasing trend of teaching statistics and probability in mathematics school curricula around the world, and the consequent demand for prepared mathematics teachers to implement the directions presented in curriculum policies. Although many countries have started initiatives to prepare their teachers to teach statistics, research indicates that lack of teacher preparation for teaching statistics at the middle and high school level is still an important issue in the education community (Franklin, 2013; Conference Board of the Mathematical Sciences [CBMS], 2012). The need to offer mathematics teachers and teachers in general, opportunities to develop themselves regarding the teaching of statistics is vital to the successful implementation of curriculum policies.

Massive Open Online Courses (MOOCs) appear to be excellent venues for delivering large-scale professional development for teachers, and more specifically, professional development focused on statistics teaching. MOOCs provide opportunities for teachers from many different parts of the world to interact with peers, to share their experiences, and to learn through interaction with materials and with each other. MOOCs for professional development also have the potential to reach across political and cultural boundaries in order to meet the international need for teachers' development in school statistics. A MOOC provides the opportunity to establish a community of teachers, and to develop life-long networked learning amongst the participants.

Although MOOCs as professional development for teachers have attracted the interest of researchers regarding geographically dispersed teachers working in online environments, research
is still scant in this field. Relatively little is known about the characteristics of MOOCs as effective professional development for teachers, and how these characteristics compare to those of effective programs in the established literature of face-to-face professional development for teachers.

To make the most of the opportunities that MOOCs offer, careful attention needs to be paid to the processes of teachers’ learning in this new professional development venue. Although many researchers have studied the effectiveness of face-to-face professional development (e.g., Blank et al., 2008; Desimone, 2009; Loucks-Horsley, Love, Stiles, Mundry & Hewson, 2010; Borko, Jacobs & Koellner, 2010), research into professional development within a MOOC is still developing. The findings of such studies will inform whether and how MOOCs might be designed and leveraged as globally available, easily accessible, professional development options. There is a definitive need to understand which characteristics of effective professional development hold in MOOCs and how participants interact with others and with materials in this environment.

This chapter provides an overview of what is known in the field regarding the implementation of statistics in schools around the world, and the preparation of mathematics teachers to face this challenge. The chapter highlights the importance of mathematics teachers’ preparation and suggests MOOCs as a potential professional development venue for teachers. It also details the characteristics of this study, its research questions, its assumptions, and its contributions to the fields of professional development of teachers and statistics education.

Mathematics Curriculum Policy Calls for Statistics at High School

Demand for statistical knowledge is increasing around the world. This is related to easy access to large amounts of information and the need for individuals to be able to interpret that
information and thus make better decisions informed by data. In tandem with this movement, schools around the world have adapted or redesigned their mathematics curricula in order to include statistics content in their students’ formation. In many different countries such as Australia, the United Kingdom, Portugal, South Africa, Brazil, and the United States, mathematics curriculum policies state that statistics content should be included in elementary and secondary school.

Analysis of the mathematics curriculum policies of these countries has shown that all of them present high school statistics content focused on data handling, data representation, and data interpretation. Some mathematics curricula (e.g. The Australian Curriculum and Reporting Authority, 2010) highlight the importance of data representation and interpretation encouraging students to interpret and investigate data presented in digital media, reports of surveys, and elsewhere. The intention is to help students understand how data was obtained to estimate population parameters and how statistics is used to support a claim. Other mathematics curricula highlight that statistics learning should also develop students as consumers of data (e.g., United Kingdom, Department of Education [DoE], 2003). This includes development of student’s understanding of the relationships between a statistical summary, its graphical representation, and its primitive data, thus helping them to construct rational arguments based on information and observations, and convey convincing results by using appropriate statistical terminologies (e.g., United Kingdom, Department of Education [DoE], 2003; Brasil, 2006).

Consequently, statistics teaching should focus on data handling (analysis and interpretation of data) and further methods of organizing, displaying and analyzing data (DoE, 2003a). Mathematics teachers should instruct their pupils to describe, interpret, and compare observed distributions through appropriate graphical representation involving discrete and continuous data, as well as explore relationships in bivariate data (United Kingdom, Department of Education, 2013b). The role of collecting and interpreting data present in national curriculum
policies provides an opportunity for mathematics teachers to implement statistics topics using modeling and technologies (e.g., Silva, Fonseca, Martins, Lopes, Fonseca, 2005; Brasil, 2006; Common Core State Standards Initiative [CCSS-M], 2010).

In the United States, the demand for teaching statistics concepts to students has been addressed with the insertion of statistics topics such as data analysis, probability, and statistics throughout reforms of the elementary and secondary mathematics curriculum (NCTM, 2000). The statistics strand has been reinforced even more with the release and implementation of the Common Core (CCSS-M, 2010), focusing on the development of students’ statistics conceptual understanding beginning in grades K-6. American national assessments also include statistics concepts, further demonstrating the need to teach statistics to students.

When focusing on high school statistics, mathematics curriculum policies from many countries afford great opportunities for students to learn statistics and to develop critical thinking skills as they encounter any type of quantitative information or results of statistics investigations. These policies also bring challenges for mathematics teachers in delivering the expected statistical content described in the official documents.

**Challenge in Teaching Statistics at High School**

Although official guidelines and reforms in Australia, the United Kingdom, Portugal, South Africa, Brazil, and the United States emphasize the importance of teaching statistics, research indicates that teachers experience difficulties in teaching statistical topics to their students (Chadjipadelis, Meletiou-Mavrotheris & Paparistodemou, 2010; Franklin, 2013; CBMS, 2012; Meletiou-Mavrotheris & Mavrotheris, 2007; Begg & Pfannkuch, 2004). The Conference Board of the Mathematical Sciences (CBMS) reports that the majority of K-12 teachers have never taken a formal statistics course (CBMS, 2001; CBMS, 2012). Difficulties in teaching
statistical topics may be related to deficits in college curricula. For those who have taken undergraduate statistics courses, these courses typically were not designed to prepare them to teach statistics as required by the curriculum policies (Franklin, 2013; Meletiou-Mavrotheris & Mavrotheris, 2007; Rossman, Medina & Chance, 2006).

Regarding in-service mathematics teachers, literature from many different countries reports their lack of knowledge and lack of confidence in teaching statistics to their students. Research in South Africa shows that many mathematics teachers do not feel confident in teaching statistics (North & Zewotir, 2006; Wessels, 2011); they tend to present statistics in a traditional way, using small, artificial data sets, and without true understanding of the analysis performed with the data. Some authors assert that a consequence of this approach may be a generation of students who have fragmented skills that will interfere with further pursuit of studies in statistics (North & Zewotir, 2006; Wessels, 2011). The lack of statistical knowledge is also seen in more experienced African mathematics teachers; before the implementation of the new South African curriculum, statistics was taught neither in elementary nor secondary school levels (North, Scheiber & Ottaviani, 2010).

Similar deficiencies in knowledge of teaching statistics exist in Brazil. Santos (2005) reported that in a survey of 52 mathematics teachers participating in the program "Teia do Saber" ("Web of Knowledge", a professional development program) 66% of the teachers had not worked with statistics content before. Mathematics teacher participants in the survey attributed their lack of statistical knowledge to the fact that they did not develop any statistics knowledge during their college preparation, and to the absence of statistics content in the school textbooks used during their formation.

Even when it is part of the curriculum, Carvalho (2006) states that statistics content is usually placed as the last part of a mathematics school program. Consequently, if some mathematics teachers spend more time on non-statistics material early in the year, they might
rush through the statistical concepts in order to finish the academic program on time. Similarly, the Portuguese Mathematics Teachers Association (APM, 1998) reports that mathematics teachers usually simplify or exclude statistics content from their teaching. Ponte and Fonseca (2000) describe that, despite the importance of statistics being recognized in the national curriculum, this topic still seems to be marginal to the Portuguese curriculum.

In countries where statistics have been fully implemented, such as Australia, research shows that mathematics teachers still encounter difficulties when dealing with the use and interpretation of data in their classes (Pierce, Chick, & Gordon, 2013). This is particularly evident when dealing with nonstandard representations of data such as a box-plot (Pierce & Chick, 2011). In some cases, mathematics teachers still had difficulty in reading, comparing, or interpreting data even when graphical representations were available to them. As a result of these difficulties, mathematics teachers tend to prefer teaching statistics by using other forms of representation, such as tabular representation.

In some cases teachers see “teaching statistics as the same as teaching mathematics” (Pierce & Chick, 2011a, p. 155). This perspective results in mathematics teachers emphasizing mathematical techniques in statistics classes, reducing the use of real data, and diminishing the explorations of statistical applications in many different areas (Holmes, 2003). Some mathematics teachers tend to be more comfortable with the application of predictable statistics formulas rather than having to address problems that may have more than one way to reach to a solution (Gattuso & Pannone, 2002). An explanation for this could be that statistics presents complex ideas and its problems are highly embedded in a context, which can mislead interpretation or lead to false intuitions during the solving of a statistics problem (Ben-Zvi & Garfield, 2004). Many statistics concepts are abstract and make use of complex notations and different representations that might be confusing for both students and teachers. Teachers also have to face a technological challenge
if they decide to teach statistics with any technological device (Batanero, Burrill & Reading, 2011).

Teaching statistics in a fashion similar to teaching mathematics is an approach taken by many mathematics teachers and is described in the literature as a lack of teachers’ content (subject area) knowledge and teachers’ pedagogical content knowledge (PCK) (Makar & Confrey, 2003; Meletiou-Mavrotheris & Stylianou, 2003a; Meletiou-Mavrotheris, Paparistodemou, & Stylianou, 2009). PCK is defined by Shulman (1987) as “the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction” (p. 8).

This brief overview of the literature demonstrates that mathematics teachers in many different countries are not prepared to face the challenge of teaching statistics (e.g., Giambalvo & Gattuso, 2008, Franklin, 2013; Lajoie & Romberg, 1998; Batanero, Burrill & Reading, 2011). Quite often, mathematics teachers have not received appropriate preparation in college, do not feel confident in teaching statistical concepts to their students, or reduce the possibilities and potential of a statistical class by teaching statistics through a procedural mathematics class.

Thus, the question at hand is, how do we provide mathematics teachers with appropriate content knowledge and pedagogical knowledge in order to better teach statistics to their students? Professional development provides an opportunity for mathematics teachers to achieve the statistics teaching requirements stated in the curriculum policies, and also for these teachers to prepare to implement fundamental changes in their instructional methods and tools employed in the classroom.
The Need for Statistics Professional Development and Support for Teachers

Content found in the literature reinforces that mathematics teachers need to know the main curriculum guidelines with regard to statistics, the students’ difficulties with the content, and how to organize their teaching in order to promote student learning (Turkman & Ponte, 2000). It is equally necessary that teachers have knowledge about the content they are teaching, develop confidence in the materials used in class and develop links to statistics topics throughout the curriculum (Holmes, 2003; Barnett, 1982). Therefore, professional development opportunities are crucial for supporting mathematics teachers learning and future implementations of statistics concepts in class (Barnett, 1982; North, Scheiber & Ottaviani, 2010; Wessels, 2011).

Literature on professional development provides two main strands regarding opportunities for teachers to develop their statistics knowledge and their skills for teaching. One is teachers taking part in training sessions and engaging with materials provided by many national offices and organizations. Another is described as teachers participating in professional-development experiences funded by districts, schools, or state programs. These two strands coexist and are important throughout the continual formation of statistics teachers.

In the first strand, many national offices and organizations have provided training, webinars, and projects to promote access, understanding, and use of data aiming to give teachers an opportunity to access and develop materials to further use in their class (Lehohla, 2002; Kong & Harradine, 2006). Examples of these projects can be found in CensusAtSchool (http://www.amstat.org/censusatschool/) and ExperimentsAtSchool (http://www.censusatschool.org.uk/resources/science), with both projects providing tools for students to collect and analyze real data, and support for teachers to integrate this real data into their classes.
For English speakers, projects such as the International Statistical Literacy Project (ISLP - http://iase-web.org/islp/), offers an online repository containing activities created to spread the use of data in statistics class. Initiatives from the American Statistical Association (ASA)/National Council of Teachers of Mathematics (NCTM) Joint Committee on the Curriculum in Statistics and Probability also contributes to this strand, offering webinars and curate materials for teachers such as peer-reviewed lesson plans for K-12 mathematics teachers (http://www.amstat.org/education/usefulsitesforteachers.cfm). International efforts such as the World of Statistics website (http://www.worldofstatistics.org/primary-secondary-school-teacher-resources/) compile and provide lists of resources for teachers who are interested in teaching statistics to their pupils at many different school levels. Significant resources could be added if National Science Foundation (NSF) research grant initiatives were considered, such as the work of Lane and his group in creating The Rice Virtual Lab in Statistics, a source for a variety of statistics applets (http://onlinestatbook.com/rvls/index.html).

Despite an abundance of materials and content made available to teachers, the reality of teaching statistics in schools shows that the availability of resources, although good, is not enough. Statistics teachers still need professional development to improve their content knowledge, to interact with and learn from their peers, to share their teaching skills, and to improve their statistics teaching.

In the second strand, teachers’ professional knowledge has been nurtured through local and state professional development initiatives that vary in content, duration, and format. The content of these initiatives focuses on increasing teachers’ statistical content knowledge and pedagogical knowledge. Initiatives that focus on advancing teachers’ statistical content tend to center efforts in getting teachers acquainted with statistical big ideas such as use of data, variability, distribution, informal inference, correlation and covariation. Initiatives that focus on advancing mathematics teachers’ pedagogical skills center efforts on developing approaches for
teaching statistics through the use of real data. Examples of these approaches make use of statistical investigations, statistical projects, and technological tools. The duration of professional development ranges from short training meetings (i.e., a one-day conference) to extensive methods such as coaching or a multiyear degree program (i.e., a master’s degree). The format of professional development also varies from being delivered face-to-face, to online meetings that happen during school hours, or outside of the school day.

Despite the existence of initiatives that are focused on providing teaching materials and training for teachers, there are still a large number of them who are teaching statistics content while having little or no training in statistics themselves. Consequently, this may limit teacher performance in class, and thus limit the learning opportunities provided to their students. This widespread situation indicates that statistics professional development for teachers should be increased, and Massive Open Online Courses (MOOCs) appear to be excellent venues to host large-scale professional development for teachers. MOOCs provide opportunities for teachers from many different parts of the world to interact with peers, to share their experiences, and to learn through engagement with materials and with each other.

MOOCs as Venues for Teachers’ Professional Development

MOOC is an acronym for Massive Open Online Course, a term coined by George Siemens and Stephen Downes when running a large online course (Cormier & Siemens, 2010). According to Yuan, Powell and Olivier (2014), the word ‘massive’ means to spread connections with the intent of establishing communities among participants. The word ‘open’ means open enrollment and free of charge, the word ‘online’ emphasizes networked learning across multiple platforms, and the word ‘course’ means participants engaging with materials and peers, sharing resources and generating their own content.
The two most common kinds of MOOCs are cMOOCs and xMOOCs. These terminologies are based on different pedagogical frameworks implemented at these MOOCs. cMOOCs follow the principles of Connectivism (Siemens, 2004; 2005) which is described in detail in Chapter 3 of this study. xMOOCs (extension MOOCs) follow the principles of Behaviorism and are mainly used by higher education institutions to “extend access to onsite learning activities, resources and events, which are typically based upon the transmission of content and verification of reception model” (O’Toole, 2013, p. 1).

MOOCs for educators or MOOC-Eds emerged as a new type of MOOCs specifically designed to attend to professional development needs of teachers and professionals serving in K-12 settings (Kellogg, Booth, & Oliver, 2014). In terms of classification, MOOC-Eds seem to be in the middle of the spectrum of cMOOCs—xMOOCs, combining elements of both perspectives. For instance, MOOC-Eds may use platforms to deliver its course content to a large group of participants as in xMOOCs, and, at the same time they may use activities that afford collaboration among peers as in cMOOCs.

The Friday Institute for Educational Innovation at North Carolina State University is one of the pioneers in offering MOOC-Eds. Their MOOCs are designed to afford teachers self-directed and flexible learning, peer-support and working from practice as teachers “engage in discussions, respond to participants’ questions, and elaborate on lessons learned” (Kleiman, Wolf, & Frye, 2013, p. 2). Coursera, in partnership with higher education institutions, has also launched a series of MOOCs designed for K-12 teachers (Empson, 2013). Their goal is to include courses that focus on basic and specific topics of teacher training and development.

These new venues for teachers’ professional development seem to attend a demand also observed by researchers of MIT (Seaton, Coleman, Daries, & Chuang, 2015) which informed that from 246899 participants enrolled in 11 MIT MOOCs (MITx) offered in Spring of 2014, 30% of these participants identified themselves as teachers, and other 9% informed working as teachers.
MOOCs for educators seems to be an attractive opportunity to provide cost-effective professional development for teachers. Moreover, they seem to be spaces for teachers’ continuing professional education, providing certification to teachers in different subjects. Thus, MOOCs as new venues of teachers’ professional development presents new opportunities to understand which characteristics of effective professional development hold in this type of MOOC and how participants interact with others and with materials in this environment.

The Study

Curriculum policies presented in the beginning of this chapter emphasize the role of statistics in high school mathematics classrooms. Teachers need a thoughtful and extensive preparation regarding pedagogical and content knowledge in statistics to implement these curriculum policies. The insertion of statistics in high school mathematics curricula and the need to prepare teachers to teach statistics at this level sets the motivation for this study.

A MOOC-Ed for statistics teachers is a promising opportunity for teachers worldwide to develop their professional knowledge by interacting with each other and with resources (course materials). It has the potential to be a venue for teachers’ professional development with teachers participating from different geographical locations, which may help to address the demand for qualified teachers to teach statistics in secondary school. To make the most of the opportunities that this type of MOOC offers, careful attention must be paid to the processes of teachers’ learning in this new professional development venue.

Although many researchers have studied the effectiveness of face-to-face professional development (e.g., Blank et al., 2008; Desimone, 2009; Loucks-Horsley, Love, Stiles, Mundry & Hewson, 2010; Borko et al., 2010), professional development within a MOOC is relatively new and in need of additional research. The findings of such studies would inform whether and how
MOOCs might be designed and leveraged as globally available, easily accessible, professional development. There is a definitive need to understand which characteristics of effective professional development hold in MOOCs as a new form of online professional development, and how participants interact with others and with materials in a MOOC for professional development purposes. Thus, the purpose of this study is to answer the following two questions:

*To what extent can the characteristics described in the literature on effective face-to-face teachers’ professional development hold in a MOOC designed for statistics development of secondary teachers?*

*What is the nature of teachers’ and others’ interactions (with materials and with each other) in a MOOC designed for statistical professional development?*

In addressing these questions, the position is taken that learning is fundamentally a social experience (Wenger, 1998; 2006) and happens through participation in social practices. Thus, this study makes use of social theory of learning (Wenger, 1998) to describe participants’ engagement in a MOOC focused on professional development of statistics teachers. Connectivism (Siemens, 2005; Siemens & Downes, 2011) is used to frame teachers’ learning through participation as they establish and experience connections in this professional online environment.

In this study, the online environment will be characterized by a MOOC for Educators (MOOC-Ed) offered by a large American university that has been specifically designed for teachers to learn about statistics teaching and the use of statistical investigations in teaching. As participants in this MOOC, teachers interact with resources (course materials) and with others as they establish and experience connections in this professional online environment. Interactions emerge as an important feature of online professional development, and this construct is particularly important when MOOCs are framed as participative online professional development, as is the MOOC object of this study. A definition of interaction, as well types of interactions relevant to this study are described in detail in Chapter 3.
**Organization of this Dissertation**

Chapter 1 has described the context of the problem, rationale, purpose of the study, and research questions. Chapter 2 describes the literature review of the main features that lead to an effective form of professional development, teachers’ professional learning, and MOOCs as spaces for teachers’ professional development and professional learning. Chapter 3 presents the Social Theory of Learning and Connectivism as the theoretical framework used in this study aligned with the concept of participants’ interactions with materials and with others in this MOOC. Chapter 4 describes the methodology and the instruments used in conducting the study. Chapter 5 and Chapter 6 describe the findings for the first and the second research questions, respectively. Chapter 7 is dedicated to MOOC implications. Chapter 8 extends these implications for research, methodology and theory, and concludes this work by presenting avenues for further research.
Chapter 2

Review of Relevant Literature

In this chapter, I present a review of the relevant literature that supports this study. I begin by presenting my understanding of teachers’ professional development in the educational field, and the characteristics synthesized from the literature that denote effective and high quality professional development for teachers. Since the object of this study is professional development designed for secondary teachers’ statistics teaching, I review studies on teachers’ professional development in statistics teaching. Next, I present the literature of teachers’ professional learning, and the importance of resources in teachers’ learning from professional development experiences. Then, I narrow the scope of this review to the literature on MOOCs. Still in MOOCs, I review the studies on participants’ engagement with videos and with forums. At the end of the chapter, I situate the two main research questions in the reviewed literature.

Teacher Professional Development

In this study, professional development refers to “processes and activities designed to enhance the professional knowledge, skills, and attitudes of educators so that they might, in turn, improve the learning of students” (Guskey, 2000, p.16). Professional development is also “the process by which, alone and with others, teachers review, renew and extend their commitment as change agents to the moral purposes of teaching” (Day, 1999, p. 4).

For almost two decades, research has supported the need for teachers’ professional development, showing that professional development is fundamental for teachers to implement changes presented in curriculum, improve their classroom instruction and consequently, their
students’ achievement (Ball & Cohen, 1999; Cohen & Hill, 2001; Darling-Hammond & McLaughlin, 1995; Day & Sachs, 2004; Garet et al., 2001; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). In terms of statistics teaching, the need for teacher professional development is even more accentuated than for teaching in general as described in Chapter 1. Research (e.g., Turkman & Ponte, 2000; Holmes, 2003; Barnett, 1982) states that teachers should know the main curriculum guidelines regarding statistics, the content they are teaching, the potential links among statistics topics throughout the curriculum, the students' difficulties with the content, and how to organize their teaching in order to promote student learning. Therefore, professional development opportunities are vital for supporting teachers’ learning and future implementations of statistics concepts in class (Barnett, 1982; North, Scheiber & Ottaviani, 2010; Wessels, 2011).

It might seem natural to visualize a chain for professional development’s effects, in which professional development enhances teacher knowledge and skills, teachers with better knowledge will improve classroom teaching, which consequently will increase students’ understanding and their achievements. However, research shows that this logic is not as straightforward as we might think (Borko, 2004; Loucks-Horsley & Matsumoto, 1999). There are many elements beyond teachers’ teaching that might influence students’ performance, such as physical health (Moore, Wehby, Hollo, Robertson, & Maggin, 2014), parental involvement (Jeynes, 2007), broadband in schools (Belo, Ferreira, Telang, 2014), anxiety (Chaman, Beswick, & Callingham, 2014), and student–teacher interactions (Winheller, Hattie, & Brown, 2013).

Due to the numerous challenges in isolating the direct effects of teachers’ professional development on students’ achievements, research has focused on investigating the links between professional development & teachers’ learning and practice, and teachers’ learning and practice & student learning (Yoon et al., 2007). To help develop a better understanding of the impact of professional development on teachers practice, and consequently on student performance, research has focused on the characteristics that comprise effective professional development,
which may produce changes in instructional practice with the potential to affect students’ performance. In the next section, these characteristics are presented.

**Characteristics of Effective Professional Development for Teachers**

Over the last 17 years, researchers (Garet et al., 2001; Desimone et al., 2002; Ingvarson, Meiers, & Beavis, 2005; Blank, de las Alas & Smith, 2007; Yoon et al., 2007; Blank & de las Alas, 2009; Gulamhussein, 2013) have been investigating the features of professional development that have a positive influence on teachers' classroom practice and students’ achievement. These studies seem to have stemmed from a pioneer study conducted by Garet and colleagues (2001) that depicts the characteristics of effective professional development for teachers.

In their study, Garet and colleagues (2001) collected data from the national evaluation Eisenhower Professional Development Program (a federal program that supported professional development for teachers, mainly in mathematics and science, http://www2.ed.gov/pubs/Biennial/95-96/eval/126-97.pdf) and proposed six characteristics of high-quality and effective professional development for teachers. According to Garet et al. (2001), the characteristics of effective professional development can be classified as core features and structural features. The core features are the essential features professional development must have, they are: (a) content focus, (b) opportunities for active learning, and (c) coherence. The structural features are the design characteristics that support the professional development activity, they are: (a) the type of the activity, (b) the duration of the activity, and (c) the collective participation.
Content Focus

Content is ‘what’ teachers have the opportunity to learn during professional development (Kennedy, 1998). Looking through the literature on teachers’ professional development, one can see that the substance (content) of professional development varies according to what the professional development intends to develop in teachers. As highlighted by Garet et al. (2001), some professional development activities emphasize teachers' knowledge of subject-matter content, others focus on teaching practices (e.g., student centered learning, classroom management), and some activities emphasize the improvement of teachers’ pedagogical content knowledge (PCK). PCK is defined by Shulman (1987) as “the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction” (p. 8). Since PCK includes teachers’ understanding of a specific subject matter, how students learn that subject, and how to make that subject accessible to students, PCK arises as an important aspect of teachers’ professional development (Van Driel & Berry, 2012).

Opportunities for Active Learning

Active learning denotes the extent to which professional development affords opportunities for teachers to become engaged in meaningful discussion, collaborative work, planning, and reflection over their practice (Garet et al., 2001; Desimone et al., 2002; Desimone, 2009; Borko et al., 2010). In this perspective, “learning is an active process wherein learners construct new understanding based on what they already know and believe” (Borko et al., 2010, p. 550). Research suggests that active learning can be achieved in a diversity of ways: reviewing students’ work, observing expert teachers or being observed, planning how new curriculum
materials and new teaching methods can be used in class, designing formative assessments, interacting with peers, developing and presenting lessons, and coaching and mentoring (Garet et al., 2001; Blank et al., 2008; Desimone, 2009; Loucks-Horsley, Love, Stiles, Mundry & Hewson, 2010; Borko et al., 2010; Hammer, 2013).

Desimone et al. (2002) show that when professional development provides opportunities for active learning, these opportunities are positively related to enhancement of teachers’ knowledge and skills. Ingvarson, Meiers & Beavis (2005) obtained similar results, finding that active learning was positively associated with teacher’s knowledge and teaching practice. Moreover, results from Martin, Strother, Beglau, Bates, Reitzes, & Culp (2010), Desimone et al. (2002) and Garet et al. (2001), highlight that active learning opportunities can also be positively associated with teachers’ use of technology and higher order instruction.

**Coherence**

Coherence is related to the “extent to which professional development activities are perceived by teachers to be a part of a coherent program of teacher learning” (Garet et al., 2001, p. 927). For Smith and Gillespie (2007) coherence reflects the match between school needs and the issues addressed by the professional development, in which “the match can be either be required (by the district) or voluntary (the school or teachers sought professional development related to the school improvement issue)” (p. 232-233). Coherence requires that professional development build on what educators have already learned, focusing on producing content and pedagogy aligned with standards and assessments, and supporting teachers in establishing and sustaining professional communication with other teachers (Garet et al., 2001).

Coherence in teachers’ professional development activities should be perceived as a unified process that starts with the teachers’ preparation program and continues throughout their
professional career. Teachers should be able to learn and change their practices, following a natural professional development path (Ponte, 2011), thus acknowledging that their development happens by the articulation of their needs, resources, and interests towards professional development opportunities. In contrast, when professional development is not coherent, teachers might feel tension in learning things that are not useful to their practice, or even dissonant to the curriculum policy they have to implement (Desimone, Nolly & von Frank, 2011). When professional development lacks coherence, teachers might not adopt or implement in practice the knowledge that was proposed (Desimone, 2002).

**Type of Activity**

The majority of professional development literature classifies the type of activity in mainly two categories: *traditional* and *reform* activities. The traditional model is usually characterized by “short-term or one-session workshops, trainings, seminars, lectures, and conference sessions” (Smith & Gillespie, 2007, p. 214). According to Smith & Gillespie (2007), the primary goals of these activities are to increase teacher general knowledge (e.g., quadratic functions), skills in teaching (e.g., time management in class), use of a new feature in class (e.g., use of graph calculators), or to expose teachers to a different methodology for teaching (e.g., problem solving).

Research has criticized the ‘sit and get’ model of professional development. The main criticism is that these isolated single trainings have a short duration, making the covered content disjointed, and producing a low impact on teachers change inside classroom (Abbott, Walton, Tapia, & Greenwood, 1999; Abadiano & Turner, 2004; Smith & Gillespie, 2007). The results from the study of Smith and Gillespie (2007) exemplify this low impact in teachers change. They report that from 31 teachers who attended a six-day workshop on effective teaching, they
implemented only 3 out of 18 concepts and strategies developed in the workshop. The majority of teachers only added some of the features to their common practice, avoiding a change in existing beliefs and practices. The traditional forms of professional development may not seem to provide experiences that produce sustained changes in teaching practice. Reform types of professional development arose as an opportunity for teachers to increase their knowledge about content and pedagogy, intending to influence the change in teaching practice (Garet et al., 2001; Darling-Hammond & Richardson, 2009; Porter et al., 2000; Smith & Gillespie, 2007; Kretlow & Bartholomew, 2010).

Reform type professional development usually happens during the regular school day and is characterized by activities such as coaching, mentoring, lesson study, study group, induction, teacher networks, and Professional Development Schools – PDS (school-university partnerships). The primary goal of reform activities is to support teachers in attaining improvement in student learning. The reform activities are usually developed with a long-term perspective and are characterized by teachers’ active participation. Content is usually focused on teacher’s studies of students’ thinking, learning materials, and pedagogical content knowledge (Smith & Gillespie, 2007).

Research suggests that spreading opportunities for professional development throughout a teachers’ regular workday may be more effective than the traditional forms of professional development, allowing teachers to make connections with classroom teaching (Ball, 1996; Smith & Gillespie, 2007; Garet et al., 2001). Once professional development is inserted into teachers’ daily life, it might be easier for teachers to work collaboratively, establishing and maintaining connections between professional development and their practice.

Examples of the reform type of professional development are vast in quantity and dense in description. For each approach (e.g., coaching, mentoring, lesson study, study group, induction, teacher networks, and PDS), research is spread across many books, conferences,
dissertations and papers. Although professional development reform types present a variety of approaches, a common theme amongst them is teacher collaboration as a way to support teacher learning and foster teaching practice. Based on the reviewed papers long-term programs, coherence, and teacher collaboration form a tripod of the main characteristics of reform type professional development.

**Duration of Activity**

According to The No Child Left Behind Act of 2001 [NCLB] (2002), high-quality professional development activities are the ones in which teachers have intensive and sustained learning experiences. Aligned with the NCLB Act, research also reinforces that professional development activities should be sustained over time (Kennedy, 1998; Garet et al. 2001; Blank & de las Alas, 2009; Desimone et al., 2002; Borko et al., 2010; Day & Sachs, 2004; Fishman, Marx, Best, & Revital, 2003; Ball & Cohen, 1999; Darling-Hammond & Richardson, 2009).

Here the term duration comprises both the number of contact hours spent in professional development and its overall span of time (Garet et al., 2001). The argument for longer duration is that when teachers have more time in professional development they can reflect over their changes and still take advantage of the feedback coming from the professional development group. When professional development meetings are spread along with classroom practice, teachers have opportunities for in-depth discussion of content, exploring student’s thinking, and pedagogical strategies (Garet et al., 2001).
Collective Participation

Research highlights a positive association between teachers engaging as a group in professional development and their implementation of teaching practice in the classroom (Garet et al., 2001; Desimone et al., 2002; Porter et al., 2000). Collegial peer group participation in professional development also opens opportunities for teachers’ continuing learning as a group, reinforcing their interactions, and giving opportunities for them to establish linkages among their experiences (Knapp, 1997; Garet et al., 2001; Desimone et al., 2002).

Garet et al., (2001) state that when professional development is designed for teachers’ collective participation, they can share curriculum materials, and discuss concepts, skills, and school limitations to implement the changes proposed by the professional development. Participation as a group may enable teachers to integrate what they learned in that professional development with other aspects of their instructional context, which may help them to sustain changes in practice over time. Garet et al., (2001) states that collective participation in professional development “may help contribute to a shared professional culture, in which teachers in a school or teachers who teach the same grade or subject develop a common understanding of instructional goals, methods, problems, and solutions” (p. 922).

Concluding Remarks about Characteristics of Effective Professional Development

Literature suggests that professional development experiences that share all or most of the characteristics presented here have a positive influence on teachers’ classroom practice and student achievement (Garet et al., 2001; Desimone et al., 2002; Blank & de las Alas, 2009). Duration, collective participation, and the core features are more important in professional development than its type or format (Garet et al., 2001; Smith & Gillespie, 2007). In terms of
content, literature indicated that it should be situated in practice and built on teachers’ PCK (e.g., Borko et al., 2010; Knapp, 2003). Content, active learning, coherence and extended duration are highlighted as important features of professional development that promote teachers’ knowledge and teachers’ change in practice (e.g., Desimone et al., 2002; Kennedy, 1998; Yoon et al., 2007; Garet et al. 2001; Blank & de las Alas, 2009; Borko et al., 2010; Day & Sachs, 2004).

Professional development initiatives should be coherent with teachers’ professional lives and aligned with other sources of guidance received by teachers, such as textbooks, assessments, and curriculum policies. Teachers should perceive that professional development helps them to be part of the curriculum implementation, allowing them to better communicate with each other, exploring their understanding of the curriculum and its alignment with possible approaches to implement it in class. The literature (e.g., Garet et al. 2001; Desimone et al., 2002) indicates that the presence of all characteristics, or a combination of some of them, give conditions for developers to design professional development initiatives that may lead teachers to improve their pedagogical and content knowledge and their capacity to use this knowledge inside the class in support of students’ learning. In social terms, the reviewed literature indicates that professional development intends to support teachers’ collaboration and the establishment (or nurturing) of collegiate groups, fostering teachers mutual learning, giving them opportunities to try different approaches in class, and helping to diminish any sense of isolation regarding to teaching practice.

**Teachers’ Change as An Outcome of Professional Development**

Teacher’s change emerges as a desired outcome of professional development initiatives. Desimone (2009) states that professional development has the potential to alter teacher knowledge, beliefs, and practice. From this tripod of changes as outcomes of professional development, researchers (Kelcey & Phelps, 2013; Desimone, 2009; Sowder, 2007; Ingvarson,
Meiers & Beavis, 2005; Garet et al., 2001) put special attention on professional development changing teacher knowledge since improvement in teacher knowledge can be considered as a directed outcome of professional development initiatives, and because improvement in teacher knowledge also has the potential to impact students’ learning.

On the other hand, research has not yet found a sound and robust way to measure changes in teachers’ knowledge or teachers’ practice. Studies that describe the characteristics for effective professional development (Desimone et al., 2002; Garet et al., 2001; Ingvarson et al., 2005; Yoon et al., 2007) have based their conclusions about changes in teachers’ knowledge and practice upon data obtained from teacher self-reporting. These studies were correlational in nature and did not present causal effects between features of professional development and the potential changes in teachers.

Change of teachers’ practices is not easy and it does not occur instantaneously when they leave a professional development session. Changing practice takes time and there are many factors that can affect a change inside the classroom such as personal factors and school factors, both of which may promote a “‘dilution’ effect of professional development” (Smith & Gillespie, 2007, p. 226). Examples of personal factors are teacher’s desire to learn, level of education, teaching experience, and teachers’ beliefs about learning and teaching. Examples of school factors are school context and culture, principal leadership, and teachers’ collegiality within the school. In the next section, I review the literature of teachers’ professional learning, and the role of resources on teachers’ learning.

**Teacher Professional Learning**

The literature of teachers’ professional development seems to be migrating from using the term “teacher professional development” to the use of the term “teacher professional
learning” instead. This phenomenon was also detected by Bleicher (2014). Using the ERIC database (https://eric.ed.gov/), searching for ‘professional development’ and comparing to a search for ‘professional learning’ in a title of peer review papers, Bleicher (2014) found out that from 1968 through 2000 “the number of articles mentioning professional learning in titles compared with professional development has grown from 2% up to the year 2000 to 12% for the period 2000–2010” (p. 802). Using the same approach done by Bleicher (2014), I noticed that the quantity of articles mentioning professional learning in titles compared with professional development has grown 21% for the period 2011-2018 according to the ERIC database.

MOOCs can be considered spaces for teacher professional development and at the same time places for teachers to enhance their own professional learning. Teachers’ professional learning is defined in this study as “learning experiences designed to help K–12 teachers learn new skills, develop insights into pedagogy and their own practice, and explore new understandings of content and resources” (Bleicher, 2014, p. 803). The MOOC used as the object of this study was designed by the provider to afford opportunities for teachers to learn and explore a pedagogical approach of teaching statistics through data investigation. In line with the theoretical grounding presented in the previous chapter, participants’ learning in this study is understood as a social experience that happens through their participation in social practices by establishing and experiencing connections with materials (resources) and with others in this professional online environment.

It is important to note that despite the increasing use in the literature, teachers’ professional development is not the same as teachers’ professional learning. The focus of teachers’ professional development is in describing the characteristics that together will comprise high-quality professional interventions that will provide space for teachers’ professional learning experiences (e.g., Desimone et al., 2002; Kennedy, 1998; Yoon et al., 2007; Garet et al., 2001; Blank & de las Alas, 2009; Darling-Hammond et al., 2009). The focus of teachers’ professional
learning is on teachers finding and engaging with these experiences that will enhance their own professional knowledge and practice in order to be better equipped to teach their students (Kentucky Department of Education, 2014; Bleicher, 2014; Avalos, 2011).

Professional learning aims to promote teachers as independent learners, allowing them opportunity to define their own professional learning needs and to “actively engage in the planning and implementation of such development” (Bleicher, 2014, p. 814). Thus, it seems reasonable to consider teachers’ professional learning based on individual features, since teachers’ professional needs may vary from individual to individual based on the contexts and experiences these teachers have passed over time (Day & Gu, 2007).Marcinek (2015) states that professional learning is “most effective when educators have the option to personalize the experience and communicate meaningfully with other educators who share their focus” (p. 1). Then, the goal of teachers’ professional development should be to support teachers’ professional learning (Timperley, 2011) that may occur as they engage in professional interactions to reflect upon their practices aiming to develop their knowledge of the subject matter as well their teaching practice. In the next section, I present the role of resources in teachers’ learning from professional development.

The Role of Resources in Teachers’ Learning from Professional Development

Literature has shown that professional development activities may follow different formats based on the theoretical framework that guides these initiatives (Roesken, 2011; Borko, Koellner, Jacobs, & Seago, 2011; Matos, Powell, Sztajn, 2009). These formats could be grouped as professional development that focus on: (a) teacher’s knowledge, goals, and beliefs, (b) the interplay of aspects of community, context and content, and (c) dimensions of action, reflection, autonomy and networking (Roesken, 2011). A common feature of these different formats of
professional development is that the majority of professional development initiatives make use of resources to develop teacher professional learning.

In general, the resources used in professional development are: curriculum materials and practice-based materials. Curriculum materials are reform curriculum artifacts that are used as objects of inquiry in professional development (Collopy, 2003). Examples of these reform curriculum artifacts are: instructional techniques, packaged programs, toolkits, and technology tools. Practice-based materials are artifacts of practice used as objects of inquiry in professional development (Herbel-Eisenmann, Steele, & Cirillo, 2013). Examples of these artifacts of practice are: technology tools, video cases, tasks, and lesson plans.

However, use of resources is not an exclusive trait of professional development initiatives. Resources are also present in teachers’ classroom practice, as they naturally look for resources outside their classrooms to use or adapt these resources into their teaching purposes. This scenario makes resources objects of both professional development initiatives and teaching classroom practice, highlighting resources as central to teachers’ work (Gueudet, Pepin, & Trouche, 2012; Gueudet & Trouche, 2009).

As teachers engage in professional development, they will interact with other teachers and with resources provided by the professional development initiative. From the professional development perspective, the intention is that these resources will “stimulate teachers to experiment in their classrooms and reflect upon their practice” (Bleicher, 2014, p. 807). From the professional learning perspective, teachers’ experiences with professional development resources will require an investment in understanding (and maybe adapting) these resources in order to fit them into their teaching goals (Bleicher, 2014; Kentucky Department of Education, 2014). In a more general sense, teachers interacting with professional development resources have the potential to support teachers in developing knowledge about the content they need to teach and
resources that may support them in this endeavor. In the next section, I present a review of teachers’ professional development through statistical investigations.

Teaching Statistics through Data Investigations

Mathematics curriculum policies of different countries such as Australia, Brazil, Portugal, South Africa, and the United States present school statistics content focused on data handling, data representation, and data interpretation. This reality puts attention on mathematics teachers as the center of reform, which makes teachers’ professional development a major mechanism of support for the implementation of curriculum policies in classrooms (Day & Sachs, 2004; Garet et al., 2001; Desimone, 2009). Professional development focusing on teaching statistics through the use of investigations emerges as a promising approach that affords teachers opportunities to work with data, to develop their statistics content knowledge, to develop their practice as well the use of technology tools in their statistics lessons. In this section, I present studies that made use of statistical investigation approach for teachers’ professional development. At the end of the section, I highlight the potentials and challenges of this approach based on the presented literature.

Research using statistical investigation in professional development for teachers is based on the Guidelines for Assessment and Instruction in Statistics Education (GAISE) report (Franklin et al., 2007) or on other similar frameworks (Friel, O’Conner, & Manner, 2006, Pfannkuch & Wild, 2004; Graham, 1987). The GAISE report (Franklin et al., 2007) reinforces the importance of students learning the statistical problem-solving process described by its four components: formulating questions (clarify the problem and formulate questions that can be answered with data), collecting data (make and implement a plan to collect appropriate data), analyzing data (select and use appropriate numerical and graphical representations to analyze
data), and interpreting results (interpret the analysis regarding the initial question). Thus, professional development initiatives that use statistical investigation aim to prepare teachers in the one or many phases of the statistical investigation described by the GAISE report.

Researchers (e.g., Santos & Ponte, 2014; Heaton & Mickelson, 2002) have stated that for teachers to teach statistics through data investigation they will need to have solid statistical content knowledge, as well as knowledge of how to facilitate students’ reasoning with data. In posing questions, Makar and Fielding-Wells (2011) and Heaton and Mickelson (2002) suggest that teachers should foster students in creating questions that motivate them to join in a statistical investigation. These questions should be open and about particular contexts (Lee & Mojica, 2008). They should be statistically rich and have potential for development of content that should be covered with students in their curriculum (Heaton & Mickelson, 2002). At the data collection and data analysis phases Santos and Ponte (2014) and Makar & Fielding-Wells (2011) assert that teachers will need to have familiarity with statistical concepts and ways of displaying data (i.e., transnumeration). Transnumeration is a term coined by Wild and Pfannkuch (1999) meaning the process of “changing representations to engender understanding” (p. 227). During the interpreting the results phase of a statistical investigation, teachers should be attentive to whether the original question was in fact answered by the investigation (Wild & Pfannkuch, 1999). For that, they will need to draw on their statistical knowledge to interpret data and draw conclusions about the investigation being made (Heaton & Mickelson, 2002; Wild & Pfannkuch, 1999).

Although the approach of teaching statistics through investigation is student-centered and follows the statistical inquiry process (Wild & Pfannkuch, 1999) in which students address non-structured problems through an investigative cycle as described in the GAISE report (Franklin et al., 2007), authors (e.g., Santos & Ponte, 2014; Heaton & Mickelson, 2002; Makar, 2010; Anderson, 2002) have stated that teachers seem to have difficulty envisioning and sometimes implementing statistical investigations in their classes.
Professional development should provide resources for teachers to use in their practice, allowing them opportunities to collaborate with others and to experience the use of statistical investigation (Makar & Fielding-Wells, 2011). Teaching through inquiry such as implementing statistical investigations will require teachers to develop new practices and to share control of their classroom with their students (Arnold, 2008). Professional development should inform teachers that by using this approach, they will take the “role of motivator, modeler of inquiry practice, collaborator, and mentor” (Makar & Fielding-Wells, 2011, p. 351) in their classes.

Professional development in statistical investigation should provide teachers with experiences as learners in statistical investigations processes. This would give teachers opportunities to experience the uncertainties that emerge when one is learning through a statistical investigation approach (Makar, 2010). Experiencing statistics investigation as learners has the potential to help teachers to “recognize the tentativeness of results, dependence on context, and that outcomes can be continually improved” (Makar & Fielding-Wells, 2011, p. 351).

Heaton and Mickelson (2002), worked with pre-service elementary teachers in a professional development experience in order to give them opportunities to put their statistical and pedagogical content knowledge into practice. In this professional development, pre-service teachers had a chance to use the process of statistical investigation themselves (i.e., as students) and later to apply the process with children. Heaton and Mickelson (2002) report that pre-service teachers, when acting as students, produced positive reflections about the potential of the statistical investigation approach in class. When they were dealing with children, they helped children to pose investigation questions, identify the variables, collect and summarize data, and report their findings.

When investigating more deeply the process of statistical investigation, Heaton and Mickelson (2002) indicate that pre-service teachers stated unsophisticated questions that did not
contain a clear statistical learning goal other than obtaining an answer from their students. In terms of data analysis, pre-service teachers’ intervention with students did not go beyond exploring a descriptive summary of data used in the investigation. The authors reiterate that the initiative did not provide enough opportunities for pre-service teachers to develop a robust statistical content knowledge through statistical investigations, nor opportunities for them become well versed on the “process of reasoning with data needed to teach children the process of statistical investigation” (Heaton & Mickelson, 2002, p. 54).

A similar approach was taken by Santos and Ponte (2014) who report a case of an elementary pre-service teacher’s professional development experience teaching a statistical investigation lesson with grade 3 students. The authors state that the pre-service teacher was able to choose a topic that could generate a discussion. However, her approach in posing the question seemed to be “associated with a need to answer or discuss major problems of society” (Santos & Ponte, 2014, p. 3) instead of aiming for questions that were related to students’ curriculum.

When enacting the statistical investigation lesson, the pre-service teacher introduced the investigation question by herself without input from the students. She did not allow students to pose their own statistical investigation questions as suggested in the literature (e.g., Wild & Pfannkuch (1999)). Data collection was narrow since the initial question posed by the pre-service teacher did not challenge the students. When representing the data, the pre-service teacher made use of frequency tables and elementary use of graphs. With respect to interpreting results, Santos and Ponte (2014) state that this phase was almost non-existent since the pre-service teacher focused on students’ errors in building a graph instead of focusing on the conclusion of the investigations. In general, Santos and Ponte (2014) state that the pre-service teacher in their case study took control of the class. They hypothesize that her behavior may have happened since the pre-service teacher was “uncomfortable with the unpredictableness” of the statistical investigation process (Santos & Ponte, 2014, p. 4).
Makar (2010) reports on a professional development done with primary teachers to develop their practices of statistics investigation (i.e., inquiry-based practices of statistics). She presents teachers’ initial experiences with statistical investigation and shows incongruences between what teachers envisioned as their experience of teaching statistics through investigation and their reality of implementing statistics investigation. According to Makar (2010), teachers envisioned the “benefits of inquiry and articulated positive, almost romantic, notions of what it would mean for their students to learn statistics through inquiry” (p. 3). However, as they enacted their lessons using the statistics investigation approach, they were frustrated that the lessons did not go as they had planned, their statistical knowledge was not extensive as they would like, and they did not feel comfortable developing students’ collaboration skills or coping with issues on students’ behavior in class (Makar, 2010).

Makar (2010) believes that the frustration of teachers’ initial experiences in teaching statistics through investigation is a unique characteristic of their first attempt to implement this approach. She clarifies that these teachers have experienced linearity in learning and teaching mathematics, in which mathematical problems are usually linearly unfolded in class following what was previously planned by teachers. On the other hand, teaching with investigations follows the inquiry mode of teaching in which students may raise new questions that the teacher has not previously thought of, ambiguities of the solution may be exposed, and this approach may bring uncertainties with respect to the directions taken to attend the problem. Moreover, teaching as inquiry will require teachers to share the control of the lesson progress with the students, which may make teachers more vulnerable to unforeseen things.
Use of Primary Data vs Secondary Data

Another strand of the literature of statistical investigation is the use of secondary data. According to Burgess (2007) there are two approaches to using statistical investigation. The first one starts with a question that will be answered as the investigation unfolds. This approach is the same as that recommended by the GAISE report (Franklin et al., 2007). The second approach starts with a data set already selected, and based on this data, a question for investigation is made. He stated that adopting the second approach avoids teachers and students facing issues about “establishing the need for data to help solve their questions” (Burgess, 2007, p. 67).

Hall (2011) presents a discussion about teachers’ decision related to using primary data or secondary data. Primary data refers to data that is obtained by observation or directly collected by students’ and/or teachers’ first-hand experience. Secondary data refers to data that are “collected by someone else for some other purpose” (Salkind, 2010, p. 1331). Hall (2011) states that as teachers design investigative tasks, they will need to consider what kind of data (e.g., continuous, discrete, numeric, categorical) will be required to fulfill the activity. Teachers may choose to use primary data collection when they intend for their students to learn about the process of collecting data and/or “data management techniques, such as how to create a questionnaire” (Hall, 2011, p. 340). If teachers would like students to explore cross-curricular activities, primary data collection may be an available option. On the other hand, the use of secondary data may simplify the question formulation and facilitate the data collection phases of an investigation process.

Hall (2011) states that “secondary data can be rapidly and efficiently obtained from various online sources, such as national statistical agencies’ websites” (p. 339). Likewise, Ponte and Noll (2018) state that by using data already collected and available on the Internet, it may make the process of using statistical investigations in professional development more efficient,
since one step of the investigation process would be reduced or eliminated. Hall (2011) argues that although teachers and students may be interested in collecting real data for their statistical investigations, teachers and students may find the process of data collection frustrating or may have difficulties finding a way to obtain the required data. Thus, using secondary data that is meaningful for students may be a way to overcome the obstacles of data collection.

As a professional development initiative, Hall (2011) reports the work of Statistics Canada’s education outreach program that promotes professional development of elementary teachers as they engage with the Census at School survey (http://censusatschool.ca/). In this professional development initiative, teachers have opportunities to generate primary data collection from their students, inputting data to the Census at School survey, as well as to use data already generated by others via the Census at School database. Hall (2008) highlights that teachers have gained understanding of statistical topics and technology as they engaged in these workshops using data generated by their (or other) students.

Batanero, Godino, and Roa (2004) conducted workshop training for pre-service high school teachers using secondary data taken from the UNESCO website (http://hdrstats.undp.org/en/tables/index.html). In the training, pre-service high school teachers investigated the relationship between the life expectancy in different countries and different international indicators of human development (Batanero et al., 2014). The authors claim that pre-service teachers established relationships between the variables and their reasoning went beyond linear regression, as they used multivariate data. Batanero et al. (2014) highlight the value of the activity in developing pre-service “teacher’s knowledge to teach correlation and regression, and to empower them for their future work” (p. 6).
Use of Technology Tools

Another strand of research related to the use of statistical investigations is the use of technology in data generation and data analysis. Researchers (e.g., Lee & Mojica, 2008; Mojica, 2006; Stohl, 2005; Batanero, Godino, & Roa, 2004) have been focused on the use of technology tools when providing teacher professional development focusing on statistics investigation. The goal of these initiatives is for teachers (and consequently their students) to develop connected knowledge between statistics and probability concepts, attending to the variation present in results from repeated experiments (Lee & Mojica, 2008; Reading & Shaughnessy, 2004; Saldanha & Thompson, 2002).

Lee and Mojica (2008, p. 3) provided professional development to middle school teachers which aimed to increase “teachers’ understanding of how to conduct statistical investigations through conducting probability experiments and simulations” using technology tools. The authors report that teachers planned, taught and reflected upon a lesson involving statistics and/or probability topics. The authors state that teachers were able to choose contexts for the investigations that were familiar to their students, such as simulating basketball throws, and engage students in investigating fairness. Teachers designed their lessons to engage students in “making predictions based on intuitions and using data collections and analysis to compare to their intuitive prediction” (Lee & Mojica, 2008, p. 4). In terms of data analysis, teachers used the experiment to compare results retrieved from theoretical probabilities to results retrieved from empirical approaches.

The authors highlight that although teachers were able to engage their students in statistical investigations with the use of technology, they “missed opportunities for deepening students’ reasoning” (Lee & Mojica, 2008, p. 5). Teachers chose small sample sizes, did not make use of pooled data generated by the class, and they did not use different forms of representation to
examine distributions and variability across samples collected in the lesson (Lee & Mojica, 2008). According to Lee and Mojica (2008), teachers failed to address important questions such as “when should estimates of probability, using an experimental or theoretical approach, be similar? What variability should be expected in results from repeated trials within a sample, and across a collection of samples?” (p. 6).

Results from Lee and Mojica (2008) reinforces a common sense in the literature that teachers do not have much experience in using statistical investigation to conduct probability experiments or simulations with data (Mojica, 2006; Stohl, 2005; Batanero, Godino, & Roa, 2004).

**Concluding Remarks about Teaching Statistics through Data Investigations**

In this section, statistical investigation was presented as a potential approach that affords teachers opportunities to work with data and develop their teaching practice of statistics. Teaching statistics through data investigation has the potential to make the statistics classroom an example of statistics practice. It provides to students and teachers opportunities for experimentation with data in varied contexts. In regard to students, this approach is in line with the worldwide trend in school curricula towards developing statistical thinking in students rather than focusing only on developing their statistical skills (Burgess, 2008). Professional development initiatives using statistical investigation presented in this section were done with pre-service and in-service teachers (elementary, middle, and high school). The literature has presented more studies with pre-service teachers than with in-service teachers, which might be related to the fact that “preservice teachers are the most readily available group for researchers working in university settings” (Ponte & Noll, 2018).
The results from the literature have shown that teachers (or pre-service teachers) are able to teach lessons through statistical investigation. However, the implementation of full statistical cycles in the investigations seems to be a challenge for them. Short-term professional development seems to not be enough to support teachers in this project of incorporating statistical inquiry in their lessons. Makar and Fielding-Wells (2011) suggest long-term professional development or extra-curricular training to support teachers in “adopting the curriculum and pedagogies associated with statistical investigations” (p. 352). On the other hand, as teachers engage in professional development initiatives with the intention to improve their learning and practices about statistical investigations, they will need to make use of these professional development venues to build robust knowledge of the content they teach as well as increase their ability to make the subject accessible to students, so that they can better implement the proposed curriculum reform (Garet et al., 2001; Desimone et al., 2002).

The incorporation of technology tools in statistical investigation has the potential to expand the use of real data or simulated data in which technology tools would help students and teachers in analyzing the data generated through an investigation. Learning statistics through data investigation with some technological tool resembles even more the practice of statisticians that naturally embrace technology tools in data analysis and statistical inferences (Ponte & Noll, 2018). Studies presented in the reviewed literature showed that teachers were able to incorporate the use of technology into their investigation lessons. However, they did not capitalize on the use of technological tools for statistical analysis, for example, they did not use different forms of representation to examine distributions and variability across samples collected in the lesson as presented by Lee and Mojica (2008).

In terms of location, professional development initiatives focusing on developing teachers’ practice of statistics may be offered in face-to-face (e.g., Lee and Mojica, 2008), online (e.g. Garfield, & Everson, 2009), or hybrid formats (e.g., Meletiou-Mavrotheris & Serradó,
MOOCs emerge in this field as a new venue for online environment of statistics teachers. In the next section, I present a literature review about research in MOOCs as well as participants’ engagement with the main features of MOOCs: videos and forums. After that, I situate the main research questions in the literature presented through this chapter.

**Massive Open Online Courses (MOOCs)**

Liyanagunawardena, Adam, and Williams (2013) made a systematic literature review of MOOC papers published from 2008 to 2012. This review showed that research on MOOCs during that period was focused on depicting the learner experience in MOOCs by using case studies (e.g., deWaard, 2011), and discussing the influence of MOOCs on higher education programs (e.g., Mehlenbacher, 2012). Participants’ drop-outs in MOOCs (e.g., Koutropoulos, et al., 2012), their motivation to register and/or persist in the course (e.g., Mak, Williams, & Mackness, 2010), and MOOCs accreditation (e.g., Levin, 2013) started to appear in the literature in this period. Liyanagunawardena, Adams & Williams (2013) indicate that MOOC research was mainly quantitative with researchers making use of data generated from MOOC platforms such as click data. At that point in time, the authors highlighted the lack of studies focusing on MOOC facilitators’ experience, and the impact of cultural differences in MOOC participation.

In 2016, Veletsianos and Shepherdson (2016) released a systematic literature review of MOOC papers published from 2013 to 2015. This review showed that, during this period, research on MOOCs was mostly focused on student characteristics, with researchers investigating students’ behavior with respect to: certification (e.g., Reich, 2014), completion rates (e.g. Ebben & Murphy, 2014), students’ perceptions and preferences (e.g., Goh, Kaur, & Chion, 2015), students’ demographics (e.g., Gasevic, Kovanovic, Joksimovic, & Siemens, 2014), and students’ motivation to take MOOCs (e.g., Xiong et al., 2015). Data collection expanded from using only
click data to the incorporation of questionnaires and surveys that “were used in 55.7% of papers”, according to Veletsianos and Shepherdson (2016, p. 9). Quantitative analysis was still the preferred method of majority of papers reviewed by Veletsianos and Shepherdson (2016). The authors alert that although the reviewed studies were centered on students’ experiences in MOOCs, “learners’ voices were largely absent” in these papers (Veletsianos & Shepherdson, 2016, p. 11). The authors recommend “an expansion of the methodological approaches” (p. 11), and qualitative research methods emerge as potential approach to portray students’ experience in MOOCs. In line with Liyanagunawardena, Adams, and Williams (2013), Veletsianos and Shepherdson (2016) also note that there is scant literature about the role of the instructor in MOOCs.

In both systematic reviews (Liyanagunawardena, Adams & Williams, 2013; Veletsianos & Shepherdson, 2016) xMOOCs and cMOOCs were considered indistinctively for the purpose of aggregate literature. However, with the spread of xMOOCs sponsored by universities, the number of publications about this kind of MOOC started to show up in more quantity in the literature (Veletsianos & Shepherdson, 2016), in which most of these papers were focused on “institutional experiences in setting up MOOCs, and MOOC studies examining higher education students” (de Waard, 2016, p. 12).

Research using MOOC demographics is still a strong strand in MOOC research. Studies focusing on students’ participation in MOOCs set out to identify the characteristics of typical MOOC participants, and learned that MOOC participants are well educated students, employed, and from developed countries (e.g., Glass, Shiokawa-Baklan, & Saltarelli, 2016; DeBoer et al., 2014; Breslow, 2016; Veletsianos & Shepherdson, 2016). For de Waard (2016), since the majority of active learners in MOOCs are employed full-time, it could lead to a potential “relation between the learner and a professional reason for following MOOCs” (p. 12). In fact, after 2014
studies started to show up in the literature depicting MOOCs as spaces for professional learning (de Waard, 2016; Milligan & Littlejohn, 2014).

**MOOCs for Teachers’ Professional Learning**

Although any participant could use MOOCs for professional development purposes due to its open enrollment, a new trend of MOOCs designed for professional learning has started to appear in MOOC platforms. The conception of these MOOCs for professional learning seems to be based on the notion that “professional work and learning are deeply intertwined” (Milligan & Littlejohn, 2014, p. 1), which suggests synergy with the possibility to access free and flexible education at any time and from anywhere. Approaching professional work and professional learning within the networked learning carried out by MOOCs makes these venues unique spaces for participants to explore their existing knowledge along with knowledge acquired from the MOOC content and from other participants who joined these venues with similar professional goals.

Research on MOOCs for teachers’ professional learning started to appear in the literature with papers focusing on (a) describing framework designs to be used in creation of MOOCs for teachers (e.g., Koukis & Jimoyiannis, 2017; Gynther, 2016; Vivian, Falkner, & Falkner, 2014), and (b) developing teachers’ capacity in different areas such as STEM proficiency (e.g., Kilde & Gonzales, 2015), English proficiency (e.g., Silvia, 2015), and statistics teaching proficiency (e.g., Lee & Stangl, 2015). These papers emerge from different areas of knowledge with authors focused on developing MOOCs for language teachers (e.g., Koukis & Jimoyiannis, 2017), computer science teachers (e.g., Vivian, Falkner, & Falkner, 2014), and mathematics teachers (e.g., Lee & Stangl, 2015). Some of them include analysis of teachers’ perceptions of the MOOC (e.g., Koukis & Jimoyiannis, 2017, Silvia, 2015), their network creation and potential learning
outcomes (e.g., Kellogg, Booth, & Oliver, 2014), and the potential for teachers’ collaboration in MOOCs (e.g., Koukis & Jimoyiannis, 2017; Gynther, 2016; Laurillard, 2016; Kellogg, Booth, Oliver, 2014; Vivian et al., 2014).

Although these papers have reported promising designs of MOOCs for teachers’ professional learning as well teachers’ perceptions of the experience of engaging in those MOOCs, the literature still falls short in depicting the nature of professionals’ learning in these MOOCs. In this study, participants’ learning is understood as a social experience that happens through their participation in social practices as in this MOOC by establishing and experiencing connections (interactions) with materials (resources) and with others in this professional online environment. In the next section, I present MOOC research focused on participants’ engagement in these online environments and for that I focus on participants’ engagement with videos and with forums. Although MOOCs are comprised of a variety types of resources (e.g., videos, documents, assessments, simulations) videos emerge as the most common resource that participants engage with as they experience MOOCs. Discussion forums emerge as open spaces in MOOCs for participants to engage with each other and to exchange knowledge. In this section the literature on participants’ engagement with videos and with discussion forums are reviewed.

**Participants’ Engagement in MOOCs**

Well-known approaches to promote participants’ engagement in MOOC's are the inclusion of visual materials, such as video recordings, and the utilization of discussion forums. Research in MOOCs has been investigating participants’ engagement with videos and forums, and I have synthesized these two branches of literature in Bonafini (2017). Based on Bonafini (2017), in this section, I present a review of participants’ engagement with video and forums in MOOCs.
**Video engagement in MOOCs.** Videos have a number of different purposes and functions in MOOCs such as advertise the course content and structure, introduce lessons, and provide assignment directions (Sinha, Jermann, Li, & Dillenbourg, 2014). As sources of MOOC content, videos also contribute with inputs of topics that will be later discussed by participants in forums. Morris and Lambe (2014) have characterized the use of videos in MOOCs as (a) introductory (to clarify goals and objectives), (b) pre-recorded lectures, (c) explanations of the course content, (d) narrative (documentary) style presentations, (e) recorded meetings, and (f) knowledge checkpoints that may include questions.

Researchers have featured the benefits of using video recordings such as the capacity to pause, fast-forward, replay, delay watching, and skip pieces of videos allowing participants flexibility in their learning (e.g., Triay, Sancho-Vinuesa, Minguillón, & Daza, 2016; Morris & Lambe, 2014). These video features are very important in MOOCs since majority of participants are not working in their primary language (e.g., Zhang et al., 2016). Engagement with videos is an individual choice for participants, therefore researchers have investigated characteristics and components of videos that can be associated with student engagement in order to find means of increasing participant activity in MOOCs. (e.g., Guo, Kim & Rubin, 2014; Glance, Forsey, & Riley, 2013). Sinha et al. (2014), analyzed students’ engagement with videos in a MOOC and claim that from "100% students who register [in a MOOC], 75% show up: 50% of them primarily watch video lectures and the rest 25% additionally work out homework and assignments” (p. 02).

Research shows (e.g., Guo, Kim, & Rubin, 2014; Coetzee, Fox, Hearst & Hartmann, 2014; Lee et al., 2015; Guo, Kim & Rubin, 2014) MOOC participants relying on videos to learn the content offered by MOOCs. The consensus view of these researchers seems to be that participant engagement with videos is tied to the perceived ease or difficulty of understanding the video content, pre-existing familiarity with the topic, the length of the video, and individual motivation.
Forum engagement in MOOCs. Forums serve as the locus for participants’ interaction in MOOCs. However, research on participants’ engagement in forums does not present a unified perspective about the effectiveness of discussion forums in MOOC environments. Some studies highlight forums as spaces for participants to get to know other participants (social learning), to interact with them about content, and to learn through their experiences (Young, 2012; Sharif & Magrill, 2015). Forums in MOOCs are spaces where participants can communicate with each other, ask and/or answer questions, and thereby check and reinforce their understanding of assignments or tasks (Young, 2012; Darabi, Arrastia, Nelson, Cornille, & Liang, 2011). Forums allow voice to virtually all MOOC participants (Walker, 2007), and have the potential to promote participants’ experiential learning by hosting cross-cultural sharing experiences among participants (Sharif & Magrill, 2015). Forums are spaces for participants to interact about course content (Thomas, 2002), and to learn from collaborating with each other (Coetzee et al., 2014). Participants who take part in forums have a higher probability of completing the MOOC (Bonafini, 2017; Bonafini, Chae, Park, & Jablokow, 2017; Yang, Sinha, David, & Rose, 2013; Kizilcec, Piech, & Schneider, 2013).

Other studies present concerns about MOOC forums stating that forums produce isolated participation (e.g., Onah, Sinclair, & Boyatt, 2014; Thomas, 2002). This perspective depicts forums as spaces for individual voices instead of spaces for collaboration of peers (Thomas, 2002). In fact, a current practice in MOOCs is to use forums to post questions or ask for advice about assignments (Cui & Wise, 2015). However, few participants seem to be willing to provide answers to others. As the course unfolds, online forums tend to become a pile of discussion threads with little engagement among participants (Thomas, 2002).

Although it is true that participation in forums is related to student completion, discussion forums seem to not be useful spaces to all kind of students (e.g., Baxter & Haycock, 2014; McGuire, 2013; Fini, 2009). As described by Schweizer (2013), participants express frustration at the level of contribution of their peers, classifying these contributions as “unfocused, tentative, and frankly,
Onah et al. (2014, p. 1) complements the experience of Schweizer (2013) claiming that in some instances, participants’ answers to each other “may be incorrect and counter-productive” for the discussion process. Moreover, some participants use forums for non-cognitive activities such as making social connections or resolving logistical or technical issues (Cui & Wise, 2015). The use of forums for non-cognitive activities may contribute to information overload in online discussions reinforcing participants’ negative perceptions of discussion forums (e.g., Schweizer, 2013; Peters & Hewitt, 2010).

In the next section, I do a brief overview of the broad areas covered in this literature review and pose the two research questions that guide this study.

**Situating the Research Questions in the Literature**

I started this chapter by presenting a review of relevant literature with respect to teachers’ professional development and the characteristics synthesized through the literature that denote effective and high quality professional development for teachers. This set of characteristics for designing an effective professional development for teachers emerged from the literature of face-to-face teachers’ professional development and has been very important in providing guidance for professional development initiatives. However, professional development within a MOOC is relatively new and in need of additional research to understand which characteristics of effective professional development hold in MOOCs as a new form of online professional development. Thus, the first goal of this study is to answer the following question: “To what extent can the characteristics described in the literature on effective face-to-face teachers’ professional development hold in a MOOC designed for statistics development of secondary teachers?”

In the chapter, I also presented the literature of teachers’ professional learning, the difference between ‘teachers’ professional development’ and ‘teachers’ professional learning’,...
and the position taken by this study that MOOCs can be spaces for teacher professional development as well places for teachers to enhance their own professional learning. Then, I presented the importance of resources in teachers’ learning from professional development experiences and narrowed the scope of the review to inform the field of teacher professional development about MOOCs and about MOOCs’ participant engagement with videos and forums. This backdrop literature, aligned with the definition of interactions presented in the previous chapter, helps me to state the second goal of this study, which is to answer the following question: “What is the nature of teachers’ and others’ interactions (with materials and with each other) in a MOOC designed for statistical professional development?”

Research on MOOCs for teachers’ professional development purposes is still scant in the literature. I expect that exploring the presence of these six characteristics in this MOOC as well as the nature of participants’ interactions with materials and with others in this MOOC may help the field of teacher professional development by providing ground to the literature about the potentialities and caveats of MOOCs as venues for teachers’ professional development.
Chapter 3

Theoretical Framework

This chapter presents the theoretical grounding that supports this study in answering its two main research questions. For that, I begin the chapter by presenting the Social Theory of Learning (Wenger, 1998; 2006) which states that learning is fundamentally a social experience, that happens through participation in social practices such as this MOOC. Participation (i.e., engagement) is depicted in this MOOC by participants connecting to materials and to each other through the network, and connectivism (Siemens, 2005; Siemens & Downes, 2011) is used to frame teachers’ learning through participation as they establish and experience these connections. Finally, I present the construct of interactions that is used to unpack the connections produced by participants in this MOOC.

Social Theory of Learning

Early conceptualization of social learning focused on individual learning taking place in a social context and being influenced by social norms. One of its founding influencers, Bandura (1977), stated that learning is social and we learn from each other by observation, imitation, and modeling. Since learning takes place in some social context, this study instead focuses on observation, imitation, and modeling to frame learning, it uses a different aspect of social learning theory that centers on the idea of learning through participation (Wenger, 1998).

In this perspective, learning is active social participation in the practices of communities. Community is defined in this study as a “body of persons of common and especially professional interests scattered through a larger society” (Merriam-Webster, n.d.). Wenger (1998) defines
“knowledge is a matter of competence with respect to valued enterprises” (p. 4), and knowing as a matter of active engagement in the world pursuing an enterprise. The definition of learning through participation fits well for the purpose of studying the nature of participants’ interactions in a MOOC focused on statistics for teachers in which participants (teachers) will have to engage with others, sharing their experiences and building learning through this process. Knowledge in this MOOC is described as teachers connecting to each other and their development of statistics knowledge for teaching. Knowing is characterized by the active participation of teachers (engagement) in the MOOC.

The conceptual framework for Wenger’s (1998) social theory of learning comprises four components: meaning, identity, practice, and community. According to Wenger (1998), participants produce meaning as an interplay of participation and reification. “Participation refers to a process of taking part and also to the relations with others that reflect this process” (p. 55). Participation is described by the social experience in the community in terms of membership. Reification is “the process of giving form to our experience by producing objects that congeal this experience into ‘thingness’” (p. 58). Through participation and reification participants can negotiate meaning in the community.

Identity is built through the process of negotiating the meanings of their experiences as a member in social communities (Wenger, 1998). In this perspective, identity is intrinsically connected to practice. Participants develop practices as they join in a community in which “members can engage with one another and thus acknowledge each other as participants” (p. 150). “Identity as negotiated experience” defines who we are by “the ways we participate and reify our selves” (Wenger, 1998, p. 86). Identity is also built by establishing a community membership and by the effects of “our learning trajectories (where we have been and where we are going)” in this community (Wenger, 1998, p. 86). Moreover, identity is when we reconcile
into one identity our membership in a variety of communities, and when we negotiate “local ways of belonging” in these communities (Wenger, 1998, p. 150).

Practice refers to participants being involved with and contributing to the community, being personable and responsible to others, treating information and resources as something to be shared (Wenger, 1998). The concept of community emerges by participants sharing a practice, in which “practice is the source of coherence of a community” (Wenger, 1998, p. 73). In this context, practice in community will have three characteristics: “mutual engagement, joint enterprise, and shared repertoire” (Wenger, 1998, p. 73). Mutual engagement refers to participants being included and being part of what matters in a community. Through mutual engagement in the community, participants build collaborative relationships that will bind them together as a social entity (Wenger, 1998). The joint enterprise is “the result of a collective process of negotiation that reflects the full complexity of mutual engagement” (Wenger, 1998, p. 77). The shared repertoire are the resources shared by the community. According to Wenger (1998), “these resources include routines, tools, ways of doing things, actions, or concepts that the community has produced or adopted in the course of its existence, and which have become part of its practice” (p. 83).

In the MOOC that is the object of this study, teachers will produce meaning (by participation and reification) with regarding statistics teaching. Teachers will negotiate meaning as they interact with MOOC materials and with other participants by interpreting, modifying, endorsing or dismissing proposed statistics teaching practices.

Becoming a participant in this MOOC may imply teachers shaping and re-shaping (by participation and reification) their identity formation as teachers. This process aligns with Sfard’s (1998) participation metaphor, in which learning is “conceived as a process of becoming a member of a certain community” (p. 6). Learning in this MOOC may go beyond teachers establishing connections with each other and gathering information through the network; it can
contribute to their process of becoming statistics teachers by building their identity through participation in the community. Practice in the context of this MOOC will reflect participants’ contributions to the community being created as the MOOC unfolds.

Teachers’ engagement in this MOOC will provide opportunities for them to interact with each other, establishing a collaborative work through peer contributions. Teachers will pursue the joint enterprise of teaching statistics by sharing their knowledge and experiences of teaching within this MOOC community. Therefore, participants will share their repertoire by establishing connections inside (and maybe outside) of the MOOC community.

**Connectivism**

Social Theory of Learning states that learning happens through participation in social practices, such as the MOOC that is the object of this study. Participation is depicted in this MOOC by participants connecting to materials and to each other through the network. Assuming this perspective, connectivism (Siemens, 2005; Siemens & Downes, 2011) is used in this study as a pedagogical tool to frame teachers’ learning through participation as they establish and experience these connections.

Connectivism (Siemens, 2004) acknowledges that with the increasing use of technology in our daily life, learning also relies on informal learning—when one engages with the network, participates in an online community, or does some work-related tasks. Connectivism is about forming connections among people through the use of technology, such as teachers forming an online community through this MOOC by establishing connections among themselves and with materials, promoting learning about statistics teaching and sharing their experiences as teachers. The starting point in connectivism is the individual seeking learning. In this MOOC, teachers will
be seeking learning in terms of professional development. Participation in this MOOC will be
teachers establishing and nurturing a diversity of connections.

Technological contexts support connectivist learning, and thus terms such as network,
connections, and nodes need to be clarified. In connectivism, network is characterized by the
establishment of connections among nodes. Nodes can be ideas, people, or communities
(Siemens, 2005), whilst connection is the action of linking one thing with another (Oxford
dictionaries, n.d.). Through the network, participants can define their learning goals, participate
and produce meaning, and contribute to knowledge creation in an open and accessible way
(Anderson & Dron, 2011). In this MOOC, participants will have the opportunity to create their
own network of knowledge interacting with others regarding statistics teaching. The nodes will
consist of the participants' network, and the connections will be the links they establish with other
nodes along with their interest in statistics teaching.

Learning in connectivism occurs within communities, in which networks support the
establishment of connections and information sharing among teachers. From this perspective the
learning process is cyclical (Kop & Hill, 2008), wherein teachers are able to learn by connecting
to a network to share and find new information. The new knowledge that has been generated by
teachers can then be shared back to the community by the use of the network, so that others can
access it.

From the social perspective, learning occurs through participation, and from
connectivism, learning also comprises one forming a diverse network of connections. Regarding
the formation of connections, learning in an online community will also embrace the notion of
actionable knowledge, meaning that understanding where to find information when it is needed is
as important as the piece of information itself (Siemens, 2005). Thus, connectivism adds to the
social learning perspective of knowledge, stating that knowledge is also a "confluence of
information arising out of multiple individuals seeking inquiry related to a common interest and
providing feedback to one another” (Kop & Hill 2008, p.04). Consequently, decision-making about establishing a connection is also part of the participants' learning process.

In an online community framed by connectivism teachers will connect to a network, build upon the knowledge of others, and share their knowledge back to the community. This process has the potential to span the concept of Communities of Practice (Lave & Wenger, 1991), since this MOOC seems to have the three main structural elements that define a Community of Practice (online or face-to-face), according to Wenger (1998; 2006): domain, community, and practice. By engaging in this professional development, teachers have an opportunity to enhance their personal knowledge (Jarche, 2006) and personal learning networks. Based on Jarche (2006), teachers' personal knowledge is defined in this study as an ongoing process of teachers seeking new information and connections, making sense of this new information, reflecting, enhancing and merging it with their existing knowledge, and sharing results back to others on the network. Teachers' personal learning network is characterized by connections established inside and outside of a community. Particularly, connections established within the community can enhance participants' mutual learning (shared repertoire), supporting them in remaining “current in their field throughout the connections they have formed” (Siemens, 2005, p. 4).

The nurturing of personal learning networks can transcend the MOOC boundaries, fostering the development of participants’ lifelong learning. Lifelong learning consists of learning experiences undertaken by a learner throughout his or her entire lifetime. More specifically, for participants in this study, their lifelong learning will be comprised of the learning activities undertaken by teachers before, during, and after their participation in this MOOC. Next, I describe the four key principles of network learning in connectivism.
Four Key Principles of Network Learning

Downes (2010a) identifies autonomy, diversity, openness and connectedness/interactivity as the four key principles for achieving network learning in connectivism. Autonomy is described as participants having a “choice of where, when, how, with whom, and even, what, to learn” (Mackness, Mak, Fai, & Williams, 2010, p. 266). Autonomy enables participant flexibility and control regarding their own learning process by allowing participants to choose the manner and extent to which they will engage with the course. Autonomy can be seen as freedom to self-organize inside a MOOC, in which participants can choose with whom and where they will interact with each other. However, boundaries are present in autonomy such as individual traits and expertise, personal learning styles, and language fluency (Mackness et al., 2010).

Diversity can be seen as participants with different backgrounds, ages, locations, cultures, and professional experiences joining together in a MOOC environment. According to Mackness et al. (2010), diversity happens when participants engage with a variety of discussions and content, and it reflects participants’ learning preferences and their individual needs. Thus, diversity among participants opens opportunities for them to learn from different perspectives as they interact with each other (Mackness et al., 2010).

Openness can be seen as open enrollment and open access to the course materials (Mackness et al., 2010). It also includes participants’ freedom to work individually or in groups, and to contribute (or not) to the network. According to Downes (2010a, para. 8), openness carries the connotation of “[participants] freely enter and leave the system, and there ought to be a free flow of ideas and artifacts within the system”. Conversely, openness can be compromised if the MOOC doesn’t clearly present its purpose and nature to its participants (Mackness et al., 2010).

Connectedness/Interactivity supports learning in a network environment, and according to Mackness et al. (2010) it can be achieved by selecting particular types of technology. However,
even when a technology that fosters connectivity is chosen it is still possible to not have connectedness and interaction among participants. Moreover, the more connectedness there is, the more time it will take for participants to bond with each other, affecting the sharing processes proposed by openness. In the next section, I describe the four types of activities for networked learning in connectivism.

Engagement Depicted through Connectivism

Through the lens of the social theory of learning, engagement with the course elements and among participants is essential to achieve learning in social communities such as in the MOOC that is the object of this study. In these spaces, participants can learn from course materials and from each other, building their personal learning network. The cyclical characteristic of learning in which teachers connect to a network to find and share information, generate new knowledge, and then share this new knowledge back to the network, will require teachers' mutual engagement. In addition to engagement with course materials and with other participants, teachers' participation will also be characterized by teachers’ contributions to each other. Siemens and Downes (2011) have identified four types of activities for networked learning practice described as: aggregate, remix, repurpose, and feed forward.

As the MOOC provides content embedded in its online resources, participants will start aggregating resources according to their main interest or main goal in the course towards building their personal learning network. Aside from these MOOC sources, it is possible that participants will search online and/or use their personal materials (e.g., class notes, statistics activities, textbooks, newspapers, etc.) to combine into this aggregation process. Aggregation may also come from resources that are shared by other participants as they interact in forums.
The second activity is called remix. After getting in touch with the material of interest it is expected that participants will store their knowledge of these materials in some place. This could be done by creating a blog, taking part in discussion forums, using Google Docs or Facebook, or creating a video on YouTube. The remix is not only a conglomerate of information acquired by the participant, but also of the participant’s reflection on the information collected among the different sources.

The next activity is repurpose. Participants will work with content created by somebody else, and express their own understanding and knowledge that comes from those materials. By expressing their own understanding from those materials, the participants are producing meaning as described in previous sections of this chapter. For example, one can adapt an activity presented in a textbook or an activity used by someone else for his or her own high school statistics classes and reflect over this action.

In feed forward participants are encouraged to share their knowledge with other participants. The sharing of knowledge (participant repertoire) will occur as teachers share their work through the network, based on the idea that others can learn with that material. The sharing process can also enhance networked learning among participants as one participant may aggregate this material, repurpose it to fit into his or her classroom, and feed-forwarding these materials with their students.

Siemens and Downes (2011) caution that in the beginning it may be difficult for participants to share their work, but once they do they will get a great reward as people see, connect to, or react to it. In Siemens and Downes' view, the action of participants creating and sharing materials that other people learn from may motivate other learners in sharing their work too. Despite the fact that sharing is emphasized in connectivism, the decision of whether or not to participate in the sharing will be deferred to each participant.
According to Siemens and Downes (2011), participants must be active and take part in the course, and this can be done via aggregation, remixing, and repurposing, then spreading the material in feed forward. In this sense the autonomy and confidence of the learner is going to be crucial for reaching high levels of engagement. Siemens and Downes (2011) claim that if participants’ engagement works as previously described it is possible to observe the cycle of content and creativity feeding on itself, with participants aggregating, creating, remixing, and sharing knowledge. This cycle highlights the cyclical networked learning among participants. Once participants can share their productions anywhere, the MOOC has the potential to contribute to lifelong learning of the participants, generating a community in which the interaction among participants will finish not with completion of the course, but when they choose to end it (Siemens & Downes, 2011).

Concluding Remarks about Connectivism

Connectivism has been offered as an alternative learning theory that recognizes how technology has impacted society and consequently, how technology has produced changes in teaching and learning processes (Siemens, 2004). Connectivism has not yet been accepted as a new learning theory for a digital age (Verhagen, 2006; Kop & Hill, 2008; Bell, 2011; Tschofen & Mackness, 2012). For the purposes of this study, connectivism is viewed as a pedagogical tool to frame participants’ engagement through their connections within the network. In this sense this study recognizes the pedagogical potential of connectivism as it frames learning in terms of learners connecting on the network (Bell, 2011; Kop & Hill, 2008). However, I concur with some critics of connectivism that for it to be considered a robust learning theory it will need substantial empirical research to validate its formal hypotheses (Verhagen, 2006; Bell, 2011; Kop & Hill, 2008; Kerr, 2007; Kerr, n.d.). For example, investigating how the theory would be depicted
outside of an online environment. Despite the criticism, when the context is constrained to an online environment connectivism carries a pedagogical approach that affords learners the ability to connect to each other using the Internet via social networking and collaboration tools, helping me as the researcher to frame (and further analyze) participation in an online environment such as the MOOC studied in this investigation.

**Participants’ Interaction in Online Environments**

From previous sections, I stated that this study makes use of the social theory of learning (Wenger, 1998) to describe participants’ engagement, and connectivism (Siemens, 2005; Siemens & Downes, 2011) to frame teachers’ learning through participation as they establish and experience connections. Connectivism does not provide specification about what type of connections happen among participants as they engage with a network, nor does it inform the process of participants experiencing connections within a network. Since this study is interested in understanding the nature of participants’ experiencing connections in this MOOC (participants’ engagement), I make use of interaction as a construct to depict participants’ engagement as they establish and nurture connections.

**A Functional Definition for Interaction**

Although the term interaction is commonly used in online learning, its definition varies throughout the literature (Anderson, 2003). Some authors (e.g., Sutton, 2000, Wagner, 1994, Vrasidas & McIsaac, 1999) define interaction as relying on its precise definition, in which interaction requires at least two human actors mutually influencing one another. Other researchers (e.g., Anderson, 2003, So, 2010) are more flexible in adapting their definitions to embrace the
reality imposed by the advancement of technology, including non-human agents’ interaction within their definitions.

Researchers such as Wagner (1994) focus on interaction for educational purposes, making use of terms such as “instructional interaction” (p. 8), in which interaction carries the intent to change learners’ behavior towards an educational goal. Other researchers as Hillman, Willis, and Gunawardena (1994) advocated for a “learner-interface interaction” (p. 33), stating that in online environments interactions happen between technology and the learner, naming learner-interface interaction as important in a global definition of interaction. In this study, interaction refers to a reciprocal communication between two or more human actors (e.g., participants or instructors), or between human actors and non-human agents (e.g., platforms, materials, and softwares), in which reciprocal communications are “events that require at least two objects and two actions” (Wagner, 1994, p. 8). Although interaction does not comprise content in its definition, for the purpose of this study teachers’ interactions will comprise not only teachers’ online conversations with each other, but also teachers’ engagement with materials (content) regarding to statistics teaching.

**Forms of Interactions in Online Environments**

Moore (1989) initially proposed three forms of interactions in online education environments: learner-teacher, learner-learner, and the learner-content. Hillman, Wills, and Gunawardena (1994) presented a fourth form of interaction occurring between learner and interface, calling it the learner-interface interaction. With the advancement of technology, authors such as Anderson and Garrison (1998) have expanded the three initial forms of interaction from Moore (1989) to include teacher-teacher, teacher-content, and content-content forms of
interactions, and Sutton (2000) has added vicarious interaction as an important form of interaction that occurs in distance learning environments.

Among the eight forms of interactions present in the literature (learner-teacher, learner-learner, learner-content, learner-interface, teacher-teacher, teacher-content, content-content, and vicarious interaction), this study will mainly focus on interactions among participants (including the MOOC instructor), and interactions of participants with the MOOC content (resources). Thus, interactions among participants comprise learner-learner and learner-instructor interactions, and interactions with the MOOC content comprises learner-content interaction.

Learner-learner interaction is defined in this study as “the interaction that takes place between one learner and other learners, alone or in group settings, either in the presence or absence of an instructor” (Gunawardena, 1999, p. 4). Learner-instructor interaction is defined in this study as “interaction between the learner and the expert who prepared the subject material, or some other expert acting as instructor” (Moore, 1989, p. 1). Interactions among participants in this MOOC and interactions between participants and the MOOC instructor will be broadly labeled as participants’ interactions. Learner-content interaction is defined in this study as the “interaction between the learner and the content or subject of study” (Moore, 1989, p. 1).

Due to its open enrollment, participants’ interactions in this MOOC will embrace all possible kinds of participants that this MOOC may have. Since all forms of interactions in the MOOC will be mediated by some kind of technology (e.g., website, chat, forum, video conference, etc.), this study will take the learner-interface interaction as a default and will not consider the influence of this form of interaction in the data analysis. Although it is reasonable to assume that some participants will engage in this MOOC by only observing the interaction of others (lurking), due to the nature of the research questions, vicarious interactions or lurking are outside the scope of this study and will not be considered in the data analysis.
Final Remarks

Assuming that learning is fundamentally a social experience, this chapter presented its theoretical grounding as a combination of the social theory of learning (Wenger, 1998; 2006) and connectivism (Siemens, 2005; Siemens & Downes, 2011). Since participation in this MOOC (i.e., participants’ engagement) is depicted by participants connecting to materials and to each other through the network, connectivism is used as a pedagogical tool to frame teachers’ learning through participation as they establish and experience these connections. Knowing that connectivism does not provide specification about the process of participants experiencing connections within the network, interactions are used to depict participants’ engagement as they establish and nurture connections. Among the eight forms of interactions presented in the literature, this study makes use of interactions among participants (including the MOOC instructor), and interactions of participants with the MOOC content (resources).

By presenting empirical research with the use of the social theory of learning (Wenger, 1998; 2006) and connectivism (Siemens, 2005; Siemens & Downes, 2011), aligned with the functional use of interactions, I expect this study to advance the literature by presenting a theoretical perspective that can be used in understanding MOOCs for teachers’ professional development as well understanding participants’ engaging in these venues. The theoretical grounding used in this study is not restricted to the domain of teachers’ online professional development. It has potential to be used as a theoretical framework to understand participants’ engagement in different MOOCs.

In the next chapter, I present methods used to answer the research questions that guide this study: *To what extent can the characteristics described in the literature on effective face-to-face teachers’ professional development hold in a MOOC designed for statistics development of*
secondary teachers? and What is the nature of teachers’ and others’ interactions (with materials and with each other) in a MOOC designed for statistical professional development?
Chapter 4
Research Design, Methodology and Data Analysis

Massive open online courses (MOOCs) have been operating in the mainstream since 2013, and have generated a disruption in higher education. MOOCs for teachers have emerged as new venues for online teachers’ professional development, providing online and free-of-charge professional development experiences for teachers. As a relatively new field of study, there is a need to thoroughly understand and characterize MOOCs as venues for secondary teachers’ statistics professional development. It is also important to understand the opportunities afforded to teachers’ learning when they engage with others and with materials in a statistics teaching MOOC. Thus, the notion of interaction presented in the theoretical framework is seen as paramount in describing the processes of teachers’ engagement in this professional development venue.

The purpose of this study is to develop a deeper understanding of the characteristics of MOOCs as venues for effective teachers’ professional development, as well as to understand the nature of participants’ (teachers’) interactions when engaged with materials and with others to learn and to improve their practice regarding statistics teaching at a secondary level. The following research questions guide this study:

To what extent can the characteristics described in the literature on effective face-to-face teachers’ professional development hold in a MOOC designed for statistics development of secondary teachers?

and
What is the nature of teachers’ and others’ interactions (with materials and with each other) in a MOOC designed for statistical professional development?

This investigation makes use of the qualitative paradigm since the nature of these questions lead to an interpretive research perspective in which the researcher seeks to understand an educational phenomenon through building upon abstractions, concepts, hypotheses, and theory (Merriam, 1998). For Denzin and Lincoln (1994) and Merriam (1998), qualitative research involves an interpretative and naturalistic approach of the subject matter, with little disruption of the natural setting, and with the research focus on the interpretation and meaning of what is being investigated.

This study is naturalistic, as participants are not playing any special role other than being themselves, and participation in the MOOC is voluntary. The researcher also plays a role in data collection, spending time within this online environment during the pilot and during the current study, observing the experiences of the participants’ interactions in order to understand the characteristics and potentialities of MOOCs as effective professional development. The researcher aims to portray, as much as possible, a holistic picture of the phenomenon being studied. Thus, qualitative research is being used as a vehicle to reveal how the parts identified by the research instruments work together to form a whole that will give the mathematics education and statistics education fields knowledge about MOOCs as professional development for statistics teachers.

Context of the Study

The context of this study is a MOOC for educators offered by a large U.S. university. This MOOC was designed for teachers’ professional development in statistics teaching and the use of statistical investigations. In line with Kleinman, Wolf and Frye (2013) a MOOC for
educators “explores a specific model designed to provide K–12 educators with self-directed, supported, flexible, yet structured learning opportunities” (p. 01). These authors also state that self-directing learning in participants, peer-supported learning, authentic project-based learning opportunities, data-informed activities, and use of case-study should be design principles of effective professional development in MOOCs for educators.

The MOOC that is the object of this study was specifically designed for teachers to learn about statistics teaching, as well to learn more about teaching statistics through the use of statistical investigations. According to Lee & Stangl (2015) the MOOC for teachers’ professional development on statistics teaching is a venue for teachers to get acquainted and also to explore the use of a framework to teach “statistics as an investigative process” (p. 58), in which one poses questions, collects data, analyzes the results, and interprets these results back in the context of the problem.

**Pilot Study**

A previous version of the MOOC used in this study was offered during the Summer of 2015, beginning on March 9th and finishing on May 4th with its platform open for several weeks thereafter to further participant’s engagement. The researcher engaged in this MOOC as a non-participant observer (lurker) to gain knowledge about the MOOC environment, its potentialities, its constraints, and evaluate if the MOOC could be an ideal environment to host this investigation.

Time spent lurking in the Summer offering of the MOOC was used by the researcher as a methodological tool when crafting the current research questions. In this study *lurking* is defined as a silent and legitimate peripheral participation in which participants “were actively following
the course but did not actively engage with other learners within it” (Milligan, Littlejohn, & Margaryan, 2013, p. 151).

Lurking was crucial to the researcher when conceptualizing the research questions of this study. As many qualitative researchers, she went to the field guided by an initial research question originally stated as “How do participants engage with materials and with each other to produce meaning regarding to statistics teaching in a MOOC for professional development purpose?” She was mainly focused on ways of participants’ engagement in this MOOC for statistics professional development. As described in the theoretical framework, engagement is understood as teachers’ participating in the MOOC through the lens of social theory of learning (Wenger, 1998), and as teachers establishing connections through the lens of connectivism (Siemens, 2005).

Through the experience of lurking during the MOOC the researcher noted that participants’ engagement could be described by their interactions with course materials and with other participants. Due to the MOOC design and characteristics, participants usually engaged first with videos, tasks, readings, and simulations, and afterwards participated in forum discussions. By lurking throughout the online professional development during the Summer (pilot study), it was noticed that the MOOC, by design, took place wholly within the Moodle platform, thus making the engagement process very predictable. It was further noted that participants did not make use of social media tools, nor did they present any hint through their discussion in the forums that they were interacting in any environment other than Moodle. Thus, it is assumed that the discussion forums were the sole venue for hosting participants’ interactions throughout the MOOC. Based on this fact, the second research question was designed to embrace the reality presented by the MOOC. It was through lurking that the researcher noticed the relevance of studying the content of participants’ interaction in this professional development. Lurking also helped the researcher in the process of comparing and contrasting the consolidated set of
characteristics of effective professional development proposed in the face-to-face literature of professional development to the potential characteristics emerging for this new venue of teachers’ professional development.

**Experimental Data Collection**

Through the Summer of 2015, a partnership between the MOOC’s professor and the researcher was established, allowing the researcher to participate as member of the MOOC research team. Through this partnership, the researcher had access to the data from the MOOC’ Summer offering which was comprised of forum content (participants’ posts and comments), participants’ characteristics (demographics), and click data (number of pages viewed, videos watched, etc.). The Summer MOOC was used as a pilot by the researcher to collect experimental data in order to start building potential answers to the current research questions:

_To what extent can the characteristics described in the literature on effective face-to-face teachers’ professional development hold in a MOOC designed for statistics development of secondary teachers?_

_What is the nature of teachers’ and others’ interactions (with materials and with each other) in a MOOC designed for statistical professional development?_

In the process of addressing the research questions, the researcher made use of qualitative research methods of content analysis (Mayring, 2000; Zhang & Wildemuth, 2009) to identify and describe the enacted characteristics of a MOOC designed for professional development in statistics teaching vis-à-vis to the characteristics of effective professional development described in the literature (Gulamhussein, 2013; Garet et al., 2001; Yoon et al., 2007; Desimone et al., 2002; Blank & de las Alas, 2009; Ingvarson, Meiers, & Beavis, 2005). Inductive coding (Thomas, 2013) was used to identify categories in the data in a process of understanding the content of
participants’ interactions, and Social Network Analysis (SNA) was used to depict the structure of the network produced by participants’ interactions within this MOOC, respectively.

Qualitative content analysis is defined in this study as a “research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns” (Hsieh & Shannon, 2005, p. 1278). Using this approach, the researcher was immersed in the data, allowing the categories to emerge from the data following an inductive coding process rather than using a set of preconceived categories (Hsieh & Shannon, 2005; Mayring, 2000). Inductive coding is defined in this study as an approach “intended to aid an understanding of meaning in complex data through the development of summary themes or categories from the raw data” (Thomas, 2013, p. 03). The inductive coding process began with the researcher reading participant’s interactions in multiple discussion forums and looking for meanings that were inherent in the text segments. In line with Thomas (2013), the researcher identified text segments that contained meaning units, created a label for that category, and assigned a segment of text to it. After coding a portion of the data the researcher developed an initial description of meaning for each category and possible links between categories or groups of categories. This process allowed one segment of text to be coded into more than one category, and a segment of text to not be coded if it is not relevant to the research objectives (Thomas, 2013). Thomas (2013) highlights the importance of continuous revision and refinement of the category system in which the researcher may include new nuances of the description of meaning of each category. Refinement happened on codes and it is explained in the section Interactive Data Analysis.

Social Network Analysis (SNA) is used to capture the structure of the network formed by participants interactions in MOOC forums. Data from participants’ interactions in forums was input into NodeXL Pro to generate the network. NodeXL is a plug-in template for Microsoft Excel, and its basic version is free and open source. Working as an extension of the Excel
spreadsheet application, NodeXL provides network analysis and visualization features (Smith et al., 2009). NodeXL displays the network relationships by presenting a graph containing vertices (nodes in the network) and edges (arrows representing connections between nodes). In this study the networks were representations of participants’ interactions in forums, in which the vertices (dots) represented participants IDs and the edges (arrows) represented the interaction between participants. The network could be built with a directed or undirected edge. In this study, the direct edge (i.e., respond to) was chosen to show each message connecting its author to the author of its parent message.

SNA techniques depict the structure of the network that was formed by the relationships between participants as they interacted in forums, which relates directly to the second research question that guides this study. From qualitative content analysis the study gains deep information about the content of participants’ posts. By implementing SNA in forums it is possible to visualize the leadership of participation in discussions about a topic or theme and identify “the nodes’ centrality measures” (Rabbany, Takaffoli, & Zaïane, 2011, p. 5) relative to each network. The combination of qualitative content analysis and SNA techniques to understand the nature of participants’ interactions in this MOOC strengthened the methods used in this dissertation.

Preliminary Analysis of the Pilot Data

Participants

The demographics from the pilot study showed that 788 MOOC participants enrolled from 43 countries, with 597 (76%) being located in the USA. From the whole group of participants, 589 participants (75%) engaged at least once with the course. The majority of participants (64%) were middle or high school classroom teachers, or college instructors. 11% of
the participants worked as teacher educators in university settings or declared work with professional development.

Analyzing Sample Data

In order to determine if the data collected through the MOOC would produce sound answers to the two main research questions, the researcher purposefully selected pieces of content from the MOOC and samples of the MOOC’s discussion forums in order to generate the sample data. The content pieces were MOOC pages, pdfs, and activities embedded in the five units of the professional development. This content (parts of the MOOC’s units) was used to identify characteristics of effective professional development in this MOOC, the object of the first main research question. The random samples of the MOOC’s discussion forums were content from discussion threads that were used to shed light on the nature of participants’ interactions in a MOOC for statistics professional development focusing on their interaction with materials and with other participants.

For the first research question, “To what extent can the characteristics described in the literature on effective face-to-face teachers’ professional development hold in a MOOC designed for statistics development of secondary teachers?” the researcher chose one characteristic of effective professional development stated in the literature and looked through the MOOC units for evidence of this specific characteristic. For example, the literature of face-to-face teacher’s professional development (e.g., Garet et al., 2001; Yoon et al., 2007; Desimone et al., 2002; Blank & de las Alas, 2009) states that ‘opportunities for active learning’ are an important feature of effective teachers’ professional development. Active learning denotes the extent to which professional development affords opportunities for teachers to become engaged in meaningful discussion, collaborative work, planning, and reflection over their practice (Garet et al., 2001;
Desimone et al., 2002; Desimone, 2009; Borko et al., 2010). An example of this characteristic enacted in this MOOC is presented below.

In Unit 2, participants were encouraged to consider different components of a statistics tasks (Figure 4-1) to evaluate different high school and middle school statistics tasks. This activity gave opportunities for teachers to actively engage with the components of a statistical task being used as a tool to develop, adapt, and analyze tasks designed to engage students in doing statistics.

The following questions can be used to consider the components of a statistical task as a teacher develops, adapts, and analyzes tasks that can engage students in doing statistics.

<table>
<thead>
<tr>
<th>Component of a Statistics Task</th>
<th>Questions to Consider</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learning Goal</strong></td>
<td>What learning goals does the task aim for students to accomplish? Does the task focus on answering questions that are statistical or mathematical? e.g., Does the task ask students to use computations or graphs? Are these in support of analyzing data to make a decision? or is the use of an algorithm or creation of a graph the focus?</td>
</tr>
<tr>
<td><strong>Data</strong></td>
<td>Does the task call for the use of data (either to collect or use already collected data to answer)? Does the data appear to come from a real source?</td>
</tr>
<tr>
<td><strong>Context</strong></td>
<td>Is context a salient part when solving the problem? Is the context likely to be of interest to the students engaging in the task?</td>
</tr>
<tr>
<td><strong>Investigation Cycle</strong></td>
<td>Does the task address only one phase of a statistical investigation, some phases, or all phases of the cycle?</td>
</tr>
<tr>
<td><strong>Pose</strong></td>
<td>Is the question already posed (by teachers, or curriculum developers) or do students have opportunities to pose statistical questions based on their interest?</td>
</tr>
<tr>
<td><strong>Collect</strong></td>
<td>Does the task offer opportunities for students to plan to collect data: sampling, sample size, attribute, and measurement? Do students conduct the data collection? Does the task provide a context so that students are aware of the measurement issues and how data were collected?</td>
</tr>
<tr>
<td><strong>Analyze</strong></td>
<td>Does the task offer opportunities for students to decide on the types of graphical representation and or numerical statistics to use when analyzing data? Does the task afford students to use alternative representations to shed light on the trends of data?</td>
</tr>
<tr>
<td><strong>Interpret</strong></td>
<td>Does the task ask students to incorporate context when making claims/inferences about the data? Does the task expect students’ claims to account for uncertainty?</td>
</tr>
</tbody>
</table>

Figure 4-1. MOOC materials - statistics task guidelines (Lee and Tran, 2015).
The process of evaluating different high school and middle school statistics tasks offered by the MOOC gave opportunities for teachers to think about important elements of a statistical task and to state their thoughts about the possibilities and caveats of those activities regarding to the main components of a statistical task. After analyzing the tasks, teachers engaged in the discussion forum by sharing their perspective about the questions such as (a) Which learning goal(s) could this task be used for students' learning?, (b) Is this task worthwhile to use to engage students in statistics through all or parts of an investigation cycle? (c) Could this task promote productive statistical habits of mind? and, (d) What would you change about this task to make it more worthwhile? Why?

The process of analyzing, reflecting, and suggesting improvements in the tasks produced meaningful opportunities for participants’ active learning as stated in the literature (e.g., Garet et al., 2001; Yoon et al., 2007; Desimone et al., 2002; Blank & de las Alas, 2009). It also helped participants to learn from others’ perspectives about how those activities would fall short regarding important elements when one is building (or analyzing) a statistics task (Figure 4-2).
For the second research question “what is the nature of teachers’ and others’ interactions (with materials and with each other) in a MOOC designed for statistical professional development?”, the researcher chose random discussion forums in which inductive coding was applied to identify the nature of participants’ interaction with materials and with others. To choose a random discussion, the functions index and randbetween from Microsoft Excel (=INDEX($A$2:$A$28501, RANDBETWEEN(2, 28501))) were used. The index function orders
a list of values of the variable of interest (discussion numbers) and the randbetween function randomly picks a value between the range. Figure 4-3 shows part of a discussion thread in which participants report their interactions with MOOC’s materials, and they also interact with others. This figure also presents the coding used by the researcher to characterize the nature of participants’ interactions.

How the Structure of the Network was Extracted and Analyzed

Discussion threads referring to materials were automatedly extracted from the MOOC forum data through Excel macros by using the forum post parent/child information generated by the MOOC provider to identify the direction of communication between participants. The extraction used ‘participants ID’ along with each ‘discussion ID’ associating each participant’s post ID to its receiver (the parent post), is exemplified on Table 4-1.
Table 4-1. Example of participants’ interactions in a discussion thread.

<table>
<thead>
<tr>
<th>Discussion ID</th>
<th>Participants ID</th>
<th>Action</th>
<th>Participant Post ID</th>
<th>Parent Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>6822</td>
<td>4513</td>
<td>Create</td>
<td>16374</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5009</td>
<td>Post</td>
<td>16480</td>
<td>16374</td>
</tr>
<tr>
<td>3</td>
<td>4963</td>
<td>Post</td>
<td>16597</td>
<td>16374</td>
</tr>
<tr>
<td>4</td>
<td>4191</td>
<td>Post</td>
<td>16597</td>
<td>16374</td>
</tr>
<tr>
<td>5</td>
<td>4814</td>
<td>Post</td>
<td>16616</td>
<td>16597</td>
</tr>
<tr>
<td>6</td>
<td>4733</td>
<td>Post</td>
<td>16616</td>
<td>16597</td>
</tr>
<tr>
<td>7</td>
<td>5527</td>
<td>Post</td>
<td>16616</td>
<td>16616</td>
</tr>
<tr>
<td></td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td></td>
<td>.</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>6822</td>
<td>6286</td>
<td>Post</td>
<td>21975</td>
<td>16374</td>
</tr>
</tbody>
</table>

In the example shown in Table 4-1, participant 4513 created a discussion with ‘Discussion ID’ #6822. After that, participant 5009 posted in this discussion replying to participant 4513 as identified by the matching numerical code in the ‘Parent Post’ (column for participant 5009) and the ‘Participant Post ID’ (column for the originating post). Next, participant 4963 joined the discussion and posted something in reply to participant 4513 (the discussion initiator). After that, participant 4191 replied to participant 4963. Note that the ‘Parent Post’ number in row 4 of participant 4191 is 16597. This number is the same as the one presented in the ‘Participant Post ID’ column for participant 4963. This means that participant 4191 replied to participant 4963 as opposed to replying directly to the discussion initiator. The automated process of recording is done for the whole discussion thread and for all discussion threads that were related to each to the three resources.

The output from NodeXL exemplified in Table 4-1 is the network of participants’ interactions in Discussion ID #6822 as shown in Figure 4-4. The origin of an arrow represents the post, while the point of an arrow represents the receiver of this post. Figure 4-4 shows the participants’ network created as they engaged in Discussion ID #6822. It shows the interactions
between participants, in which the nodes represent participants labeled with their Participant ID, and the edges (arrows) represent an interaction between those participants (i.e. one message sent). The edges in Figure 4-4 do not visually represent the number of messages exchanged between the two distinct participants. For instance, if participant 4147 sent a reply to participant 4854, the network will show an arrow from participant 4147 (source) to participant 4854 (recipient). If participant 4147 sent ten additional replies to participant 4854, the network representation will be the same as before; however, this metric is stored in the software for future use.

Figure 4-4 shows the structure of the network of participants’ posts in discussion #6822 after the 300th interaction of the Fruchterman and Reingold algorithm. The Fruchterman and Reingold is an interactive algorithm meaning that in each interaction, the graph shows more clearly the position of the nodes on the screen by grouping together similar nodes and spreading out nodes that are not connected to other pairs of nodes (i.e., clustering participants). Discussion #6922 shown in Figure 4-4 is comprised of 7 sub-groups of participants (clusters).

Figure 4-4. Structure of the network of participants’ interactions in discussion #6822 after the 300th interaction using the Fruchterman and Reingold interactive algorithm.
Important Measurements of SNA

In addition to visual representation, NodeXL also provides overall metrics of the network and individual centrality measures that were used in the current analysis. The overall metrics used in this study are presented in Table 4-2. The information in Table 4-2 was constructed based on the description made by Hansen & Smith (2015).

<table>
<thead>
<tr>
<th>Graph type</th>
<th>Directed or undirected type.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertices</td>
<td>The number of vertices in the graph.</td>
</tr>
<tr>
<td>Unique edges</td>
<td>The number of edges that do not have duplicates (i.e. number of arrows that only appeared once).</td>
</tr>
<tr>
<td>Edges with duplicates</td>
<td>The number of edges that have duplicates.</td>
</tr>
<tr>
<td>Total edges</td>
<td>The number of edges in the graph. This is the sum of unique edges and edges with duplicates.</td>
</tr>
<tr>
<td>Self-loops</td>
<td>The number of edges that connect a vertex to itself.</td>
</tr>
<tr>
<td>Graph density</td>
<td>This is a ratio that compares the number of edges in the graph with the maximum number of edges the graph would have if all the vertices were connected to each other. Duplicate edges and self-loops are ignored.</td>
</tr>
<tr>
<td>Modularity</td>
<td>When the graph has groups, this is a measure of the &quot;quality&quot; of the grouping. Graphs with high modularity have dense connections among the vertices within the same group but sparse connections among vertices in different groups. When the graph does not have groups, this is undefined. Modularity values falls between the range of ([-1/2,1]), meaning that “high values of modularity indicate good partitions” (Fortunato, 2010, p.26). Positive values of modularity indicate that “the number of edges within groups exceeds the number expected on the basis of chance.” (Modularity, n.d.).</td>
</tr>
</tbody>
</table>

The overall metrics produced by NodeXL for discussion #6822 are presented in Table 4-3. Looking at Table 4-3 we can see that this discussion has 38 nodes and 42 unique edges. It is also shows that the discussion did not present participants clarifying or replying to themselves.
(self-loops = 0). The arrows shown in Figure 4-4 are a true representation of participants’ interactions with each other since there are no duplicated edges as shown in Table 4-3. The network is not dense due to the relatively low number of connections (graph density = 0.02987). A network is dense when each node is connected to almost all other nodes in the network (Hansen & Smith, 2015). A network is sparse when each node is connected to a small number of nodes, as in the case of discussion #6822. The groups in discussion #6822 present a fairly good similarity (modularity = 0.581633). “The similarity between two nodes is a measure that quantify the relationship (closeness) between vertex (node) i and j”. (Saoud & Moussaoui, 2018, p. 1960)"

Table 4-3. NodeXL overall metrics for discussion #6822.

<table>
<thead>
<tr>
<th>Graph type</th>
<th>Directed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertices</td>
<td>38</td>
</tr>
<tr>
<td>Unique edges</td>
<td>42</td>
</tr>
<tr>
<td>Edges with duplicates</td>
<td>0</td>
</tr>
<tr>
<td>Total edges</td>
<td>42</td>
</tr>
<tr>
<td>Self-loops</td>
<td>0</td>
</tr>
<tr>
<td>Graph density</td>
<td>0.02987</td>
</tr>
<tr>
<td>Modularity</td>
<td>0.581633</td>
</tr>
</tbody>
</table>

Centrality is “equal to the number of connections that an actor (a node) has with other actors” (Otte & Rousseau, 2002, p. 447). The individual centrality measures also identify the most important vertices within a network. The individual centrality measures used in this study are presented in Table 4-4.

Table 4-4. NodeXL individual centrality measures used in this study.

<table>
<thead>
<tr>
<th>In-Degree</th>
<th>Count the number of “arrows” that link to the person. “An actor with a high in-degree is regarded to be prominent or to have high prestige, as many other actors seek to directly connect to them” (Chan &amp; Liebowitz, 2006, p. 24).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out-Degree</td>
<td>Count the number of “arrows” that go away from the person. “An actor is often said to be influential if it has a high out-degree as it is able to make others aware of its views” (Chan &amp; Liebowitz, 2006, p. 24).</td>
</tr>
</tbody>
</table>
### Betweenness Centrality
Measure the “extent to which a node is connected to other nodes that are not connected to each other. It is a measure of the degree to which a node serves as a bridge” (Soliman, Nasraoui, & Cooper, 2016, p. 671). The actor with high betweenness plays an important ‘broker’ or ‘gatekeeper’ role with a potential for control over others” (Chan & Liebowitz, 2006, p. 24). This actor also plays “the role of connecting different groups” (Otte & Rousseau, 2002, p. 447).

### Closeness Centrality
Measure the “degree to which a node is near all other nodes in a network” (Soliman, Nasraoui, & Cooper, 2016, p. 671). This measure emphasizes “the distance of an actor from all others in the network by focusing on the geodesic distance from each actor to all others. Geodesic distance is the number of relations in the shortest possible path from one actor to another” (Chan & Liebowitz, 2006, p. 24). “A high closeness for an actor means that he or she is related to all others through a small number of paths” (Otte & Rousseau, 2002, p. 447).

### Eigenvector Centrality
“Accounts not only for the node’s own degree, but also the degrees of the nodes to which it connects” (Aldhous, 2012, p. 9). Eigenvector Centrality measures the importance of a node by the importance of its neighbors (Messarra, 2014).

For discussion #6822, the individual centrality measures produced by NodeXL are presented in Table 4-5. From Table 4-5 we can see that in this discussion, participant 4513 was the most prestigious one, since they have the highest count in degree measure (number of arrows that link other people to him). Participant 4513 works as a bridge in this discussion with a betweenness centrality equal to 1118. He is also the nearest node to all other nodes in this network (closeness centrality = 0.014). Consequently, he is also the most important node in this small network (eigenvector centrality = 0.111). The out-degree presents participants 4258, 4346, 4513, and 4409 as the most influential ones in this small network.
Table 4-5. NodeXL individual centrality measures for discussion #6822.

<table>
<thead>
<tr>
<th>Centrality Measure</th>
<th>Participant with Highest Centrality</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In-Degree</strong></td>
<td>Participant 4513</td>
<td>Highest in-degree = 13.</td>
</tr>
<tr>
<td><strong>Out-Degree</strong></td>
<td>Participant 4258, 4346, 4513, and 4409</td>
<td>Highest out-degree = 2</td>
</tr>
<tr>
<td><strong>Betweenness Centrality</strong></td>
<td>Participant 4513</td>
<td>Highest betweenness centrality = 1118.</td>
</tr>
<tr>
<td><strong>Closeness Centrality</strong></td>
<td>Participant 4513</td>
<td>Highest closeness centrality = 0.014.</td>
</tr>
<tr>
<td><strong>Eigenvector Centrality</strong></td>
<td>Participant 4513</td>
<td>Highest eigenvector centrality = 0.111.</td>
</tr>
</tbody>
</table>

**Categories Developed from Coding Using the Pilot Data**

The outcome from the inductive coding process used to describe the nature of participants’ interactions with materials and with others in this MOOC was the development of categories that summarized the raw data as described by Thomas (2013). The categories that emerged from the coding of the discussion forums generated the topology of participants’ interactions in forums and are presented in Figure 4-5. The topology of participants’ interactions in forums provides a big picture of the content of the interactions enacted by the participants when they engaged with materials and with others in the MOOC.
After coding a portion of the data, the codes were (a) labeled by using a short phrase, (b) described by its meaning, and (c) illustrated by example(s) of participant’s posts, as the example presented in Table 4-6. The codes referring to the same theme were grouped to form categories, they were: content of participants’ interactions in forums related to themselves, content of participants’ interactions in forums related to their peers, content of participants’ interactions in forums related to their students, content of participants’ interactions in forums related to MOOC materials.
Table 4-6. Coding explanation (example).

<table>
<thead>
<tr>
<th>Label</th>
<th>Management of Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meaning</strong></td>
<td>Management of learning describes participants’ roles (or intended roles) in the constitution of their classes. It includes their ideas of grouping students, planning of statistical tasks and statistical activities, and setting class norms and so on.</td>
</tr>
<tr>
<td><strong>Example</strong></td>
<td>I had not considered sharing the framework with students but it makes a lot of sense now that you have suggested it. I really like the idea that students can use the framework to self-regulate and propel forward.</td>
</tr>
</tbody>
</table>

Although the Summer offering of the MOOC (study pilot) provided three different sources of data (forum content, demographic data of participants, and click data), in order to properly answer the research question concerning the interaction of participants in this online professional development, it was important to know more about their own perceptions of their interactions within that MOOC. For that, an online survey was created and implemented in the next offering of the MOOC, thereby expanding the forms of data collection of the current study. Since the research question is focused on participants’ interactions within this MOOC, it was also important to understand the perspective from the instructors’ team who designed the MOOC and interacted with participants. Thus, an individual interview with each member of the MOOC’s instruction team was conducted and added to the body of collected data.

The addition of the online survey and the instructor team interviews helped the researcher in the process of data triangulation by increasing the breadth and depth of understanding of the participants’ interactions with materials and with others in this MOOC. Triangulation is defined in this study as “a validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study” (Creswell & Miller, 2000, p. 126). The expansion of data sources in the current study made use of triangulation for confirmatory and completeness purposes (Denzin, 1978), which increase the study accuracy and the validity measures (Creswell, 2008; Denzin, 1978).
Current Study

The MOOC observed for this study was an eight-week course offered from September 28th 2015 to November 9th 2015, with its content distributed across 5 units (Figure 4-6), and its platform open for further participants’ interactions until December 14th 2015.

The structure of the majority of units (Figure 4-7) was comprised of an introduction video that welcomed teachers and informed them of the unit goals. Each unit also included a video in which the MOOC’s instructor spoke with expert statisticians and expert teacher’s statistics educators. A typical unit was completed by teachers accessing the materials provided by the MOOC, and reacting to them by interacting with others in the unit forums.

<table>
<thead>
<tr>
<th>Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1: Considering the Possibilities of Teaching Statistics with Data</td>
</tr>
<tr>
<td>Unit 2: Engaging in Statistics</td>
</tr>
<tr>
<td>Unit 3: Introducing Levels of Statistical Sophistication</td>
</tr>
<tr>
<td>Unit 4: Delving Deeper into the Investigation Cycle</td>
</tr>
<tr>
<td>Unit 5: Putting it All Together</td>
</tr>
<tr>
<td>Participate with a Project</td>
</tr>
</tbody>
</table>

Figure 4-6. MOOC’s Units.

The materials provided by the MOOC varied in a range from readings to simulation statistics tasks. MOOC participants also had a chance to discuss statistical tasks and interact with
different technological tools such as TuvaLabs, Stat Crunch, and NZ Graphe. No activity was mandatory, and although the course officially finished on November 9th 2015, all materials and the forums were still available for participants until December 14th 2015.

For those who wished to receive a certificate of participation (20 hours certificate) they were required to post at least once in the discussion forums in each unit. For those who wanted to receive a 25 hours certificate, in addition to the requirement above, the participant also had to submit a course final project, which usually consisted of the creation of a statistical task or the design of a statistical task implementation.

**Study Participants**

All participants in this study were adults over the age of 18 years old who enrolled as a MOOC participant or as a MOOC instructor. Thus, this study made use of two kinds of participants: those who participated in the MOOC, and those who led it. These two groups of subjects will be hereafter referred to as ‘MOOC participants’ and ‘Instructor participants’, respectively.

Enrollment in this MOOC was open to anyone interested in learning about teaching statistics through data investigations. The statistical concepts covered in this MOOC are often introduced to students from their middle school through early college. The primary audience of this MOOC and the primary participants of this study are K-6 through K-12 teachers and post-secondary teachers. Participants in this study also included non-teacher participants in the MOOC; interactions of such individuals with classroom-teacher participants can be an important part of the effectiveness of professional development for statistics teachers (e.g., Peters, 2009).
Data Sources

Multiple sources of data collection were used in order to improve the quality of the research findings as recommended by Patton (1990). The sources in this study were MOOC materials, click data, demographics, discussion forums content, online survey, and interviews with MOOC instructors. The use of multiple data sources equipped the researcher with a broad perspective regarding the characteristics of the MOOC as an effective professional development for teachers, as well as the nature of participants’ interactions in this professional development.

MOOC Materials

MOOC materials were comprised of all pages, links, documents, videos, simulations, and datasets provided by this professional development throughout the period in which the MOOC was available. Access to these materials was granted to the researcher via login and password to the MOOC’s platform (Moodle). The MOOC’s materials (its pages and resources) were used in this study as evidence to develop answers to the first research question regarding the characteristics of effective professional development for teachers that are (or not) present in this MOOC.

Click Data

Click data was comprised of the whole clickstream data of pages viewed and resources accessed by each participant accumulated during their engagement in MOOC. In this study click data was comprised of every MOOC page, document, video watched, etc. Click data was used to give a macro view of participants’ interactions with materials and with others in order to build answers to the second research question.
**Demographics**

Demographics were collected by the MOOC provider during participants’ enrollment. The input in this form provided demographic information for each participant such as name, age, gender, state, country, level of education, primary job role, years of experience, and primary goals for taking this MOOC. Demographics were used in this study to unveil the characteristics of the participants. Based on the demographics presented in the pilot study, the researcher envisioned a similar composition of participants in the current study.

**Discussion Forum Content**

Discussion forum content was comprised of the information in the online interactions among MOOC’s participants. The content of the discussion forums were posts (originated when one created a new discussion thread) and comments (originated when one replies to another post). The content of discussion forums was used in this study as primary data to build answers to the second research question, in which its purpose was to understand the nature of MOOC participants’ interactions with materials and with each other.

**Online Survey**

The online survey was created by the researcher in Qualtrics and hosted by the university of the MOOC provider. The purpose of the survey was to capture participants’ perceptions regarding their interactions with others during their participation in the MOOC. The survey consisted of 35 questions designed for MOOC participants (excluding instructors). The first part of the survey was developed to collect relevant data about their interactions with other participants in the MOOC. The second part of the survey was focused on their interactions with
MOOC materials, and the third part of the survey addressed participants’ demographics information that was automatically collected by Qualtrics. The survey utilized check box questions, percentage scale questions, and essay questions as in the example in Figure 4-8. Participation in this online survey (see Appendix A) was voluntary and a randomized drawing for a $100 Amazon gift card was offered as incentive to complete the survey.

![Check box](image1.png)

![Percentage scale](image2.png)

![Essay question](image3.png)

Figure 4-8. Examples of the online survey questions.

Five doctoral students, two professors, and the researcher all pilot tested the online survey before it was put online in its final version. The purpose of the pilot was to give feedback to the researcher about the flow of questions, clarity, and intentions with each question included in the survey. Results from the pilot helped the researcher to clarify the text of some questions, grouping questions that had the same topic and also reorganizing the flow of questions presented in the survey document.
The survey was released to MOOC participants on October 28th 2015, with two reminders being sent on November 12th and December 10th, and a final thank you note on December 21st 2015. The survey generated 92 responses with 13 of the participants willing to give additional information about their interaction in the MOOC. The results from the online survey were used as secondary data in building answers to the research question focused on understanding the nature of MOOC participants’ interactions with materials and with others.

**Interview with MOOC Instructors**

The researcher conducted a semi-structured interview (as shown in Appendix B) with each member of the MOOC instruction team, totaling six individual interviews with an average duration of 75 minutes. Five of the interviews were performed at the university that hosts the MOOC, and one was performed via Skype videoconference. All of them were recorded using dual audio recording devices. The purpose of interviewing members of the instruction team was to better understand their perspectives about participants’ interactions in that MOOC.

The interview protocol was created in tandem with the online survey and contained some of the questions presented in the online survey, such as the question: ‘How did you perceive the overall amount of participation in the discussion forums?’ The interview protocol was pilot tested with a mathematics education professor who has vast experience in teachers’ professional development. The purpose of the pilot was for the researcher to check the length of the interview, the flow of questions and potential follow-ups. Redundant questions were eliminated, and additional questions were added for clarification. Aside from helping the researcher in gaining the MOOC’s instructors’ perspectives of designing and implementing an online professional development for statistics teaching, interviewing members of the instruction team proved to be another source for data triangulation.
The Role of the Researcher

In this study, the researcher assumed the role of participant observer during the data collection from discussion forums and discussion views produced by MOOC participants. The researcher was restricted to non-participant observation when data came from the online survey conducted with participants of the MOOC. The researcher assumed the role of an instructor’s peer when interviewing the instructor’s team of this MOOC.

Assumptions

Based on the work of Knowles, Holton, and Swanson (1998, 2005) regarding adult learning, the following assumptions exist in this study. The first assumption is that the MOOC’s participants are adults and self-directed individual learners who pursue interactions related to their own desire or necessity to learn. Second, these participants bring previous experiences that will characterize unique contributions of each participant in the MOOC discussion forums. Third, this study assumes that the MOOC’s participants are willing to learn something that is relevant to them or something that will help them to better teach their class. Fourth, this study assumes that participants are motivated to learn and engage in a MOOC with the purpose of enhancing their own professional knowledge regarding statistics teaching. Fifth, participants engage in the MOOC with previous intentions and they will pursue the MOOC if the course fit their previous intentions. The last assumption is that participants will appreciate the things that they judge important for them to know.
Validity and Reliability

As a qualitative study, the concepts of reliability and validity in this study have the purpose of helping the reader to “understand a situation that would otherwise be enigmatic or confusing” (Eisner, 1991, p. 58). With this purpose in mind, this section presents the actions taken by the researcher to ensure that data collection was undertaken in a consistent manner (Long & Johnson, 2000).

First, the generation of data from discussion forums was not produced by the researcher, nor previously produced to fulfill the research questions. Second, the researcher made use of multiple data collection techniques (online survey, interview, and forum content analysis) to balance the participant observation role of the researcher. Third, this study used a combination of open and closed questions in the online survey and in the interview, allowing participants to provide their own responses, clarify questions, or skip questions. Fourth, this research made use of a preliminary study (pilot) to understand the nuances and intricacies of MOOCs as professional development. Fifth, this study used a sample that reflects a wide variety of teachers, and is not limited to a particular geographic area or teaching background.

When conducting a qualitative study, it is important that the validity and reliability of the conclusions can be verified. In qualitative research, reliability is commonly achieved via triangulation: “the process of using multiple perceptions to clarify meaning, verifying the repeatability of an observations or interpretation” (Stake, 2000, p. 443). Triangulation is used in this study through the implementation of multiple sources of data and instruments in the data collection.

The researcher also made use of peer-debriefing. Robson (1993) describes peer debriefing as ‘exploring one’s analysis and conclusions to a colleague or other peer on a continuous basis” (p. 404). Knowing that peer debriefing can happen in many different instances,
as the researcher discussed the findings with knowledgeable colleagues, presented and defended the findings and methods used in meetings and in conferences, and presented the findings and implications to interested groups, such as other MOOC researchers. Long and Johnson (2000) reinforce that the process of reviewing a study with colleagues helps researchers to explore additional perspectives and current explanations at different various stages of the study. This process may also help prevent “premature closure of the search for meaning and patterns in the data” (Long & Johnson 2000, p. 34).

Persistent observation (from September 28th 2015 to December 14th 2015) was also used as a way to enhance researcher involvement with the data. According to Guba and Lincoln (1989), persistent observation helps the researcher “to identify those characteristics and elements in the situation that are most relevant to the problem or issue being pursued and to focus on them in more detail” (p. 237). The set of actions taken by the researcher aimed to produce conclusions supported by evidence found in the transcript of the discussion forums, compilation of the answers from the online survey, and/or transcripts of the interview with instructor’s team.

**Data Collection Timeline**

<table>
<thead>
<tr>
<th>MOOC Duration</th>
<th>MOOC Extension Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep 28th to Nov 09th</td>
<td>Nov 10th to Dec 14th</td>
</tr>
<tr>
<td>Oct 28th to Dec 18th</td>
<td>Dec 16th to Dec 17th</td>
</tr>
</tbody>
</table>

Online Survey | Instructors’ Individual Interviews

Figure 4-9. Data Collection timeline.
**Appropriateness of Data Collection**

Table 4-7. Appropriateness of Data Collection.

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Sources</th>
<th>Triangulate with</th>
</tr>
</thead>
<tbody>
<tr>
<td>To what extent can the characteristics described in the literature on effective</td>
<td>MOOC materials</td>
<td>Online Survey</td>
</tr>
<tr>
<td>face-to-face teachers’ professional development hold in a MOOC designed for</td>
<td>Discussion forums content</td>
<td>Interview with MOOC</td>
</tr>
<tr>
<td>statistics development of secondary teachers?</td>
<td>Click data</td>
<td>instructors</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is the nature of teachers’ and others’ interactions (with materials and</td>
<td>Discussion forums content</td>
<td>MOOC materials</td>
</tr>
<tr>
<td>with each other) in a MOOC designed for statistical professional development?</td>
<td>Click data</td>
<td>Demographics</td>
</tr>
<tr>
<td></td>
<td>Online Survey</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interview with MOOC instructors</td>
<td></td>
</tr>
</tbody>
</table>

**Data Analysis Preparation**

Before starting work on data analysis, the data from the online survey were compiled and the data collected from the interviews were fully transcribed.

**Online Survey**

The survey generated 92 responses, of which 80 responses were fully completed. From these 80 responses, 13 participants were willing to provide more information if requested. The results from the online survey were collected in an Excel spreadsheet format and the researcher used descriptive statistical analysis to present results from quantitative questions as in the example below (Figure 4-10). Data from qualitative questions were used in the triangulation process with the interactions in forums.
The compiled content from the online survey was used to give a sense of whether the perceptions and interactions (in this case posts and comments) that occurred in the MOOC align with the needs and expectations of participants when engaging in this professional development. Participants’ perceptions of what influenced them to comment or not in certain forums may also give information about the type of forum content (or topic) that these participants are comfortable with and or which kind of forum discussion they are looking for.
Interviews

This study includes six individual interviews conducted by the researcher with members of the instruction team, with an average duration of 75 minutes. All interviews were professionally transcribed so that they could be studied in detail and linked with the other sources of data and codes. To ensure that what was said was accurately transcribed, the researcher reviewed each transcription, verifying that each captured features of speech such as emphasis and pauses.

The researcher provided instruction to the transcriber about the specific purposes of the transcriptions and the requirements for the transcripts final product. The use of a specific transcription protocol provided by professional transcriber services helped to ensure consistency in transcripts developed for qualitative analysis, thus supporting the researcher in addressing trustworthiness in the study (Dressler & Kreuz, 2000).

Once the transcriptions were complete, these data were used to capture the instructor’s perception of her or his interactions regarding all interactions that happened in the MOOC. One of the purposes of the interview was to elicit the instructor’s point of view regarding the purpose of the discussion forums in the MOOC.

Interactive Data Analysis

The data analysis was developed in two ways in order to draw answers to the two main research questions. For the first research question “To what extent can the characteristics described in the literature on effective face-to-face teachers’ professional development hold in a MOOC designed for statistics development of secondary teachers?”, the researcher proceeded as in the pilot study. One specific characteristic was chosen at a time, such as active participation,
and special attention was paid to instances of this feature throughout the MOOC. This process was repeated to cover all characteristics of effective professional development highlighted by the researcher in the literature review chapter.

Since the question focuses on ‘to what extent a characteristic holds in a MOOC designed for statistics development of secondary teachers’, the researcher used qualitative content analysis (Mayring, 2000; Zhang & Wildemuth, 2009) to document the instances in which the characteristic being analyzed happened within the MOOC. The primary data used in answering the first research question was the MOOC materials aligned with content of the discussion forums, click data, and demographics in a combination that varies according to each characteristic of effective professional development that is being analyzed. For example, when analyzing the characteristic ‘opportunities for active learning’, in addition to checking the MOOC materials and the forum content, the researcher also accessed the click data (e.g., number of posts, comments, and discussion views) to depict participants’ active learning experience. In this case, demographics were used to further investigate the professional experience of these participants. The use of click data and participants’ demographics helped the researcher in better understanding the nuances of this characteristic of effective professional development manifested in the MOOC, therefore increasing the trustworthiness of the study.

In the process of answering the first question, parts from the online survey and parts from interviews with the instructors were also considered in a triangulation procedure to support the validity of the study’s findings. Still in the example of analyzing the characteristic ‘opportunities for active learning’, the researcher explored participants’ perception of their active learning by analyzing the input of participants when answering questions from the online survey such as “how often did you comment into others’ post to acknowledge that they have been heard?” and “what were the most valuable discussions that you participate in the forums?”. Focusing on results from the interviews with instructors, more specifically on questions such as ‘what were the
purposes of discussion forums?’ may contribute (or not) to the big picture drawn by the researcher concerning to ‘active learning’ characteristic in professional development MOOCs.

For the second research question “*What is the nature of teachers’ and others’ interactions (with materials and with each other) in a MOOC designed for statistical professional development?*”, the researcher started by coding the posts in the discussion forums by using the categories established through the pilot data as shown in Figure 4-5. The researcher coded the data once and rechecked the coding process three times through the whole data to assure accuracy through the coding process. In this interactive process of coding and rechecking the codes, some codes were reformulated being aggregated or re-written to better represent the data. The codes ‘discussion starters’ and ‘super-posters’ were combined into one code labeled ‘discussion starters & super-posters’ since many of discussion starters were also super-posters. Similarly, the codes ‘lack of statistical knowledge’ and ‘participants’ self-affective sensitivity’ were combined into one code labeled ‘participants’ statistical insecurities’ since participants manifested their insecurities regarding to statistics content and statistics teaching. The code ‘participants’ statistical knowledge’ was re-written since it was, in fact, representing ‘participants’ statistical claims and/or statistical questions’ instead of their knowledge about statistics. The final topology of participants’ interactions is presented in Figure 4-11. Next, I detail each code by presenting a statement that describes its meaning and examples of the identification of the code on the data.
Description of the Codes

In this section I present a description of the codes in each category that were used to analyze participants’ interactions in forums in order to produce answers to the second research question. For each code, I present a statement of the code meaning and instances of the code in participant’s posts.

Content of Participants’ Interactions Related to Themselves.

Statistical insecurities. An interaction among participants was coded as statistical insecurities when participants expressed their perceptions about their discomfort related to their
experience with statistics and/or statistics teaching. Table 4-8 presents indicators of participants’ statistical insecurities.

Table 4-8. Indicators of participants’ statistical insecurities.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Example of participant’s forum post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of experience</td>
<td>“I am still an undergraduate student, but for some reason, in my limited experience”</td>
</tr>
<tr>
<td>Struggle</td>
<td>“I always struggled with statistics as a student myself”</td>
</tr>
<tr>
<td>Knowledge gap</td>
<td>“It's a little strange; I consider myself a reasonably strong teacher / mathematician, and I've been teaching math for over 20 years, but CCSS instantly escalated what I need to know (and to teach) about statistics to the extent that I actually need to supplement my field of knowledge. I hope this class helps.”</td>
</tr>
</tbody>
</table>

Participants’ statement of opinions. An interaction among participants was coded as participants’ statement of opinions when participants expressed their point of view regarding any topic discussed in the forums. Table 4-9 presents indicators of participants’ statement of opinions.

Table 4-9. Indicators of participants’ statement of opinions.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Participant’s forum post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improvement of school systems</td>
<td>“I think, there should be a radical improvement in the school systems”</td>
</tr>
<tr>
<td>Importance of statistics in school</td>
<td>“The more I teach stats the more I feel like it is 'the most important math class'. But I also feel like it is the most neglected in other courses - it's the thing that's cut when there's not a lot of time.”</td>
</tr>
</tbody>
</table>

Participants’ intentions in this MOOC. An interaction among participants was coded as participants’ intentions with this MOOC when participants expressed their goals for taking this MOOC. Table 4-10 presents indicators of participants’ intentions with this MOOC.
Table 4-10. Indicators of participants’ intentions with this MOOC.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Participant’s forum post</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am looking forward</td>
<td>“I am looking forward to immersing myself more fully into the world of stats teaching during this course and hopefully correcting some of my misconceptions along the way!”</td>
</tr>
<tr>
<td></td>
<td>“I am so looking forward to share ideas with other professionals and become a better instructor.”</td>
</tr>
<tr>
<td>I am here to learn</td>
<td>“I am here to learn how to engage my students in more complex ways, but I have to understand more about statistical reasoning, and that is why I am here!”</td>
</tr>
</tbody>
</table>

**Participants’ perceptions of learning.** An interaction among participants was coded as participants’ perceptions of learning in this MOOC when participants expressed gaining knowledge from their interaction with the MOOC’s materials. Table 4-11 presents indicators of participants’ perceptions of learning in this MOOC.

Table 4-11. Indicators of participants’ perceptions of learning in this MOOC.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Participant’s forum post</th>
</tr>
</thead>
<tbody>
<tr>
<td>My biggest take from [Unit/Resource]</td>
<td>“I think my biggest take from Unit 1 is knowing about Gapminder.”</td>
</tr>
<tr>
<td>From [Resource] I have learned</td>
<td>“From the assessment I have learned that being able to interpret the results is as important as learning how to compute them.”</td>
</tr>
</tbody>
</table>

**Participants’ statement of change.** An interaction among participants was coded as participants’ statement of change when participants expressed their intentions to implement an approach or tool that they had interacted throughout this MOOC. Table 4-12 presents indicators of participants’ statement of change.
Table 4-12. Indicators of participants’ statement of change.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Participant’s forum post</th>
</tr>
</thead>
<tbody>
<tr>
<td>I'm going to introduce [resource]</td>
<td>“I had never used it before, but I'm going to introduce it to my students next week!”</td>
</tr>
<tr>
<td>I am going to have my students [action verb + resource]</td>
<td>“After watching the video of the year 8 students, I am going to have my students watch that video and then find a country (besides Haiti or the Dominican Republic) to investigate and write a paragraph report.”</td>
</tr>
</tbody>
</table>

**Affective Sensitivity to peers.** An interaction among participants was coded as affective sensitivity to peers when participants expressed concordance with others. Table 4-13 presents indicators of participants’ affective sensitivity to peers.

Table 4-13. Indicators of participants’ affective sensitivity to peers.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Participant’s forum post</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel the same [Participant name/you]</td>
<td>“I feel like I'm in the same boat as you guys!”</td>
</tr>
<tr>
<td>I agree with [Participant name/you]</td>
<td>“I agree with you!”</td>
</tr>
</tbody>
</table>

**Cognitive sensitivity to peers.** An interaction among participants was coded as cognitive sensitivity to peers when participants expressed concordance with others regarding their opinion about a material of this MOOC. Table 4.14 presents the indicator of participants’ cognitive sensitivity to peers.

Table 4-14. Indicators of participants’ cognitive sensitivity to peers.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Participant’s forum post</th>
</tr>
</thead>
<tbody>
<tr>
<td>I agree with [Participant] about [Resource]</td>
<td>“I agree [Participant 3526] that it is a good task that can lead into a discussion about different data collection methods, measurement issues, and bias”.</td>
</tr>
<tr>
<td></td>
<td>“I agree. I absolutely loved the rich discussion the students were having towards the end of the video”.</td>
</tr>
</tbody>
</table>
Content of Participants’ Interactions Related to their Students.

Affective sensitivity to students. An interaction among participants was coded as affective sensitivity to students when participants expressed their students’ enjoyment, excitement, or boredom. Table 4-15 presents indicators of participants’ affective sensitivity to students.

Table 4-15. Indicators of participants’ affective sensitivity to students.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Participant’s forum post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students’ enjoyment</td>
<td>“It took over a lesson to collect the data, but the students really enjoyed this process and are now creating presentations on an investigation they have done with our data”.</td>
</tr>
<tr>
<td>Students’ excitement</td>
<td>“Let the collection phase be fun, exciting, and a treat for the students”.</td>
</tr>
<tr>
<td>Students’ boredom</td>
<td>“In fact, I think that most students in middle school and high school may be bored and would love to be more challenged.”</td>
</tr>
</tbody>
</table>

Cognitive sensitivity to students. An interaction among participants was coded as cognitive sensitivity to students when participants expressed the importance of students to learn or to advance their knowledge about statistics. Table 4-16 presents indicators of participants’ cognitive sensitivity to students.

Table 4-16. Indicators of participants’ cognitive sensitivity to students.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Participant’s forum post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students need/doing [Something]</td>
<td>“Students need more experience with applying and interpreting statistical data.”</td>
</tr>
<tr>
<td></td>
<td>“The deeper understanding of Statistics and the underlying concepts that is gained when you get your students to do the likes of the Census at Schools survey is invaluable”</td>
</tr>
<tr>
<td></td>
<td>“I teach AP Biology and my students need to be familiar and adept with using statistics to analyze data”.</td>
</tr>
<tr>
<td>[Something] will help students</td>
<td>“I think these resources will help students understand why statistics is so applicable to life and isn't just limited to the math classroom.”</td>
</tr>
</tbody>
</table>
**Management of learning.** An interaction among participants was coded as management of learning when participants described their classroom activities and/or their classroom norms. Table 4-17 presents indicators of participants’ management of learning.

Table 4-17. Indicators of participants’ management of learning.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Participant’s forum post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom activities</td>
<td>“We do a few contrived book problems but I would like to add a (writing) project where students analyze a real data set”.</td>
</tr>
<tr>
<td>Classroom norms (classroom timing constrains)</td>
<td>“Our school is on a block schedule so my AP class meets every day for 90 minutes for the entire year! We have a lot of time to develop statistics and play around with concepts”.</td>
</tr>
</tbody>
</table>

**Statistical claim or statistical question.** An interaction among participants was coded as statistical claim or statistical question when participants described their opinion or inquiry about the subject of statistics. Table 4-18 presents indicators of participants’ statistical claim or statistical question.

Table 4-18. Indicators of participants’ statistical claim or statistical question.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Participant’s forum post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opinion about statistics</td>
<td>“Statistics has a lot of the things I love about mathematics. It has problem solving, and there are relatively simple procedures, but the analysis of results requires thoughtfulness”.</td>
</tr>
<tr>
<td></td>
<td>“The joy of statistics is that the mechanics of number crunching much less important than understanding what's going on before and after the computations (which I let the computer do)”</td>
</tr>
<tr>
<td>Question about statistics subject</td>
<td>“How might the sampling method throw off your results?”</td>
</tr>
</tbody>
</table>
Content of Participants’ Interactions Related to MOOC Materials.

Interaction with materials. An interaction was coded as interaction with materials when participants made statements about the materials they had interacted with in this MOOC. Table 4-19 presents indicators of participants’ interaction with materials.

Table 4-19. Indicators of participants’ interaction with materials.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Participant’s forum post</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Citation of MOOC material]</td>
<td>“I absolutely loved the rich discussion the students were having towards the end of the video”.</td>
</tr>
<tr>
<td></td>
<td>“This task at least can get a teacher's mind going on how to BEGIN planning a great statistical task”.</td>
</tr>
</tbody>
</table>

Interaction with materials (intended). An interaction was coded as interaction with materials (intended) when participants made statements about their desire to implement a MOOC resource. Table 4-20 presents indicators of participants’ interaction with materials (intended).

Table 4-20. Indicators of participants’ interaction with materials (intended).

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Participant’s forum post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant [verb] use [MOOC material]</td>
<td>I would love to use an online assessment like this with my students before starting a statistics unit to evaluate their prior knowledge.</td>
</tr>
<tr>
<td></td>
<td>I was practicing with the gapminder tool and I will definitely use it with my students.</td>
</tr>
</tbody>
</table>

Codes Distribution

The distribution of codes with respect to each category is presented in Table 4-21. Table 4-21 gives us an overview of what participants were talking about as they interacted with others in forums. It shows that as they engage in forums, they referred to their students (3507 times) more often than they referred to their MOOC peers (1799 times) or to themselves (1363 times).
Interactions with materials seems to be important to these participants, since they refer to some material of this MOOC 1228 times. Data from Table 4-21 will be used to answer the second research question that will be presented in Chapter 6.

Table 4-21. Distribution of codes with respect to each category.

<table>
<thead>
<tr>
<th>Codes by Category</th>
<th>Quantity of codes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content of participants’ interactions related to themselves</strong></td>
<td></td>
</tr>
<tr>
<td>Statistical insecurity</td>
<td>176</td>
</tr>
<tr>
<td>Statement of opinions</td>
<td>677</td>
</tr>
<tr>
<td>Intentions with this MOOC</td>
<td>309</td>
</tr>
<tr>
<td>Perception of learning from this MOOC</td>
<td>116</td>
</tr>
<tr>
<td>Statement of change</td>
<td>85</td>
</tr>
<tr>
<td><strong>Quantity of codes of content of participants’ interactions related to themselves</strong></td>
<td>1363</td>
</tr>
<tr>
<td><strong>Content of participants’ interactions related to their peers</strong></td>
<td></td>
</tr>
<tr>
<td>Affective sensitivity to peers</td>
<td>996</td>
</tr>
<tr>
<td>Cognitive sensitivity to seers</td>
<td>803</td>
</tr>
<tr>
<td><strong>Quantity of codes of content of participants’ interactions related to their peers</strong></td>
<td>1799</td>
</tr>
<tr>
<td><strong>Content of participants’ interactions related to their students</strong></td>
<td></td>
</tr>
<tr>
<td>Affective sensitivity to students</td>
<td>462</td>
</tr>
<tr>
<td>Cognitive sensitivity to students</td>
<td>1416</td>
</tr>
<tr>
<td>Management of learning</td>
<td>1262</td>
</tr>
<tr>
<td>Statistical claim or statistical questions</td>
<td>367</td>
</tr>
<tr>
<td><strong>Quantity of codes of content of participants’ interactions related to their students</strong></td>
<td>3507</td>
</tr>
<tr>
<td><strong>Content of participants’ interactions related to MOOC materials</strong></td>
<td></td>
</tr>
<tr>
<td>Interaction with materials</td>
<td>943</td>
</tr>
<tr>
<td>Interaction with materials (intended)</td>
<td>285</td>
</tr>
<tr>
<td><strong>Quantity of codes of content of participants’ interactions related to materials</strong></td>
<td>1228</td>
</tr>
<tr>
<td><strong>Total quantity of codes</strong></td>
<td>7897</td>
</tr>
</tbody>
</table>
Ethical Issues

This study met all requirements for the protection of human subjects in accordance with the Pennsylvania State University Institutional Review Board. The consent process for ‘MOOC participants’ was orchestrated by the university hosting the MOOC, with the consent process being embedded in the MOOC webpage where participants registered themselves for this MOOC. In this way, consent was obtained before participants started the course.

Consent for the online survey was embedded in the survey form (see Appendix A) and the completion of the survey served as participant’s consent as described in the invitation letter (see Appendix C). The consent process for the interview with the MOOC’s instructors was described in the interview invitation (Appendix D) and took place via their participation throughout the interview with the researcher. Semi-structured interview questions that were used in the interview with the MOOC’s instructors can be found in Appendix B.
Chapter 5

Findings

This chapter presents the findings in answer the first research question: *To what extent can the characteristics described in the literature on effective face-to-face teachers’ professional development hold in a MOOC designed for statistics development of secondary teachers?* The data sources used for the analysis were: (a) MOOC webpages, (b) MOOC forum discussion threads, (c) an online survey applied to participants (d) interviews with the instruction team, and (e) click data. In addressing this research question, I first recall the six characteristics of effective professional development from the literature (Chapter 2), then I discuss in detail how these characteristics are present in this MOOC. I start with the core characteristics that describe the fundamental features an effective professional development should have (content focus, opportunities for active learning, and coherence) followed by the structural features that affect teacher learning in professional development (type of the activity, duration of the activity, and collective participation). This chapter will show that when a MOOC is used as a venue for teachers’ professional development, the characteristics of effective professional development were not manifested identically as described in the face-to-face professional development literature, they were modified by the constraints and possibilities embedded in this MOOC. I employ principles of connectivism to support and understand how these characteristics are enacted in this MOOC. More specifically, connectivism is used in this study to frame teachers’ learning through participation as they establish and nurture connections in this professional development. At the end of the chapter, I highlight autonomy as a common factor present in all
six characteristics and discuss potentialities and caveats of this professional development through the lens of effective professional development for teachers.

**Presence of the Characteristics of Effective Professional Development**

Literature on teachers’ professional development (e.g., Garet et al., 2001; Desimone et al., 2002; Ingvarson, Meiers, & Beavis, 2005; Blank, de las Alas & Smith, 2007; Blank & de las Alas, 2009; Yoon et al., 2007; Gulamhussein, 2013) proposed six characteristics of high-quality and effective professional development. These characteristics appeared in Garet’s et al. (2001) seminal paper, emerged from face-to-face professional development experiences, and are intended to synthesize main features of professional development that can have a positive influence on teachers' classroom practice and students’ achievement. Because the literature referring to a set of characteristics for an effective professional development seems to stem from Garet’s pivotal paper, I will be using this paper as reference for the presence of these characteristics of effective professional development in this MOOC.

According to Garet et al. (2001), the characteristics of effective professional development are classified as core features and structural features. The core features are the essential features professional development must have, they are: (a) content focus, (b) opportunities for active learning, and (c) coherence with other learning activities. The structural features are the design characteristics that support the professional development activity, they are: (a) the type of the activity, (b) the duration of the activity, and (c) the collective participation. Since research on MOOCs for teachers’ professional development purposes is still scant, I expect that exploring the presence of these six characteristics in this MOOC may help the field of professional development of teachers by providing ground to the literature about the potentialities and caveats
of MOOCs as venues for teachers’ professional development. I start the chapter by presenting results about the core features of professional development, followed by its structural features.

**Content Focus**

Content is what teachers have the opportunity to learn during professional development (Kennedy, 1998). Content in professional development varies according to the intended development in teachers. It can be represented by professional development activities that are designed for improvement in teachers' knowledge of subject matter, teaching practices, and teachers’ pedagogical content knowledge (PCK). Several authors (Kennedy, 1998; Garet et al., 2001; Blank, de las Alas & Smith, 2007; Cohen & Hill, 2001; Gulamhussein, 2013) state that professional development programs that focus on subject matter content and how students learn it had the largest positive effect on student learning.

Content as a characteristic of effective professional development is analyzed in two ways in this study. First, the intended content available to participants that is embedded in the MOOC webpages and its aggregate resources (i.e., pdf files, videos, links, apps), including the intended goals of these materials. Second, the content embedded in the resources that participants shared back to the network.

Using the MOOC webpages and its resources (i.e., pdf files, videos, links, apps, etc.) as sources of data, I observed that the intended content of this MOOC was centered on developing in participants the notion of teaching statistics as a process in which data has a crucial role. I also noticed that the materials proposed by this professional development were in service of this goal as will be described in subsequent sections. The evidence collected through my observations as researcher of the MOOC webpages and its resources available to participants were aligned with
the main instructor’s purpose in designing this MOOC. When describing the structure of the MOOC in an interview, the main instructor states

> We added a dive into data this round versus in the Spring [MOOC offering] because we wanted to give those early and constant experiences since the MOOC was about using data investigations. We wanted them to have opportunities to dive into data small little chunks (Instructor A, Interview, December 2015).

Analyzing the structure of the MOOC and its units, the MOOC’s intended content was distributed through five units aiming to develop participants’ knowledge about teaching statistics through data investigations. The course units were designed to walk participants through the investigation cycle called the SASI framework. The SASI framework Students’ Approaches to Statistical Investigations (Lee & Tran, 2015), comprises four components of the statistical problem solving process: posing a question, collecting data, analyzing data, and interpreting results. Next, I describe each unit of the MOOC and how they are related to the investigation cycle (SASI framework).

The content of Unit 1 was centered on raising participants’ awareness of the importance of using real data in teaching statistics through investigations. This content is aligned with the use of data in the statistical problem-solving process described in the SASI framework. Through the content of Unit 1, participants had the opportunity to explore videos and materials on the importance of using real data in statistical classes as well as students dealing with real data in doing investigations.

The second Unit of the MOOC focused on explaining what a statistical investigation is, what the main differences are between mathematics and statistics, and what kind of statistical habits of mind these teachers can develop in their students by teaching statistics through data investigation. The content of Unit 3 gave an overview of the SASI framework, showing participants how to use the SASI framework to create, adapt, and analyze statistical tasks.
Participants also watched videos of students with different levels of statistical sophistication engaging in a statistical task.

To engage participants in doing statistics through data investigation as well as in phases of the SASI framework, Unit 4 focused on participants learning what to consider when their students engaged in collecting and analyzing their own data. Unit 5 focused on participants reflecting on their experiences, assessing their own knowledge, and sharing their experiences gained during the MOOC.

By observing the content available in the MOOC pages, I noticed that this MOOC embraced the content characteristic of effective professional development as a process of doing statistics instead of as subject matter content as reinforced in the literature of effective professional development (e.g., Garet et al., 2001; Yoon et al., 2007; Desimone et al., 2002; Blank & de las Alas, 2009). Instead of focusing on developing statistical procedures and concepts in teachers (e.g., confidence intervals, significance tests, normal distribution), this MOOC focused on developing the notion of statistics as a process. This conception of statistics as a process can be evidenced throughout the MOOC in its implementation of the SASI framework (Lee & Tran, 2015).

The MOOC seems to be based on the idea that for teachers to be able to teach their students how to formulate a statistics question, they first need to understand the differences between mathematics and statistics and the use of data in their statistics lessons. To clarify the differences between mathematics and statistics, the MOOC provided a document in which participants could learn about the subtle differences between mathematical and statistical reasoning (Tran & Lee, 2015b). Through its available resources, the MOOC approached these differences by highlighting the importance of context and variability in statistics reasoning contrasted to the deterministic and context-free approach in mathematics. The MOOC also raised awareness about the importance of using real data that matters to students. It made it by providing
real data that can be used by teachers in their classrooms (i.e., Gapminder and Census @ School) and examples of students engaging with statistical investigations (i.e. Schoolopoly activity).

For teachers to understand data collection and data analysis (the second and third step in statistical problem solving), the MOOC resources focused on developing participants’ learning about what to consider while their students are engaged in collecting and analyzing their own data. Participants had opportunities to discuss the use of data previously collected by a third party and compare to the possible implementation of data collection in their classes. They also had the opportunity to interact with real data presented by the Census @ School (http://ww2.amstat.org/CensusAtSchool/) and explore this data by using free statistical tools as TuvaLabs (tuvalabs.com). In this sense, the MOOC is aligned with the recommendations of the Mathematical Education of Teachers (MET II) (Conference Board of the Mathematical Sciences [CBMS], 2001) which states that in preparation for teaching statistics, “teachers should see real-world data sets, understand what makes a data set good or bad for answering the question at hand, appreciate the omnipresence of variability and see the quantification and explanation of variability via statistical models that incorporate variability” (p. 58).

Statistical interpretation was performed in this MOOC by participants watching videos of students' reasoning at different levels of the SASI framework when working in a statistical task. Participants had the chance to watch students reasoning quantitatively and making their argument supported by data in a video of a statistical tasks called Schoolopoly. This video depicted cartoon versions of students' reasoning when working with the Schoolopoly task in a simulation software to decide whether or not a die is fair. Participants could watch two videos of students performing a statistical investigation in the Schoolopoly task, one video displaying students at level A/B of sophistication (middle school students) and the other video displaying students at level B/C of sophistication on the SASI framework (high school students).
In addition to analyzing the intended content depicted by the aggregation of materials (resources) available to participants in this MOOC, I observed that content was also co-constructed by MOOC participants through their sharing of resources back to the network as they participated in this professional development. In the next paragraphs, this resource sharing process is presented with more details.

Due to the openness of the MOOC and interactivity among participants, they shared extra resources related to the MOOC content throughout this professional development. The sharing process provided opportunities for new resources (i.e., tasks, links, pdfs, applets, etc.) to be aggregated to the course core content materials. This aggregation of resources to the course content happened in two ways. First, when the MOOC incorporated resources created or suggested by prior participants who took the course in a previous cohort. Second, when participants of the current cohort used the discussion forums to share extra resources with others. These additional resources may or may not be incorporated into the next MOOC offering.

Figure 5-1 exemplifies the case in which the MOOC incorporated resources created by participants from a previous cohort. It shows a piece of the current MOOC webpage which presents links to lesson plans for statistical investigation created by a previous participant of the MOOC. These lesson plans were comprised of statistical tasks giving opportunities for current MOOC participants to see how Gapminder could be used in a statistical lesson. The lesson plans created by this participant are now part of the content of Unit 2 in the current MOOC and this participant was invited to join the current MOOC as a member of the instruction team.
Figure 5-1. Statistical investigation tasks created by a participant from the preceding MOOC.

Another instance of the current MOOC incorporating resources created or suggested by participants from a previous cohort to its content occurred when a participant from the preceding MOOC cohort created a Geogebra simulation for the Schoolopoly activity as presented in Figure 5-2. As current participants engage with this Geogebra simulation, they will have the opportunity to perform the task as students did in the Schoolopoly activity video, allowing them to perform data collection and data analysis techniques to make a claim about fairness of the dice.

Additionally, this Geogebra simulation is also a tool that these teachers can use with their future students. Out of respect for privacy, the participant’s name was excluded from the image.
Different moments exemplify instances in which participants of the current MOOC shared extra resources with others through their participation in discussion forums. In analyzing the nature of the resources being shared they comprise links to online textbooks, classroom activities, articles, free statistical software, data websites and videos. All these resources have in common their freeware nature and their potential use to develop some or all phases of the statistical investigation. For example, participant 5352 suggested in a discussion forum a new free statistics software called VassarStats (http://vassarstats.net/), a web-based tool for statistical computation and statistical analysis. This tool is aligned with students analyzing data and interpreting results in the SASI framework discussed in this MOOC. Similarly, participant 4346 suggested the website Nate Silver's FiveThirtyEight.com (https://fivethirtyeight.com/) for use of
statistics in social media. This tool is aligned with students formulating questions, analyzing data and interpreting results in the SASI framework discussed in this MOOC. Another example of resource shared in the current MOOC was provided by participant 5488 who shared in a discussion forum a lesson plan and lesson activity from the NSF-funded AIMS Project (Garfield, delMas & Zieffler, 2007) available in https://serc.carleton.edu/sp/library/datasim/examples/cokepepsi.html. This resource is aligned with students performing all phases of the SASI framework.

The free resources shared by participants in the discussion forums were indirectly added to the available set of MOOC resources content made new statistical tools more accessible to participants who were engaged in the MOOC. Some participants stated their intention to share these materials with other teachers in their schools, as stated by participant 3284 “Definitely looks like a good resource. I look forward to sharing it with some of the middle school teachers I work with”.

Due to the aggregation of materials fostered by participants’ network, the current content of this MOOC is already a product of aggregation done by its main instructor and participants who engaged in the previous MOOC cohort. Likewise, the content of the next MOOC cohort is projected to be a conjunction of materials that were initially established for the professional development plus materials that were integrated from participants’ addition in the current MOOC as represented in the Figure 5-3:
This aggregation process implies that content in the MOOC carried a flexible format when content is understood as an aggregation of resources represented by bubbles of varied sizes in Figure 5-3. Since MOOCs engage hundreds of participants, it embraces the potential of more participants contributing to the network by sharing resources related to its content focus. The phenomenon of resource aggregation and resource sharing in the MOOC is an example of participants’ actionable knowledge described in Connectivism, meaning “an understanding of where to find knowledge may be more important than answering how or what that knowledge encompasses” (Duke, Harper & Johnston, 2013). This resource aggregation and resource sharing in the MOOC is fostered by the asynchronous characteristic of MOOCs. Participants engaging asynchronously in forums allows time for them to reflect upon what is being shared and to
volunteer in searching for extra resources to be shared in their next interaction with the professional development group.

**Opportunities for Active Learning**

Active learning is not well-defined concept/term in the literature on teachers’ effective professional development, but the literature provides many examples of contexts in which active learning is believed to happen. Many scholars contend that active learning occurs when teachers engage in discussions, collaborative work, planning, and reflection over their practice (Garet et al., 2001; Desimone et al., 2002; Desimone, 2009; Borko et al., 2010). Scholars suggest that active learning in professional development can arise in various ways, such as observing expert teachers or being observed, reviewing students’ work, planning how new curriculum materials and new teaching methods can be used in class, designing formative assessments, interacting with peers, giving and receiving feedback, developing and presenting lessons, and coaching and mentoring (Garet et al., 2001; Desimone & Stuckey, 2014; Gulamhussein, 2013; Blank et al., 2008; Desimone, 2009; Loucks-Horsley, Love, Stiles, Mundry & Hewson, 2010; Borko et al., 2010).

Implicit in this list of ways in which active learning arises are assumptions about what learning is. As presented in Chapter 3, learning in this study is social and it is framed by connectivism (Siemens, 2004). Learning through the lens of connectivism happens as participants establish connections with resources and with others through the network. Learning is a *cyclical process* in which “learners will connect to a network to share and find new information, will modify their beliefs on the basis of new learning, and will then connect to a network to share these realizations and find new information once more” (Kop & Hill p. 2). In this study, the
cyclical process of active learning is evidenced as participants both engage in discussions forums and contribute to the network through their posts.

From this perspective, lurking (observing but not posting) is not active learning. MOOC lurkers did not contribute back to the network and therefore were not included in the analysis of opportunities for active learning presented in this section. The decision to exclude MOOC lurkers also aligns with the literature of professional development which emphasizes that opportunities for active learning are best represented when teachers are engaged in meaningful activities in which they can analyze their practice “followed by interactive feedback and discussion” (Desimone, 2009, p. 184). Without posting and giving back to the network within the MOOC environment, lurkers are not engaged in the interactive feedback and discussion.

This MOOC provides spaces for active learning by offering 11 discussion forums distributed throughout this professional development. By providing space for participants to share their understanding about MOOC materials, to learn from the experiences of their peers, and to reflect over their own practice as teachers, this MOOC is providing opportunities for active learning to its participants. Participants’ active learning in forums is analyzed in two ways. In this section, quantitative analysis is used to show how many times participants both enter into discussions (i.e., discussion views) and contribute to forums (i.e., discussion creation and posts). In the next chapter, qualitative analysis is used to show the subject of participants’ interactions with resources and with others in forums. The sources of data for this section are: quantitative click data that indicates the number of times participants accessed information and the number of times that participants posted information and the online survey administrated to participants that indicates their perceptions about contributing back to the network (posting). Findings presented in this section are complemented by results presented in the next chapter where qualitative analysis is used to unveil the subject of participants’ interactions in forums.
From quantitative analysis of participants’ contributions in forums, here understood as instances of participants’ active learning enacted by participants in this MOOC, 333 of the 825 participants registered in the MOOC engaged in discussion forums by creating a new discussion and/or replying to other participants’ posts. Their engagement in forums is represented by the creation of 2370 posts in which 646 posts were from participants who started new discussion threads and 1724 were from participants who posted (replied) to others. These posts and comments were cumulatively viewed more than 28,520 times by MOOC participants.

Although participants presented a large number of interactions with peers (total of 2370 posts) showing multiple instances of active learning, the total number of 2370 posts was not uniformly distributed throughout the discussions forums as shown in Figure 5-4. Some discussions (spaces for active learning) generated a higher number of posts (participants’ engagement) when compared to other discussions as exemplified by an excerpt of data presented in Table 5-1. As we can see, discussion 6826 hosted 48 posts in which participants were describing tasks they do with their students. In this discussion thread participants were sharing their experience with the use of real world data in their classes. Posts from this discussion thread show that these teachers care about implementing real data sets in their classes and care about the experiences their students will have with statistics in their classes.
Figure 5-4. Uneven distribution of total number of posts throughout the discussions.

Table 5-1. Excerpt of data showing variation of number of posts from different discussions.

<table>
<thead>
<tr>
<th>Discussion ID</th>
<th>Discussion topics that engaged most number of participants</th>
<th>Number of posts</th>
</tr>
</thead>
<tbody>
<tr>
<td>6826</td>
<td>Teachers are sharing classroom activities that they do in their statistics class</td>
<td>48</td>
</tr>
<tr>
<td>8036</td>
<td>Importance of analyzing data in context relevant for students to do statistical investigation</td>
<td>32</td>
</tr>
<tr>
<td>5452</td>
<td>Gapminder Videos</td>
<td>31</td>
</tr>
<tr>
<td>5624</td>
<td>Pros and cons of provided data vs. created data to students</td>
<td>21</td>
</tr>
<tr>
<td>8284</td>
<td>Use of Census @ School</td>
<td>20</td>
</tr>
<tr>
<td>7552</td>
<td>Students performing statistics by hand vs using computer simulations</td>
<td>16</td>
</tr>
<tr>
<td>5588</td>
<td>Analysis of the items in LOCUS test</td>
<td>10</td>
</tr>
<tr>
<td>5365</td>
<td>Participant 3966’s introduction</td>
<td>7</td>
</tr>
<tr>
<td>5572</td>
<td>Participant 5551’s introduction</td>
<td>4</td>
</tr>
<tr>
<td>5492</td>
<td>Communicating results of a statistical analysis</td>
<td>4</td>
</tr>
</tbody>
</table>
The uneven distribution of participants’ engagement in discussion forums evident in Figure 5-4 and Table 5-1 indicates that participation in discussion forums is uneven, meaning that participants’ active learning in a MOOC for online professional development purposes is a matter of individual choice (personal) and varies among participants. To exemplify it, I compare in Table 5-2 30 interactions of two random participants (5488 and 4346) to show the cyclical process of active learning as participants engage in discussions forums and contribute to the network by creating a post or replying to posts of others. To choose a random participant, the functions index and randbetween from Microsoft Excel (=INDEX($A$2:$A$28501, RANDBETWEEN(2, 28501))) were used. The index function orders a list of values of the variable of interest (participant ID) and the randbetween function randomly picks a value between the range. Autonomy and diversity of participants helps us to understand the results presented here, which is consistent with the interpretation that participants were free to join and post (or even start a new discussion thread). Thus, participants’ engagement in forum is evidence that they chose their opportunities for active learning.
Table 5-2. Excerpt of active learning from participants 5488 and 4346.

| Timestamp | Action         | Discussion ID | Participant #4346 | | Timestamp | Action         | Discussion ID | Participant #5488 |
|-----------|----------------|---------------|--------------------|-----------|----------------|------------------|--------------------|
| 9/28/2015 20:42 | View Discussion | 5628         | 10/1/2015 19:51    | View Discussion | 6526 | 10/1/2015 19:51    | View Discussion | 6526 |
| 9/28/2015 20:54 | View Discussion | 5722         | 10/1/2015 20:06    | Create Discussion | 6535 | 10/1/2015 20:06    | Create Discussion | 6535 |
| 9/28/2015 20:55 | View Discussion | 5499         | 10/1/2015 20:06    | View Discussion | 5883 | 10/1/2015 20:06    | View Discussion | 5883 |
| 9/28/2015 20:55 | View Discussion | 5509         | 10/1/2015 20:08    | View Discussion | 6535 | 10/1/2015 20:08    | View Discussion | 6535 |

In order to learn more about participants’ perceptions of contributing back to the network (posting), this study also made use of an online survey in which one of its questions asked participants about the benefits of writing a post and/or commenting on a post of others. The goal of the survey question was to learn more about participants’ perspectives with relation to posting or creating a discussion in forums. Their responses to this question help us to understand their perceptions about their active learning in discussions which helps in providing evidence (triangulating) to the claim that active learning is an individual matter.

Among 92 respondents who took this study online survey, when asked about the benefits of writing a post and/or commenting on a post of others, 34 participants out of 52 respondents to this question reported that the process of writing a post and/or commenting on the posts of others...
was beneficial to their own learning process. The benefit of writing a post and/or commenting is exemplified by two participants Anonymous1, “It helped me to sum up and think through ideas” and Anonymous2, “Yes because it helped me to internalize and express what I learned and understood”. Other participants stated that writing a post helped them to “think about the subject deeper” (Anonymous3) and it required them “to reflected on their own teaching and learning” (Anonymous4). This data supports the literature in which opportunities for active learning happen when professional development affords teachers opportunities for reflection (Garet et al., 2001; Desimone, 2009).

On the other hand, 18 participants out of 52 respondents to this question stated that the experience of writing a post and commenting on posts of others were not significantly beneficial to them, as said by a participant Anonymous5, “I did not post or comment often. The benefit to me was just in following the discussions, commenting occasionally”. Issues of time showed up as a factor in their active learning expressed by their lack of engagement in forums, as stated by participant Anonymous5 when responding about the benefits of writing a post and/or commenting on a post of others, she/he said, “not particularly, just because I had not much time and was not particularly engaged with the discussions”. Some participants stated that they benefited from reading posts of others, as said participant Anonymous6, “I was benefited in reading the posts, but I don't feel that I really benefited for writing any of the posts”. This data shows that active learning represented by active engagement in forums was not an attractive feature to some participants in this MOOC. This evidence reinforces that active learning is an individual matter, showing that not all participants are interested in being actively engaged in discussion forums.

Although active learning is an individual trait that varies among participants, it is also important to consider some features that may foster or constrain participants’ active learning. Participants’ active learning varied among discussion threads based on the topic that was being discussed, the amount of time participants could devote to a discussion, and participants’ personal
interests. Moreover, results show that opportunities for active learning in this MOOC were fostered by the content embedded in the MOOC resources. For instance, in Unit 1 the MOOC provided a video of 13-14 year old students interacting with Gapminder software (a free data visualization tool). In this video, students displayed multiple variables from a real-world data set in a dynamic way that allowed them to compare and contrast these different variables for different countries of interest. Participants’ active learning with this video generated 126 discussions about Gapminder in the forums. The number of discussion showed that participants were interested in knowing more about this free tool and the content of these discussions evidenced that they were interested in knowing more about the potentialities of this tool in teaching statistics using real data.

In a broad view, opportunities for active learning in this MOOC were depicted in forums in which discussion threads were symbolically represented by a potential worldwide round table where participants voluntarily joined in and out as represented in Figure 5-5. In MOOCs, there is no limitation regarding the number of participants per discussion thread (number of seats in the figure) other than the capacity of the platform; however, literature shows that discussion threads with a very large number of participants may constrain participants’ interactions and learning, which may turn the discussion into a pile of posts where participants do not communicate with others (Thomas, 2002). Through participants’ active learning they had opportunities to access materials and peers not otherwise possible in other forms of professional development, thus provided to participants the opportunity to extend their reach and overcome limits of time and geography.
Observing that active learning in this MOOC was a matter of personal choice that varied among participants, I also noticed that the dynamic combination of participants joining each discussion thread varied as well. This fact demonstrates that participants’ assemblages created by discussions were dynamic and varied from discussion to discussion. Participants’ assemblages is a name I am giving to these dynamic clouds of participants that varied from discussion to discussion. This diversity and variation of participants’ assemblages engaging in each discussion thread will impact on collective participation, another characteristic of effective professional development that will be discussed in further sections within this chapter.

Coherence

Coherence in the literature on effective professional development is related to the extent to which professional development activities are perceived by teachers to be a part of a coherent
program of teacher learning (Garet et al., 2001; Cohen & Hill, 2001; Smith & Gillespie, 2001; Blank, de las Alas & Smith, 2007). For Smith and Gillespie (2007) coherence reflects the match between school needs and the issues addressed by the professional development, in which “the match can be either be required (by the district) or voluntary (the school or teachers sought professional development related to the school improvement issue)” (p. 232-233). Coherence requires that professional development build on what educators have already learned, focusing on producing content and pedagogy aligned with standards and assessments, and supporting teachers in establishing and sustaining professional communication with other teachers (Garet et al., 2001).

Coherence in this MOOC is present in two ways. First, there was coherence among all the activities and materials provided by this professional development, and second there was coherence implicitly constructed individually by participants as they set their goals and pursued this professional development. Regarding the first, coherence was observed through the MOOC resources being arranged by the MOOC provider to develop knowledge and experience in participants about teaching statistics through data investigation. By focusing on developing in participants the pedagogical approach of teaching statistics through data investigation, this MOOC is aligned with a global educational movement of incorporating statistics in k-12 mathematics classes and incorporating data investigations in statistics. Evidence of coherence of this professional development with curriculum policies can be found by analyzing the curriculum policies from different countries such as Australia, the United Kingdom, New Zealand, Portugal, South Africa, Brazil, and the United States. As documented in the rationale of this study (Chapter 1), curriculum policies from these countries present high school statistics content focused on data handling, data representation and data interpretation, which aligns with the preparation that this MOOC aimed to give to its participants.
Coherence of materials presented in this MOOC is also aligned with recommendations of developing in teachers the notion of a statistical problem-solving process across students’ grade levels, as recommended by the Guidelines for Assessment and Instruction in Statistics Education – GAISE (Franklin et al. 2007) and the Statistical Education of Teachers (SET) (Franklin, Bargagliotti, Case, Kader, Schaeffer, & Spangler, 2015). This alignment supports the notion of learning (and later teaching) statistics as a process that may help participants in this MOOC to perceive it as a part of a coherent program in their own professional learning. In the spirit of Smith and Gillespie (2007), coherence in this professional development reflects the match between global educational movements and the issues addressed by the professional development.

To illustrate coherence among materials and activities, the MOOC started presenting possibilities of teaching statistics with real data through videos and pdf documents. Participants explored the difference between mathematics and statistics and what would be the statistical habits of mind developed through statistics investigations. Later, the MOOC provided different tasks for participants to identify different features in these tasks that could engage students in the statistics investigation process. Three of these tasks were focused on middle school teaching, while the other three were focused on high school teaching. Participants had the chance to choose which set of activities to engage with and then use previous materials available in this MOOC such as the SASI framework (Lee & Tran, 2015) and the statistical habits of mind (Lee & Tran, 2015) to better understand the potential and caveats regarding statistical investigation in each task.

In this process, participants identified the tasks’ learning goals, their affordances of the statistics investigation approach, their promotion of any statistical habits of mind, and potential changes participants would do to make these tasks more aligned with the statistics investigation process (SASI framework). Participants also had the chance to share with others in forums their
views of the tasks as well potential modifications they would make to them. This example shows coherence among materials available in the MOOC (in this case the SASI framework and the description of statistics habits of mind) and activities performed by participants (choosing tasks that afford statistics instruction through investigation). Besides coherence among materials and activities, the MOOC offered options for participants to engage with materials that were more suitable to their practice and to their goals in this MOOC. By having options in materials to choose from, this MOOC reinforced the notion of coherence as an individual process going beyond organization and display of materials in this professional development. Seeing coherence as an implicit phenomenon that is related to participants’ individual choices ties coherence to participants’ active learning, another characteristic of effective professional development described in previous section in this chapter.

In this MOOC coherence was also implicitly constructed individually by participants as they pursued this professional development. From the data, coherence was an individual process that varied from person to person in which participants (teachers) made (or not) coherent this professional development according to their own needs. At the individual level, coherence can be seen by the alignment of participants’ initial goals pointed out at their enrollment in this professional development, and their engagement throughout this MOOC as shown by the same geometrical shapes and unbroken line connecting goals and engagement in Figure 5-6.

Participants’ engagement considers the materials with which they interacted (represented by MOOC pages), the forums in which they took part, and their volunteer statements of what they took from this MOOC. In this perspective, coherence is perceived as a volunteered match as suggested by Smith and Gillespie (2007), in which participants who intended to know about the content available in this MOOC freely engaged with resources and people that were related to their professional development needs.
Alternatively, lack of coherence at the individual level would be a rupture or absence of alignment between participants’ goals to this professional development and their engagement in it. This lack of coherence can happen in two ways. When participants pointed out their goals but do not present sustained engagement (drop-out), represented by participant 4 in Figure 5-7 or when participants’ engagement completely differs from their initial goals, represented by participant 5 in Figure 5-7.

It is also possible that some participants present a partial lack of coherence between their goals for this professional development and their engagement in it. Partial lack of coherence may also happen when participants’ engagement and intentions differ in part from their initial goals as represented in Figure 5-8.
Since coherence is depicted as an individual process of alignment between participant’s goals and engagement, it may vary from person to person as represented by participants 1 and 2 in Figure 5-9. When coherence is viewed at a macro level in which participants’ individual coherences are compared to each other in a group of participants as all representations presented in Figure 5-9, alignments between goals and engagement may differ from person to person, reinforcing the notion of coherence as an individualized process residing on participants’ realm.

In the next paragraphs, I focus on detailing coherence as an individual process. For that, I start by presenting the main goals of participants in regard to this professional development. After that, instead of analyzing the alignment between goals and engagement for all participants of this professional development to support the fact that coherence is an individual process, I randomly
select two participants and analyze the alignment between their goals and their engagement. To choose a random participant, the functions index and randbetween from Microsoft Excel

\(=\text{INDEX}($A$2:$A$28501, \text{RANDBETWEEN}(2, 28501))\) were used. The index function orders a list of values of the variable of interest (participant ID) and the randbetween function randomly picks a value between the range. My goal is to expose with data this individuality in coherence between these two random participants which is inherent to all participants in this MOOC. I expect this analysis will help the reader to visualize with data coherence as an individual process represented by the schematic representation created in Figure 5-9 that shows variations in alignment of goals and engagement.

To explore coherence as an individual process implicitly constructed by participants as they pursue this professional development it is important to recall that, by design, participation in this MOOC is voluntary. This means that it was expected participants to engage and disengage with course materials and with others according to their own interests and priorities. This way, coherence is related to participants’ goals, rather than only to the goals allowed and encouraged by the MOOC design (goals external to participants). To understand participants’ interests (goals) in this MOOC, I made use of a survey completed by participants during the registration process. At the MOOC registration, participants were asked by the MOOC provider to fill out a form classifying their goals in this professional development by order of importance. The first column of Table 5-3 shows 12 options for participants choose from as their goals in this professional development. Table 5-3 also shows participants’ three main goals (first goal in blue, second goal in orange and third goal in green) as they engaged in this MOOC.

Compiling the answers from 824 participants, we learned that participants’ three main goals in this professional development were: (1\textsuperscript{st}) strengthen their understanding of how to engage students in statistical investigations (chosen as goal 1 by 54\% of participants), (2\textsuperscript{nd}) deepen their understanding of how students reason with data (chosen as goal 1 by 22.02\% of
participants), and (3rd) improve their ability to use rich data sources to support investigations (chosen as goal 1 by 16.11% of participants). By the numbers from Table 5-3, we notice that not all participants shared the same goals and the order of importance of these goals in regard to this professional development. We want to observe whether participants’ engagement is in line with their goals. For that I randomly chose two participants (Participant 3348 and Participant 3966) and present a comparison of their goals and their engagement with the MOOC platform. To choose a random participant, the functions index and randbetween from Microsoft Excel were used as described in previous sections.

Table 5-3. Participants’ three main goals in this MOOC.

<table>
<thead>
<tr>
<th>Options</th>
<th>Goal 1</th>
<th>Goal 2</th>
<th>Goal 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>Count</td>
<td>%</td>
</tr>
<tr>
<td><strong>Strengthen my understanding of how to engage students in statistical investigations</strong></td>
<td>54.00%</td>
<td>445</td>
<td>12.95%</td>
</tr>
<tr>
<td><strong>Improve my ability to use rich data sources to support investigations</strong></td>
<td>10.32%</td>
<td>85</td>
<td>17.23%</td>
</tr>
<tr>
<td><strong>Deepen my understanding of how students reason with data</strong></td>
<td>9.59%</td>
<td>79</td>
<td>22.02%</td>
</tr>
<tr>
<td><strong>Improve my ability to use dynamic tools to visualize and analyze data</strong></td>
<td>7.16%</td>
<td>59</td>
<td>12.18%</td>
</tr>
<tr>
<td><strong>Engage in fun and inspiring activities</strong></td>
<td>5.95%</td>
<td>49</td>
<td>11.66%</td>
</tr>
<tr>
<td><strong>Collect new resources or tools</strong></td>
<td>4.61%</td>
<td>38</td>
<td>9.46%</td>
</tr>
<tr>
<td><strong>Make changes to my professional practice</strong></td>
<td>3.52%</td>
<td>29</td>
<td>5.18%</td>
</tr>
<tr>
<td><strong>Exchange ideas and experiences with other educators</strong></td>
<td>2.18%</td>
<td>18</td>
<td>5.44%</td>
</tr>
<tr>
<td><strong>Experience learning in a MOOC-Ed</strong></td>
<td>1.70%</td>
<td>14</td>
<td>1.42%</td>
</tr>
<tr>
<td><strong>Earn a certificate of completion</strong></td>
<td>0.61%</td>
<td>5</td>
<td>1.68%</td>
</tr>
<tr>
<td><strong>Collaborate on joint projects</strong></td>
<td>0.36%</td>
<td>3</td>
<td>0.78%</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>0.00%</td>
<td>0</td>
<td>0.00%</td>
</tr>
</tbody>
</table>
Participant 3348 stated her goals in the registration survey as: (1st) improve my ability to use rich data sources to support investigations, (2nd) strengthen my understanding of how to engage students in statistical investigations, and (3rd) make changes to my professional practice. The logs of her click data shows she engaged 1210 times with the MOOC pages (resources and forums) accessing multiple times resources and discussion forums that were connected to her goals (represented by the number in parentheses): (1st) use of rich data sources to support investigations such as Census @ School (accessed 47 times), and (2nd) students engaged in statistical investigations such as the description and details about levels of sophistication of the SASI Framework (accessed 10 times). With regard to her third goal of making changes in her professional practice, she voluntarily stated in a discussion forum: “[…] this MOOC definitely changed how I think about how to teach statistics, what to emphasize on, and how to deliver it to students”. In a different discussion forum, she shared that the materials provided in this MOOC helped her to practice her skills in statistics and to gain knowledge about dealing with real data (by sharing her experience with the Census @ School website):

All the tools, and especially videos provided me with a great experience to practice my skills in statistics, and more importantly made me appreciate the importance of understanding the language, visuals, variables, and trends before delving into data to make analysis and interpretations. I also spent some time on trying different scenarios with interactive tools that had School Census data in it and had a chance to see which chart works best with which variable, the links between graphs, the relations among variables, and so more!

It is interesting to note that not all of her goals overlapped with the goals of the majority of participants, showing once more that coherence as alignment between goals and engagement is related to participants’ individual choices. Analyzing her goals, her engagement with the MOOC platform, and some of her posts as above, help us to understand what she is taking from this MOOC, which builds evidence of coherence as an individual process.
Similarly, analyzing the goals and engagement of participant 3966 (another random participant), the data supports once again that coherence in this professional development is related to participant’s goals. In the case of participant 3966, she stated her three main goals as: (1<sup>st</sup>) strengthen my understanding of how to engage students in statistical investigations, (2<sup>nd</sup>) deepen my understanding of how students reason with data, and (3<sup>rd</sup>) exchange ideas and experiences with other educators. Observing the logs of her click data, she engaged 860 times with the MOOC pages (resources and forums) accessing multiple times resources and discussion forums that were connected to: (1<sup>st</sup>) strengthen her understanding of how to engage students in statistical investigations such as the description and details about levels of sophistication of the SASI Framework (9 times), and (2<sup>nd</sup>) deepen her understanding of how students reason with data as students engaged in statistical investigations such as the Schoolopoly activity (accessed 39 times). Regarding to the goal of (3<sup>rd</sup>) exchange ideas and experiences with other educators, participant 3966 created 9 discussion threads, replied to other participants 15 times and view discussions 132 times. In one of her posts she replies to participant 1478

Hi Participant 1478! I really like that last sentence on feeling how students feel. I think that is so important when being a teacher. We need to relate! Also, I have to agree, if students were given a strong foundation in statistics, built throughout their high school career, they should be able to answer these questions. However, that if is the key. I find in my area at least, that statistics is not an important focus in the classroom and many teachers do not make it meaningful or engaging when it is taught. That makes it really hard for students to retain and understand the information taught to them. What do you think? Do you find the same problems occurring in your area? (Participant 3966 discussion #5722)

Although this MOOC was open to anyone interested in the theme, its content was centered on middle and high school statistics teaching, in which teaching statistics is conceived as a process as described in the first section of this chapter. It is fair to assume that lack of coherence may exist and it can be expressed by participants in three ways: by dropping out the MOOC, by presenting an engagement that differs from participant’s initial goals, or by revealing some form
of incoherence or dissatisfaction between their goals and the engagement with MOOC materials through their posts.

Lack of coherence happens at the individual level when there is a lack of alignment between participant’s goals and engagement. For the first case, participants point out their goals but do not present sustained engagement (drop-out). An example of lack of alignment between participant’s goals and engagement was presented by participant 4474. At the beginning of the MOOC, she/he stated main goals as: (1°) earn a certificate of completion, (2°) deepen my understanding of how students reason with data, and (3°) collect new resources or tools. However, she/he dropped the MOOC on the first day of the professional development, showing absence of alignment between goals and engagement, and thus lack of coherence. A similar case was presented by participant 4635 who also stated the desire to earn a certificate of completion as her first goal in this professional development but didn’t engage with others in forums, dropping the MOOC on the second day of the professional development.

For the second case, lack of coherence at the individual level happens when participants’ engagement differs from their initial goals. An example of lack of alignment of participant’s goals and engagement was presented by participant 2291. At the beginning of the MOOC, she stated her main goals as: (1st) collaborate on joint projects, (2nd) strengthen my understanding of how to engage students in statistical investigations, and (3rd) deepen my understanding of how students reason with data. In order for her to fulfil her first goal it was expected she would engage with others in forums (by creating discussions and/or replying to posts of others) as a way to contact others and collaborate in joined projects. However, participant 2291 did not engage with any other participant in forums. In fact, after her introductory post she became a lurker, viewing posts of others 26 times.

Partial lack of coherence may happen when participants’ engagement and intentions differ in part from their initial goals. Participants still engage with the MOOC platform but reveal
some form of incoherence between their goals and the MOOC materials they engaged or would like to engage, as presented in the next two examples. Participants 3225 and 3304 completed the registration survey indicating their goals. Both indicated in their goals the interest to improve their ability to use rich data sources to support investigations. Later in the discussion forums, they declared their desire to develop statistical knowledge and to develop knowledge of statistical tools as R, a statistical programming software (R Core Team, 2016). Since the course was not designed to provide knowledge about statistics content nor statistical programming software such as R, members of the instruction team suggested to them a different MOOC that would be more focused on statistics concepts and statistical analysis using R and other programming software. The suggested MOOC is called ‘Master Statistics with R’ and is conducted by Dr. Mine Çetinkaya-Rundel from Duke University.

These two examples highlight that if partial lack of coherence happens (when the MOOC doesn’t address some expectations of participants) it is still possible that participants may continue engaging with the MOOC because it may provide value related to participants’ other two goals. Despite the fact that these two participants presented partial coherence, both of them concluded the professional development. These two cases show how important it is for professional development leaders (in this case, the main instructor) to understand participants’ needs towards this professional development and how to deal with participants who point out lack of coherence in the professional development. In a broader perspective, lack of coherence may affect participants’ active learning and their number of contact hours in this professional development (duration).
Type of the Activity

Historically the literature on face-to-face professional development has classified the types of professional development activities in two main categories: traditional and reform. The traditional approach is described by short-term or one-session workshops, trainings, and seminars (Smith & Gillespie, 2007). The reform approach is described by initiatives that support curriculum reform implementation (Darling-Hammond, 1996; Garet et al., 2001; Blank & de las Alas, 2009; Yoon et al., 2007; Penuel, Fishman, Yamaguchi & Gallagher, 2007). Reform types of professional development usually take place during the regular school day, are activities developed with a long-term perspective, and characterized by teachers’ active participation (Garet et al., 2001; Penuel et al., 2007; Blank & de las Alas, 2009; Yoon et al., 2007).

The dichotomic notions of traditional and reform types of professional development date from twenty years ago (e.g., Darling-Hammond, 1996) and have had an important role in the field of professional development highlighting the differences between these approaches. However, nowadays it is hard to classify a professional development initiative as traditional or reform approach. This is because there is a spectrum of possibilities between these two extremes called traditional and reform, which allows a professional development to be comprised of features from both sides of this spectrum. In the case of this MOOC, I argue that it is situated in the middle of the spectrum, slightly towards the reform type of professional development, carrying characteristics of both traditional and reform forms of professional development (Figure 5-10).
Figure 5-10. Locating MOOC in the spectrum of professional development approaches.

Figure 5-10 presents on its left-side features of traditional professional development and on its right-side features of reform professional development as described in the literature, Chapter 2. It also shows this MOOC located in between the spectrum with the items that comprised the rationale I used to locate this MOOC in this spectrum. In the next paragraphs, these items are described.

**Pre-Defined Content Based on Standards for Student Learning**

The MOOC had a pre-defined (standard) content focused on teaching statistics as a process, described in the *content* section at the beginning of this chapter. The content of this professional development was in line with curricular reforms and mainly focused on middle and high school statistics. Due to worldwide participation (participants from various parts of the world), the MOOC content wasn’t tailored to the needs of any specific school.
Resides Outside the School Day and Makes Use of Asynchronous Mode of Communication

This MOOC was hosted outside of the school walls, taking place outside of the regular teachers’ school day, and it ran on a 24/7 basis meaning that participants (teachers) were able to connect with materials and with others at any time and from anywhere. Literature has reinforced that reform types of professional development tend to occur during the regular school day and for a long period of time (Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet et al., 2001; Birman, Desimone, Garet, & Porter, 2000). The argument is that “locating opportunities for professional development within a teacher’s regular work day, reform types of professional development may be more likely than traditional forms to make connections with classroom teaching, and they may be easier to sustain over time” (Garet et al., 2001, p. 921). Since this MOOC was fully developed online, it is counter to the notion of professional development happening inside physical schools. In fact, it expands this notion making it possible for teachers to bring their professional development wherever they go, including during the period they are at schools.

Focused on Practice

The proximity of practice offered by the activities of this MOOC such as Schoolopoly, Census @ School, and Statistical Tasks, among others reinforces the potential connection with classroom teaching as suggested by proponents of reform type of professional development (e.g., Gulamhussein 2013; Garet et al., 2001; Darling-Hammond & Richardson, 2009).
Collaborative through Forum Engagement

The MOOC provided opportunities for collaboration as teachers shared their experiences and exchanged materials with others in forums. Although it was possible for participants to work together in this MOOC, data from participants’ discussion posts shows no evidence that they joined together in a collaborative activity aside their engagement in forums. Teachers also had opportunity to work with others in the MOOC final project, however all eight participants who submitted final projects opted to do it individually.

Happens through Sustained Period of Time with Participants Engaging with it 24 by 7

The MOOC was available from Sep 21st 2015 to Dec 14th 2015. Through this period, participants could engage with the MOOC platform and with others multiple times and at any time of the day, which makes this MOOC running on a 24 by 7 basis. It was up to participants to decide the amount of time they would allocate to this professional development. When considering time dedicated to this professional development, it was possible to observe participants engaging with the course for a short amount of time (e.g., participants #3411, #3546, #3375, #3169), which emulates the format of ‘sit and get’ workshop, a characteristic from traditional forms of professional development. On the other hand, it was possible to observe participants engaging with the course for a long amount of time (e.g., participants #4346, 4314, #3547, #3128), which emulates the ‘sustained period of time’ characteristic of reform forms of professional development.
Not Designed for Follow-up to Implementation

An important aspect of reform type of professional development is support for teachers’ classroom implementation, meaning that a long and situated professional development allows time for teachers to implement the changes in practice learned from their professional development (Darling-Hammond & Richardson, 2009; Garet, et al., 2001; Birman et al., 2000; Loucks-Horsley, Hewson, Love, & Stiles, 1998). In this sense, this MOOC fell short regarding implementation of changes in practice. Although this MOOC was opened for three months to participants, it may not have provided enough time for them to absorb the new learning, implement it in their practice, return to the professional development venue to share their learning from this process with others, receive feedback, and implement modifications. A possibility to minimize this caveat would be participants to re-take the same MOOC for free and then share with others (probably a different crowd of participants) what worked and what didn’t work in the implementation of changes fostered by this professional development initiative. In the next section, the duration as a characteristic of effective professional development is discussed.

Duration of the Activity

In the literature the term duration encompasses the number of contact hours spent in professional development and its overall span of time (Garet et al., 2001; Birman et al., 2000; Penuel et al., 2007). The argument for longer duration in face-to-face initiatives is that when teachers have more time in professional development they can reflect over their changes and still take advantage of the feedback coming from the professional development group (Blank & de las Alas, 2009; Penuel et al., 2007; Borko et al., 2010; Day & Sachs, 2004; Darling-Hammond & Richardson, 2009). In this study duration is analyzed in two ways: the overall span of time in
which this professional development was available, and participants’ logs of access to the
platform distributed throughout the MOOC. The choice in using participant logs to the MOOC
platform instead of the number of contact hours has to do with the fact that it is not possible to be
certain if a participant was truly engaged with the MOOC page in the space of time between one
click and another.

Regarding the overall span of time, this MOOC was officially available from September
28th 2015 to November 9th 2015. Although the starting date was September 28th, the course
platform was opened for participants on September 21st 2015. In these first two weeks
participants could get to know the platform and also introduce themselves in the orientation unit.
By design, the MOOC platform was kept open beyond the official ending date of Nov 9th
extending participants engagement with the MOOC resources until December 14th 2015. Figure
5-11 shows participants’ course logs during the whole period the course was open (Sep 21st to
Dec 14th). The solid lines (orange color) represent the official duration of the MOOC (Sep 28th
to Nov 9th). The dotted lines (green color) represent the extension in duration made by the
MOOC provider (Sep 21st to Dec 14th). The arrows (at the bottom of the graph) represent the
course units. The numbers along with the graph shows participants’ engagement represented by
their course logs throughout the period the MOOC platform was opened.
Duration as availability of professional development supports participants’ engagement. In this sense, longer duration in professional development affords more time for teachers to learn new practices, engage with others, try these new practices and share their experiences with others (Garet et al., 2001). When considering data from participants’ engagement (Figure 5-11) distributed throughout the MOOC duration, we notice that participants’ engagement had its peak at the first week of the course (official starting date September 28th) with 19,435 course logs, and decreased as the professional development progressed. The decay in participants’ engagement raises concerns about what would be the optimal duration for MOOCs that will keep a sustained participants’ engagement throughout the professional development. Or still, how MOOCs could be used to provide longer duration for professional development as suggested in the literature of effective teachers’ professional development?
This decay of participants’ engagement seen in Figure 5-11, may be related to many different factors that affect the effectiveness of duration as proposed by the literature of teacher professional development. To have a better sense of duration in this professional development and its relation to participants’ engagement, it is important to remember that MOOCs are free and open courses that attract a high volume of participants who enroll in the course but do not stay active throughout the course period. This phenomenon tends to happen at the beginning of the course, which I call the ‘bubble effect’, the period in which the MOOC receives a high number of enrollments. Based on the literature (Rosé et al., 2014; Wen, Yang & Rosé, 2014; Ramesh et al., 2013), it is possible to hypothesize reasons for this drop of engagement as time goes by such as participants’ autonomy, lack of financial commitment with the course, age, time management, self-motivation, their perceptions of openness, lack of interactivity at some moments of the course, and diversity among participants. In the case of this MOOC, it is possible that the reasons above or a combination of them might have influenced participants to diminish engagement or to disengage from this professional development, which consequently affects the effect of course duration in this professional development. Unfortunately, understanding the specific reasons for participant drop-out lays out of the scope of this study.

On the other hand, the extension period (from Nov 10th to Dec 14th) after the end of the course (Nov 9th) proved to be an extra chance for participants to engage with the MOOC pages (resources and forums) before the platform was completely closed. From Figure 5-11, we notice that this period generated an additional of 14196 logs on the MOOC platform. Based on click data, 114 participants took advantage of this extension period. Fifteen of these 114 participants had not accessed the MOOC platform during the official duration of this professional development. Ninety-nine participants used this period as an extension of their professional development revisiting pages that they had previously accessed and exploring content that they hadn’t previously accessed during the official duration of the MOOC. In this extension period,
participants visited for the first time and/or revisited: forum posts, videos, transcriptions of videos, resources involving use of data in statistics, and resources about technology. Some participants used this extra time to revisit forums and leave comments to someone else’s posts while others updated the completion status of their course with the intention of obtaining a course certificate.

This extension in duration of this MOOC generated an increase in participants’ engagement as seen in Figure 5-11 and as discussed above. One may argue that this increasing in participants’ engagement is aligned with the literature of effective professional development in the sense that longer professional development activities are more likely to provide more opportunities for teachers to learn and engage with others (Garet et al., 2001, Darling-Hammond & Richardson, 2009). However, even with this extension period and a marginal increasing in participants’ posts, it seems participants didn’t have enough time to try out new practices and reflect upon changes implemented in their classrooms as an outcome of extended duration foreseen on the literature (Garet et al., 2001, Darling-Hammond & Richardson, 2009).

When analyzing duration as number of contact hours spent in this professional development, the literature from face-to-face professional development (Garet et al., 2001, Gulamhussein, 2013, Darling-Hammond & Richardson, 2009) does not make a specific recommendation regarding the number of contact hours a participant should spend in a professional development, nor specify a number for overall span of time that a participant should spend in a professional development to classify it as short or long duration. In Darling-Hammond and Richardson (2009) there is a mention that “research suggests that professional development of 14 hours or less has no effect on student learning, while longer-duration programs show positive and significant effects on student achievement” (p. 20). In Gulamhussein’s (2013) report there is another mention (based on study conducted by French, 1997) that “teachers may need as many as 50 hours of instruction, practice and coaching before a new teaching strategy is mastered
and implemented in class” (p. 4). In this MOOC, participants could control the number of contact hours spent in this professional development, although the total span of time (from date started to date finished) is still constrained by the MOOC provider.

For MOOC participants who were interested in obtaining a certificate of completion, two options were offered as presented in Figure 5-12. To receive a certificate of completion for 20 hours of professional development, participants had to access and engage with the essentials modules in all units, post at least one discussion or comment in each unit forum, and complete the units’ investigations. To receive a certificate of completion for 25 hours of professional development, participants had to complete the requirements of 20 hours certificate, submit a project, and provide support through the project forum discussion for at least one other participant.

![Figure 5-12. Requirements for MOOC certificate.](image)

Analyzing the criteria for certificate of completion, it is possible that a participant may have obtained a certificate of completion (e.g., a 20 hours certificate) by engaging with the MOOC platform for less than 20 hours, while other participants may have obtained the same certificate by engaging with the MOOC platform for more than 20 hours. This means that the number of contact hours in this professional development varies among participants. This variation happened not only for participants who aimed for certificate of completion but also for the ones who didn’t intend to earn a certificate. To illustrate this variation, I am comparing
engagement (participants’ click data) of two distinct participants who obtained the course certificate, participants 6286 and 3722 (Table 5-4). My decision in comparing participants’ log to the MOOC platform instead of comparing the number of contact hours between these two participants has to do with the fact that it is not possible to be certain if a participant was really engaged with the MOOC page in the space of time between one click and another. The concrete evidence that we have is that a participant clicked in a certain MOOC page at a time identified in the time stamp of that click. Thus, comparing the number of logs to the MOOC platform of participants 6286 and 3722 (Table 5-4) shows that participant 6286 presented more engagement with the MOOC platform (more posts) than participant 3722, which may indicate that these participants perceived duration in this MOOC differently. Table 5-4 also shows that duration as window of engagement varied between these two participants, in which participant 3722 engaged with the MOOC during the period of September to November, while participant 6286 engaged with the MOOC in the period of September to December. The fact that participants presented different amounts of engagement with the MOOC platform, distributed in different months, reinforces the results discussed in the active participation section, where active participation was shown to be an individualized process in this MOOC.

Table 5-4. Number of Logs of participant 3722 and 6286.

<table>
<thead>
<tr>
<th>Number of Logs of participant 3722</th>
<th>Number of Logs of participant 6286</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep</td>
<td>Out</td>
</tr>
<tr>
<td>9</td>
<td>184</td>
</tr>
<tr>
<td>Total # of logs</td>
<td>425</td>
</tr>
</tbody>
</table>

An important feature that this MOOC brings in regard to duration (represented by number of contact hours) is the use of asynchronous mode of engagement. Engagement in this MOOC was fully based on asynchronous interactions, in which asynchronous interactions are
“online communication that takes place independent of time or location” (Song & Wang, 2008, p. 670-677). Besides the idea that this MOOC congregates people from different locations (which will be explored in the next section), the possibility of accessing MOOC content at any time allows participants to engage with MOOC content by accessing its resources at time $t_1$, and later return at time $t_2$ and re-engage with the same (or modified) content that they had engaged in time $t_1$. By making use of asynchronous interactions, the concept of duration detaches even more from the linear notion of time that is seen in synchronous face-to-face professional development literature. Due to asynchronous interactions, participants can ‘go back in time’ and access what others have said in the past. Thus, as professional development makes use of asynchronous engagement, duration and overall span of time have the potential of being stretched which may extend the number of contact hours of that professional development.

Results from this section lead to the conclusion that duration tends to be a fluid concept when professional development is delivered through asynchronous mode of communication as the case of this MOOC. It shows that participants had freedom to engage and to disengage at any time and in any quantity with this MOOC, impacting the notion of duration of professional development in the sense that duration is not only a fixed trait that occurs at same time and in the same way for all participants. Although duration understood as course availability is still the same for all participants (Sep 21 to Dec 14), duration also becomes a matter of personal choice, which leads participants to the opportunity of maximizing the duration of their professional development by spending more time engaged with the platform, which connects duration to participants’ interaction with resources and with others as discussed in the next chapter.
Collective Participation

Literature points out a positive association between teachers engaging as a group in professional development and their implementation of teaching practice in their classrooms (Garet et al., 2001; Desimone et al., 2002; Porter et al., 2000). The argument is that collegial peer group participation in professional development opens opportunities for teachers’ continuing learning as a group, reinforcing their interactions, and giving opportunities for them to establish linkages among their experiences (Knapp, 1997; Garet et al., 2001; Desimone et al., 2002). For Garet et al. (2001), collective participation in professional development “may help contribute to a shared professional culture, in which teachers in a school or teachers who teach the same grade or subject develop a common understanding of instructional goals, methods, problems, and solutions” (p. 922).

In this MOOC, the notion of collective participation was expanded to diverse participation in which teachers had opportunity to be part of a worldwide community made of participants who voluntarily engaged in an open form of professional development to improve their professional knowledge. Since this MOOC was bounded by its availability (duration), the community generated by participants’ interactions within this MOOC were also bounded by the MOOC duration. Participation in this MOOC was not restricted to collegial peer group participation as locally defined in the literature described above. Participation was individual and a product of participants’ autonomy of interacting or not with the MOOC resources and with other participants. Although participants entered in this MOOC individually, they shared their experiences and practices about teaching statistics with others as they interacted in forums. In the next chapter, I use qualitative analysis to unpack the content of these interactions (forum posts), which will expose their shared concerns about the challenge of teaching statistics to their
students, and their interactions regarding the pedagogical approach of teaching statistics through data investigations (object of this MOOC).

In this section, I use quantitative analysis to present participation as a composition of participants’ characteristics: (i) geographical location, (ii) academic background, and (iii) professional roles. Since participants did not have any restriction regarding their country of origin, experience or background to engage in forums, participation is evidenced by combinations of these participants’ characteristics as they engage together in forums. To explore the characteristics of participation, I first made use of demographics to present participants’ geographical location, academic background, and professional roles. Participants’ demographics were collected by the MOOC provider at the moment of participant registration. To register in this MOOC, the individuals needed to complete this survey.

Next, I presented a sample of 11 discussions highlighting participants’ characteristics in each one to demonstrate the organic and diverse composition of participation in each discussion. The sample was randomly chosen with the intention of showing discussions with different numbers of participants, using the functions index and randbetween from Microsoft Excel (=INDEX($A$2:$A$28501, RANDBETWEEN(2, 28501))). The index function orders a list of values of the variable of interest (discussion numbers) and the randbetween function randomly picks a value between the range. Data shows that the discussions forums embraced a variety of participant combinations (with repetition) as we analyze the composition of the discussion threads. These combinations of participants organically generated by discussion threads creates participants’ assemblages of people engaging in different forums. Diversity emerges as a common characteristic for the three characteristics of participation presented in these participants’ assemblages.
Geographical Location

Results from exploratory data analysis on demographics data show that from a total of 817 participants, the majority of them were from the United States (597 participants), followed by 68 participants from New Zealand. Twenty-six participants were from the U.K., 20 were from Australia, and 106 were from other countries represented on Table 5-5 and on Figure 5-13.

Table 5-5. Worldwide Participants Distribution.

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of Participants</th>
<th>Country</th>
<th>Number of Participants</th>
<th>Country</th>
<th>Number of Participants</th>
<th>Country</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE</td>
<td>2</td>
<td>EC</td>
<td>1</td>
<td>IL</td>
<td>1</td>
<td>MY</td>
<td>2</td>
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<tr>
<td>AL</td>
<td>1</td>
<td>EG</td>
<td>1</td>
<td>IN</td>
<td>6</td>
<td>NG</td>
<td>1</td>
</tr>
<tr>
<td>AR</td>
<td>1</td>
<td>ES</td>
<td>3</td>
<td>IQ</td>
<td>1</td>
<td>NP</td>
<td>2</td>
</tr>
<tr>
<td>AU</td>
<td>20</td>
<td>FR</td>
<td>2</td>
<td>IR</td>
<td>2</td>
<td>NU</td>
<td>1</td>
</tr>
<tr>
<td>BR</td>
<td>2</td>
<td>GB</td>
<td>26</td>
<td>IT</td>
<td>4</td>
<td>NZ</td>
<td>68</td>
</tr>
<tr>
<td>CA</td>
<td>9</td>
<td>GR</td>
<td>8</td>
<td>JO</td>
<td>2</td>
<td>PI</td>
<td>4</td>
</tr>
<tr>
<td>CH</td>
<td>2</td>
<td>GU</td>
<td>1</td>
<td>JP</td>
<td>1</td>
<td>PK</td>
<td>2</td>
</tr>
<tr>
<td>CR</td>
<td>1</td>
<td>HK</td>
<td>1</td>
<td>KE</td>
<td>4</td>
<td>PL</td>
<td>1</td>
</tr>
<tr>
<td>DE</td>
<td>5</td>
<td>HN</td>
<td>1</td>
<td>MW</td>
<td>1</td>
<td>PR</td>
<td>2</td>
</tr>
<tr>
<td>DO</td>
<td>1</td>
<td>IE</td>
<td>9</td>
<td>MX</td>
<td>1</td>
<td>PS</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 5-13. Worldwide map participants’ distribution.

Participants from different countries joined together in discussions forming assemblages.

Table 5-6 shows a sample of 11 discussions highlighting participants’ countries and the number
of participants from each country. Ten of the 11 discussion threads involve participants from more than one country. Since the MOOC had 597 participants coming from United States, it seems natural to have more participants from this country in the discussions. Since this MOOC didn’t separate its discussion forums by countries, participants could interact with others according to their own interests regarding the topic that was being discussed in the forums.

Table 5-6. Sample of 11 discussions showing participants’ countries.

<table>
<thead>
<tr>
<th>Discussion #6826</th>
<th>Number of participants</th>
<th>Discussion #8036</th>
<th>Number of participants</th>
<th>Discussion #5452</th>
<th>Number of participants</th>
<th>Discussion #5624</th>
<th>Number of participants</th>
<th>Discussion #8284</th>
<th>Number of participants</th>
<th>Discussion #7552</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR</td>
<td>1</td>
<td>GB</td>
<td>1</td>
<td>PH</td>
<td>1</td>
<td>NZ</td>
<td>2</td>
<td>AR</td>
<td>1</td>
<td>AE</td>
<td>1</td>
</tr>
<tr>
<td>AU</td>
<td>1</td>
<td>NZ</td>
<td>1</td>
<td>US</td>
<td>6</td>
<td>PR</td>
<td>1</td>
<td>PH</td>
<td>1</td>
<td>US</td>
<td>15</td>
</tr>
<tr>
<td>GR</td>
<td>1</td>
<td>US</td>
<td>5</td>
<td>US</td>
<td>18</td>
<td>US</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NZ</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PH</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VG</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Academic Background**

In this study, participation also embraces the idea of participants with diverse backgrounds engaging together in this professional development. From demographics, we see that participants had a variety of education level backgrounds (Figure 5-14) in which: 161 participants have a Doctoral Degree, 428 participants have a Masters Degree, 170 participants have a 4-Year College Degree, 13 participants have a 2-Year College Degree, 16 participants have a Professional Degree (e.g. JD, MD), and 29 participants have a High School Degree. In terms of gender, enrolled participants self-identified as 541 females and 276 males. Table 5-7 shows participants education levels in the same sample of discussions. We note that each of the 11 discussions that were randomly chosen embraced participants with different education levels,
although majority of participants in this MOOC have a higher education background (72% of participants have a Doctoral Degree and/or a Masters Degree).

![Distribution of Participants' Education Backgrounds](image)

Figure 5-14. Distribution of participants’ education backgrounds

Table 5-7. Sample of 11 discussions showing participants’ education backgrounds.

<table>
<thead>
<tr>
<th>Discussion #6826 Number of participants</th>
<th>Discussion #8036 Number of participants</th>
<th>Discussion #5452 Number of participants</th>
<th>Discussion #5624 Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doctoral Degree 14</td>
<td>Masters Degree 20</td>
<td>Masters Degree 22</td>
<td>Doctoral Degree 8</td>
</tr>
<tr>
<td>Masters Degree 21</td>
<td>Doctoral Degree 8</td>
<td>Doctoral Degree 6</td>
<td>Masters Degree 7</td>
</tr>
<tr>
<td>4-Year College Degree 11</td>
<td>4-Year College Degree 4</td>
<td>4-Year College Degree 1</td>
<td>4-Year College Degree 5</td>
</tr>
<tr>
<td>High School 1</td>
<td>2-Year College Degree 1</td>
<td>High School 1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Discussion #8284 Number of participants</th>
<th>Discussion #7552 Number of participants</th>
<th>Discussion #5588 Number of participants</th>
<th>Discussion #5365 Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masters Degree 14</td>
<td>Masters Degree 7</td>
<td>Masters Degree 5</td>
<td>4-Year College Degree 4</td>
</tr>
<tr>
<td>4-Year College Degree 3</td>
<td>4-Year College Degree 6</td>
<td>High School 2</td>
<td>Doctoral Degree 1</td>
</tr>
<tr>
<td>Doctoral Degree 2</td>
<td>Doctoral Degree 3</td>
<td>Doctoral Degree 2</td>
<td>Masters Degree 2</td>
</tr>
<tr>
<td>Professional Degree (e.g. JD, MD) 1</td>
<td></td>
<td></td>
<td>4-Year College Degree 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Discussion #5572 Number of participants</th>
<th>Discussion #5492 Number of participants</th>
<th>Discussion #5430 Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-Year College Degree 2</td>
<td>Doctoral Degree 1</td>
<td>Masters Degree 3</td>
</tr>
<tr>
<td>Doctoral Degree 1</td>
<td>Masters Degree 3</td>
<td>Doctoral Degree 4</td>
</tr>
<tr>
<td>Masters Degree 1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Professional Roles

Participation can also be seen as participants with diverse professional roles engaging together in this professional development. Table 5-8 shows 410 participants were Classroom Teachers (k-12 and Special Education teachers), 109 participants were Teacher Developers (Curriculum Specialist, Professional Development Consultant, Teacher Education, and Instructional Coaches), 115 participants were College Instructors (College Professor and Math/Stat College Professor), 25 participants were College Student Graduates, 50 participants were College Student Undergraduates (Pre-Service teacher and College Student undergraduate), and 108 were Other (Statistician, Educational Product/Service Provider, and Instructional Technology Facilitator). With respect to their professional experience, most participants had between 5 and 10 years of professional experience.

Table 5-8. Participants’ job role.

<table>
<thead>
<tr>
<th>Job Role</th>
<th>Number of Participants</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom Teachers (k-12 and Special Education teachers)</td>
<td>410</td>
<td>50.18%</td>
</tr>
<tr>
<td>Teacher Developers (Curriculum Specialist, Professional Development Consultant, Teacher Education, and Instructional Coaches)</td>
<td>109</td>
<td>13.34%</td>
</tr>
<tr>
<td>College Instructors (Math/Stat College Professor, and College Professor)</td>
<td>115</td>
<td>14.08%</td>
</tr>
<tr>
<td>College Student Graduates</td>
<td>25</td>
<td>3.06%</td>
</tr>
<tr>
<td>College Student Undergraduates (Pre-Service teacher and College Student undergraduate)</td>
<td>50</td>
<td>6.12%</td>
</tr>
<tr>
<td>Other Participants (Statistician, Educational Product/Service Provider, and Instructional Technology Facilitator)</td>
<td>108</td>
<td>13.22%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>817</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

The same sample of discussions was used to demonstrate the mix of participants’ job roles engaging in forums. Table 5-9 shows participants who perform different job roles engaging
together in each of the 11 discussions as a feature of diverse participation. Although the discussions present diversity with regard to the job role performed by these participants, we note that classroom teachers participated in a large amount when compared to others. This seems to be related to the fact that classroom teachers make 50.18% of total participants.

Table 5-9. Sample of 11 discussions showing participants’ job role.

<table>
<thead>
<tr>
<th>Discussion #6826</th>
<th>Number of participants</th>
<th>Discussion #8036</th>
<th>Number of participants</th>
<th>Discussion #5452</th>
<th>Number of participants</th>
<th>Discussion #5624</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other</td>
<td>4 Classroom Teaching</td>
<td>19 Professional Development</td>
<td>1 Teacher Preparation - College/University</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classroom Teaching</td>
<td>20 Special Education</td>
<td>2 Classroom Teaching</td>
<td>9 Instructional Technology</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Preparation - College/University</td>
<td>40 Other</td>
<td>2 Teacher Preparation - College/University</td>
<td>2 Classroom Teaching</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curriculum and Instruction</td>
<td>5 Instructional Technology</td>
<td>1 Student (College/Graduate School)</td>
<td>1 Student (College/Graduate School)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student (College/Graduate School)</td>
<td>5 Student (College/Graduate School)</td>
<td>5 Other</td>
<td>1 Curriculum and Instruction</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructional Technology</td>
<td>2 Teacher Preparation - College/University</td>
<td>1 Instructional Technology</td>
<td>Other</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td>1 Research</td>
<td>1 Curriculum and Instruction</td>
<td>Other</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mentor</td>
<td>1 Professional Development</td>
<td>2 Special Education</td>
<td>Other</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional Development</td>
<td>1 Curriculum and Instruction</td>
<td>Other</td>
<td>1</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Discussion #8284</th>
<th>Number of participants</th>
<th>Discussion #7552</th>
<th>Number of participants</th>
<th>Discussion #5432</th>
<th>Number of participants</th>
<th>Discussion #5365</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom Teaching</td>
<td>11 Research</td>
<td>1 Classroom Teaching</td>
<td>9 Student (College/Graduate School)</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student (College/Graduate School)</td>
<td>2 Classroom Teaching</td>
<td>10 Teacher Preparation - College/University</td>
<td>8 Research</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td>1 Professional Development</td>
<td>1 Student (College/Graduate School)</td>
<td>2 Other</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Preparation - College/University</td>
<td>2 Other</td>
<td>1 Mentor</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Professional Development</td>
<td>1</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Special Education</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Discussion #5572</th>
<th>Number of participants</th>
<th>Discussion #5452</th>
<th>Number of participants</th>
<th>Discussion #5432</th>
<th>Number of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional Development</td>
<td>1 Classroom Teaching</td>
<td>1 Teacher Preparation - College/University</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructional Technology</td>
<td>2 Student (College/Graduate School)</td>
<td>1 Teacher Preparation - College/University</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classroom Teaching</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As we saw above, participation was enacted in this MOOC by a variety of combinations of participants who bought their cultural experiences, their educational background and their professional experience as they engaged in discussion threads as assemblages. Although it is possible to have repetition of participants in the assemblages’ compositions, participation in this MOOC transcends the notion of collective participation in which all participants perform the same activities during their professional development. Because participants had autonomy to decide which discussion to engage with others, they didn’t engage in this MOOC as an intact group. Even when an overlap of participation happens among discussions as exemplified in red and bold on Table 5-10, the set of participants in each discussion was still a different set from one another characterizing once more the assemblages (i.e., dynamic clouds of participants), as previously presented. By embracing diversity of participants and diversity of engagement this
MOOC disrupted the idea of professional development delivered to collegial peer group and through local participation described the literature of face-to-face professional development (Knapp, 1997; Garet et al., 2001; Desimone et al., 2002).

Table 5-10. Participants overlap in two random discussion each with 23 posts.

<table>
<thead>
<tr>
<th>Participant ID</th>
<th>Geographical localization</th>
<th>Job role</th>
<th>Academic background</th>
</tr>
</thead>
<tbody>
<tr>
<td>296</td>
<td>US</td>
<td>Teacher Preparation - College/University</td>
<td>Doctoral Degree</td>
</tr>
<tr>
<td>3225</td>
<td>US</td>
<td>Classroom Teaching</td>
<td>Masters Degree</td>
</tr>
<tr>
<td>3284</td>
<td>US</td>
<td>Instructional Technology</td>
<td>Masters Degree</td>
</tr>
<tr>
<td>3323</td>
<td>US</td>
<td>Research</td>
<td>Masters Degree</td>
</tr>
<tr>
<td>3547</td>
<td>US</td>
<td>Classroom Teaching</td>
<td>Masters Degree</td>
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<td>Masters Degree</td>
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</table>

Although participation in this MOOC was worldwide, I noticed through their posts that some participants already knew each other, as in the cases of participants who were from the same location (e.g., participants 3128 and 3486), were colleagues before interacting with each other in this MOOC (e.g., participants 3128 and 4164), and were members of a group (e.g., participants 3970, 3817, 3845 4791, 3760, 3814, 3794, etc.). Although interacting individually in this professional development, for these participants MOOC forums were opportunities for them to experience a potential collective participation as a subset of individual participation as they could interact with each other within the group inside and outside the MOOC environment. An example was the group of pre-service teachers who took this MOOC as part of their regular college class, as stated by participant 4963: “Hi there! My name is 4963 and I am a ‘Blank’ University student studying mathematics education. My entire class is taking this course so we
can gain some new perspectives on how to teach statistics”. Evidence shows that some participants from this pre-service teacher group presented some form of collegial engagement as they exchanged their experiences regarding their preparation to teach statistics to their future students such as the post and reply by participants 3766 and 3794 after taking the LOCUS test:

Seeing as how I didn't get 100% on the Middle School assessment [...] This is most likely due to some misconceptions that I have, and which I would then pass on to my own students. Something I learned from this was that if I don't have a strong understanding of the mathematics, I won't be able to help my students develop their own strong understanding. (Participant 3766, discussion 6611)

I feel the same way you do as a teacher, there are obviously some misconceptions that I have about statistics that I may not even be aware of, and I might inadvertently pass those on. I need to make sure that I have a clear understanding so that I can pass that on to my future students. (Participant 3794, discussion 6611)

Although this group of pre-service teachers arguably shared the same professional culture (since they were from the same undergraduate class), had interactions about the same topic of interest as showed above, and established linkages among their experiences through their participation in forums, participation was still an individual act instead of a collective act as suggested in the literature of face-to-face professional development (CITE). The mode of engagement seems to differ from the literature of face-to-face professional development, in which teachers from the same school or district join a professional development activity with the intention to “develop a common understanding of instructional goals, methods, problems, and solutions” (Garet et al., 2001, p. 922). Here, data suggests that participants join to this professional development MOOC with the intention to learn more in order to be able to teach their students. By engaging individually, participants took advantage of the worldwide opportunity of engagement provided by this MOOC as they interacted with people from different locations and with different backgrounds as presented in the next chapter.
Summary for the Characteristics of Effective Professional Development – Answering the First Research Question

This chapter presented results regarding the first research question of this study: *To what extent can the characteristics described in the literature on effective face-to-face teachers’ professional development hold in a MOOC designed for statistics development of secondary teachers?* The characteristics were: content focus, opportunities for active learning, coherence, type of the activity, duration of the activity, and collective participation. In answering this question, I made use of multiple sources of data (MOOC webpages, discussion forums, an online survey, interviews with the instruction team, and click data) as well the literature of teachers’ professional development and the literature of MOOCs to capture the essence of each characteristic as it might be experienced in this MOOC. The MOOC embodied all characteristics of effective professional development. Clearly, these characteristics weren’t transferred in a straightforward fashion from face-to-face professional development literature into this MOOC. In fact, this study advances the field of teacher professional development by showing how differently these characteristics are depicted when a MOOC is used as venue for statistics development of secondary teachers. Participants’ autonomy is highlighted as a common element that modifies all characteristics explored in this chapter.

Participants’ Autonomy

From the theoretical framework, autonomy is understood by participants having “choice of where, when, how, with whom, and even, what, to learn” (Mackness, Mak, Fai, & Williams, 2010, p. 266). Analyzing the core features of professional development (content, active learning, and coherence), we noticed the effect of participants’ autonomy as they engaged with others and with materials in this form of professional development. Autonomy allowed participants to
engage and to aggregate materials to the course content, making content in this professional development a co-constructed product as participants take resources and share them back to the network. Autonomy also allowed participants the freedom of joining and posting in discussions, building a path of engagement that showed coherence between what they were looking for and the experiences they took part in the MOOC.

Participants’ autonomy also played a key role in the structural elements of effective professional development (type of the activity, duration of the activity, and collective participation). Although this MOOC was aligned with the tenets of reform professional development, participants’ autonomy shaped their experiences in this MOOC as traditional or as reform professional development. Similarly, when analyzing duration of this professional development the decision about the number of contact hours they would allocate to this experience was in participants’ hands. The notion of collective participation was augmented to worldwide participation as this MOOC embraced diversity of participants represented by participants from different geographical locations, with different academic backgrounds, and different professional roles. Autonomy played a role in diverse participation as participants engaged in discussions as assemblages, in which different discussion threads embraced different sets of participants.

In this professional development, participants could exercise autonomy having control over their own professional learning. Participants’ engagement with this MOOC represents their autonomy and their possible commitment to their own learning, their school, and their students. Thus, this study advances the field of teachers’ professional development acknowledging that through this MOOC the locus of control of professional development changes from schools and districts to teachers. This change of control allows teachers ownership in choosing the professional development and its impact on practice, rather than professional development being imposed by their employer organizations. In this sense, teachers’ development happens by their
articulation of their own needs, resources, and interests towards professional development opportunities.

**Discussion of the Relationship Among the Characteristics of Effective Professional Development**

The six characteristics of effective professional development originating in Garet’s paper didn’t occur in this MOOC as isolated matters. Revisiting all characteristics presented in this chapter, similarly to Garet’s study, in this MOOC these characteristics were related to each other. The arrows in Figure 5-15 shows the relationship among the six characteristics presented in this MOOC. The dotted arrow with the ‘G’ indicates that the relationship seen in this MOOC was also pointed out by Garet et al. (2001).

![Figure 5-15](image)

**Figure 5-15. Relationship among the six characteristics of effective professional development presented in this MOOC**

Content seems to have an influence on active learning. Based on what is being offered at first (initial content of this professional development), participants will (or not) register in this MOOC and later engage (or not) with the MOOC platform by aggregating the resources (content) and sharing their experiences and other resources back to the network. Thus, it is possible to
hypothesize that a MOOC may have more or less active learning depending upon the type and variety of content that is being offered (i.e., statistical topic, amount of resources, etc.). For Garet et al. (2001) duration also impacts active learning, since professional development that occurs through sustained periods of time may offer different opportunities for teachers to try new approaches and share them back with the professional development group. In this MOOC, the extension in duration (course availability) presented an increase in participants active learning as shown in Figure 5-11. Likewise, active learning impacted duration when duration is understood as number of contact hours in a professional development. As a participant’s active learning increased it also increased the number of contact hours this participant had with the MOOC. Duration as availability of number of hours impacts the content of this professional development (Garet et al., 2001). In this sense, the depth of content covered in a professional development seems to be a matter of the number of hours the MOOC provider will make available for this initiative. In the case of this MOOC, it is possible to infer that if duration were to be extended, more content could be included or the current content could be presented deeply and with more details.

Garet’s paper informs us that type of activity (traditional or reform) influences the duration of a professional development, in which traditional forms of professional development tend to happen in a ‘one sitting’ meeting while reform types tend to happen for a more extended period of time. The content of this MOOC was aligned with tenets of reform type of professional development and it was defined by the MOOC provider that the content should be delivered to participants in an extended period (Sep 21st to Dec 14th). In this MOOC, type of activity seems to have influenced participants’ active learning. Since the MOOC was focused on teaching statistics investigations with use of data (aligned with reform types of professional development), it attracted engagement of participants interested in the theme (as seen by participant’s goals in this MOOC) and coming from different geographical locations, with different academic
backgrounds, and different professional roles. When considering participants’ points of view, the types of activities embedded in this MOOC (reform or tradition type) and amount of time spent on it (duration) acted as elements of coherence which were aligned with participants’ goals toward this professional development. Active learning transcended collective participation, becoming diverse participation, in which participants engaged with materials and with others to fulfill their intentions to learn and share experiences about how to teach statistics with the use of data investigation. On one hand, coherence in a professional development affected duration, in which duration is represented by the time spent by participants in this professional development. In this MOOC, this happened as participants continued to engage (and re-engage) with course materials and with others after the official MOOC period (Sep 21st to Nov 9th). On the other hand, time span and contact hours (aspects of duration) affected coherence. For Garet et al. (2001), it is expected that longer professional development will include more opportunities for teachers to build connections between what is being learned in the professional development and their practice. In this MOOC, participants could control the number of contact hours spent in this professional development and their engagement was fully based on asynchronous interactions. By making use of asynchronous interactions, this MOOC offered the opportunity for participants to maximize active participation and potential coherence of this professional development with their goals, since they could engage and re-engage with the MOOC’s materials and with its participants.
Discussion of the Structural Features of Effective Professional Development and this MOOC

In this section, I focus on the structural features of effective professional development and argue that this MOOC challenged the common understanding of the structural features presented in the literature.

Duration is defined in the literature as the number of contact hours spent in professional development and its overall span of time (Garet et al., 2001; Birman et al., 2000; Penuel et al., 2007). Regarding the overall span of time, this MOOC challenged the notion that longer duration in professional development is better for teachers’ engagement. The notion of longer duration is represented in the literature by recommendations such as teachers should engage in sustained and intensive periods of professional development (e.g., Desimone, 2011; Darling-Hammond & Richardson, 2009; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). In this MOOC, participants’ engagement wasn’t sustained through its duration. In fact, participants’ engagement decreased as the professional development progressed through time. In terms of intensity, here understood as quantity of posts in forums, this professional development presented intense interactions of participants with others at the beginning of the MOOC and these interactions also decreased as time passed. These facts provide counter evidence to the literature of duration (length of professional development) and raised the need for more investigation regarding to the ideal duration of an online professional development like this one.

For type of activity, this MOOC presented a novelty to the literature of teachers’ professional development, in which two opposite perspectives of professional development (traditional and reform) could harmoniously coexist in the same online professional development initiative as the one studied here. Although this MOOC was aligned with the tenets of reform professional development, participants’ autonomy shaped their experiences in this MOOC as traditional or as reform professional development.
In terms of collective participation, the MOOC allowed worldwide participation by hosting engagement of participants from different locations with different skill levels, showing that novices and experts can act as regular participants in a professional development and share inquiry about the practice of teaching statistics with data. In this sense, this professional development presented the possibility of engaging novices and experts in what is commonly seen in other forms of professional development (e.g., lesson study, coaching and mentoring) and in communities of practice. Opportunities for shared inquiry as presented in this MOOC allowed participants to explore network learning, benefiting from the experiences brought by novices, experienced teachers, teacher educators, and researchers in an environment in which all participants worked towards a common goal of improving their teaching and learning of statistics.

Empirical research such as this dissertation, showed that MOOC as a venue for teachers’ professional development challenges the status quo that longer duration is better, it allows two opposite perspectives of professional development (traditional and reform) to harmoniously coexist in the same environment, and it expands the notion of collective participation (“groups of teachers from the same grade, subject, or school should participate in professional development activities together”, Desimone, 2011, p. 29) proposed in the literature. This indicates that these structural characteristics of professional development need to be revisited and updated.

Discussion of MOOC’s Caveat as Venues for Teachers’ Effective Professional Development

Conceived as it is now, this MOOC presents a caveat to its being a venue for effective professional development of teachers. This is because this MOOC fell short in duration to support teachers during the implementation of changes in their practice. Figure 5-16 presents the cycle of professional development learning implementation created by me and inspired by the work of Darling-Hammond and Richardson (2009). Analyzing the cycle compared to the experiences
provided to participants in this MOOC, it is possible to identify participants getting acquainted with the notion of teaching statistics with data (‘learn about’ in Figure 5-16) and discussing their practice as they share their experiences back to the network (‘share their experiences back to the network’ in Figure 5-16). It is possible to capture their intentions of implementation in practice throughout their posts in forums, but it is not possible to capture their attempt to try out new techniques or methods, their reflections upon a new practice, and their sharing back to the network about this new experience.

Figure 5-16. MOOC experience within the cycle of professional development learning implementation, inspired by Darling-Hammond and Richardson, (2009).

In the next chapter, I heavily rely on participants’ discussion forums to reveal the nature of their interactions with materials and with others in this professional development, answering the second research question of this study.
Chapter 6

Findings

This chapter presents the findings in answer to the second research question of this study: *What is the nature of teachers’ and others’ interactions (with materials and with each other) in a MOOC designed for statistical professional development?* In addressing this research question, I take the position that learning is fundamentally a social experience (Wenger, 1998; 2006), that happens through participation in social practices such as this MOOC. This study makes use of the social theory of learning (Wenger, 1998) to describe participants’ engagement, and connectivism (Siemens, 2005; Siemens & Downes, 2011) to frame teachers’ learning through participation as they establish and experience connections. Since participants’ engagement in this MOOC occurs through their interactions with materials and with other participants, it is important to keep in mind the definition of interaction previously introduced in Chapter 3. Interactions are reciprocal communication between two or more human actors (e.g., participants or instructors) or between human actors and non-human agents (e.g., platforms, materials, and software”) (Wagner, 1994, p. 8).

To study the nature of participants’ interactions with materials and with each other, this chapter makes use of participants’ click data and participants’ posts as its main sources of data. MOOC webpages, an online survey applied to participants, and interviews with the instruction team are also auxiliary sources of data when characterizing the nature of participants’ interactions in this professional development. The data sources used in this chapter are both quantitative and qualitative in nature. On the quantitative side, I present numbers (quantities) extracted from participants’ click data (the recording of participants clicks while interacting with the MOOC),
such as the number of posts about a certain topic or theme. On the qualitative side, I present
participants’ posts to provide evidence of the content of their interactions that are relevant to the
point being made.

In a macro view, when presenting results about a theme or topic, participants’ posts were
chosen using the criteria of selecting posts from various discussion threads and MOOC units. In a
micro view, when presenting results related to their engagement within a theme or topic,
participants’ posts were chosen using the criteria of selecting evidence coming from participants
with different professional roles (e.g., pre-service teachers, high school teachers, and college
teachers) and different levels of experience (e.g., novices and experienced teachers). Use of this
approach illustrates the diversity of participants in this MOOC (as presented in the previous
chapter) and demonstrates to the reader the variety of perspectives that in combination make the
argument described in this chapter representative of the data presented by this MOOC.

In line with the research question, this second results chapter is organized in two main
parts. First, I present results depicting the nature of participants’ interactions in forums (i.e., their
posts) with respect to materials. Second, I present results depicting the nature of participants’
interactions in forums (i.e., their posts) with respect to themselves, other participants, and their
students. This structure is also aligned with the starting point in connectivism that is the
individual seeking learning. As participants are seeking learning in terms of professional
development, learning through participation is depicted by participants establishing and nurturing
a diversity of connections with materials and with others. Moreover, participants’ engagement
with resources and other participants is also the heart of any professional development initiative.
The Nature of Participants’ Interactions in Forums with Respect to Materials

To understand the nature of participants’ interactions in forums with materials, I start this section by describing the broad set of materials that were vehicles for participants to learn about teaching statistics through data investigation. Then, I focus on understanding the nature of the content of participants’ posts with respect to three resources that generated a high number of participants’ interactions in forums. Next, I make use of Social Network Analysis (SNA) to present the structure of the network of participants’ interactions in forums with respect to these three resources. I also explore how the discussions of provided materials were initiated in forums and discuss the role of discussion prompts and discussion starters (participants who opened new discussion threads).

Which Materials were Vehicles for Participants to Interact with Others in this MOOC?

Participants’ interactions with others in forums stem from their previous interactions with the MOOC’s webpages and its aggregate resources (i.e., pdf files, videos, links, apps). In the content section of the previous results chapter, I briefly described the types of resources that were available for participants to learn about teaching statistics as a process in this professional development. In this section, I categorized the diverse set of materials available in this MOOC according to their similarities in purpose and type of media as criteria to better understand the nature of participants’ interactions in forums with these materials. Eleven types of materials emerged from this categorization as available materials for participants to engage with in this MOOC:

- Webpages with course content and course instructions for participants,
- Unit introductory videos with the main instructor,
• Videos of experts in statistics education discussing the experience of teaching statistics to students,
• Videos of students (or cartoon representations of students) doing statistics investigations,
• PDF documents containing articles, Statistical Tasks, and lesson plans,
• Assessment items (e.g., Locus test),
• Datasets,
• Links to free statistics tools (e.g., Gapminder, Census at School, TuvaLabs, Tableau Public, and Plotly),
• Links to free statistical software (e.g., Codap and NZ Grapher) and commercial statistical software (e.g., StatCrunch and JMP),
• Links to free applet simulations (e.g., GeoGebra simulation),
• Links to blogs (e.g., The Statistics Learning Centre),
• Links to YouTube videos about statistics content and statistics teaching.

Participants’ click data showed that to some degree, participants accessed most of the available materials. Curiously, some materials accessed by them generated a high number of participants’ posts in forums, while others not as much. Materials that generated a high number of participants’ posts in forums were: (a) the LOCUS test (a statistical content knowledge assessment applied to MOOC participants), (b) the Gapminder (free data visualization software), and (c) the Statistical Tasks (a set of statistical middle school and high school tasks).

Some materials available in this MOOC did not generate any participant engagement in forums, as in the case of a paper from Whitaker and Jacobbe (2014) that compares the experience of two groups of students responding to an open assessment item from the LOCUS test. Although this resource didn’t emerge in participants’ interactions in forums, nor was fostered by the
MOOC’s discussion prompts, using click data it can be seen that participants accessed this resource 131 times, which may indicate some form of interest by participants in this resource but the click data doesn’t inform us much about what they did with this resource. This example illustrates the fact that some resources were privileged over others in participants’ interactions, a phenomenon that can be understood by the MOOC design and by studying participants’ engagement in forums.

By design, one of the two forums available in each unit contained prompts or questions related to some resources from that unit. Thus, it is natural to expect that participants’ engagement in forums will be related to materials embedded in those prompts. Further in this chapter, I focus on how the discussions were initiated in this MOOC and I elaborate on the role of these prompts in shaping the topic of participants’ interactions. In the next section, I concentrate on the nature of participants’ interactions related to three different types of resources that were vehicles for a high amount of participants’ interactions in forums.

**Nature of the Content of Participants’ Posts with Respect to the LOCUS Test, Gapminder, and Statistical Tasks**

Some materials available to participants generated a high number of participants’ posts in forums. These materials were: (a) the LOCUS test, a statistical content knowledge assessment applied to MOOC participants, (b) the Gapminder, a free data visualization software, and (c) the Statistical Tasks, a set of middle school and high school statistical tasks. The quantity of discussions created, posts, and discussion views related to each of these three materials appears in Table 6-1.
Table 6-1. Participants’ forums interactions related to Locus test, Gapminder, and Statistical Tasks.

<table>
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<tr>
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<th>Number of Discussions Created</th>
<th>Number of Discussion Posts</th>
<th>Number of Discussion Views</th>
<th>Total</th>
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<td>4900</td>
<td>5323</td>
</tr>
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<td>Gapminder</td>
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<td>1482</td>
<td>1643</td>
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<td>300</td>
<td>3119</td>
<td>3489</td>
</tr>
<tr>
<td>Total</td>
<td>190</td>
<td>764</td>
<td>9501</td>
<td>10455</td>
</tr>
</tbody>
</table>

To understand the nature of participants’ interactions in forums with respect to these three resources, in this section I present the content of their posts with respect to these three resources. In the next section, I present the structure of the network created by participants’ interactions in forums in regard to these three resources. The rationale for choosing participants’ posts about these three resources has to do with the fact that the combined quantity of participants’ posts related to these three resources comprised one third of the total engagement in forums.

These three resources represent examples of materials that are used by teachers in their profession: assessment, technology, and tasks. Teachers’ use of assessments, technology and tasks are supported by the literature of teacher education (e.g., Datnow, & Hubbard, 2015; Ertmer, 2005, and Collins, Brown, & Newman, 1989 respectively) as well in curriculum policies such as Common Core (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Thus, exploring participants’ interactions in forums with respect to these three types of materials will shed light on the nature of their interactions with others, which will help me in answering the research question that guides this chapter. The results presented in this section contribute to the literature of teachers’ professional development by building understanding about the nature of participants’ interactions in forums, and its
relationship with materials with which participants have engaged throughout this professional development.

The amount of participants’ interactions with these materials could be measured by the quantity of accesses to these resources as in the case of the Gapminder and the Statistical Tasks. Since the LOCUS test is a resource that resides outside the MOOC platform (https://locus.statisticseducation.org/take), I was not be able to precisely quantify the number of accesses and attempts in taking the assessment. Although the quantity of accesses retrieved from click data would give us a sense about the number of times one accessed certain material through this MOOC, it would fall short in helping this study to depict the nature of participants’ interactions with materials and with others in this professional development. To understand the nature of participants’ interactions with materials and with others in this MOOC, instead of relying only on the quantity of times participants accessed a resource, I chose to focus on the content of participants’ forum posts that were ignited by their previous interactions with these three specific materials (LOCUS test, Gapminder, and the Statistical Tasks) as well on the structure of the network created by participants’ interactions in forums in regard to these three resources. In the next three subsections, I present: the resources, what was given and asked to participants by the MOOC provider, and an analysis of what participants gave back to the network with regard to these resources (i.e., analysis of the content of their posts). Later in this chapter I will present the structure of their interactions about these resources.

### Nature of Participants’ Posts with Respect to the LOCUS Test

The Levels of Conceptual Understanding in Statistics (LOCUS) is an assessment that measures conceptual understanding of statistics (Whitaker, Foti, & Jacobbe, 2015). The assessment was created in line with the Guidelines for Assessment and Instruction in Statistics
Education (GAISE) Pre-K-12 framework (Franklin et al. 2007) and the Common Core State Standards for Mathematics. The LOCUS test was positioned in the first unit of the MOOC and was intended to provide an opportunity for participants to assess their own knowledge of statistics content. By using the LOCUS test participants could individually measure their own statistical understanding at two levels: beginner/intermediate and intermediate/advanced. Participants were instructed that the former was suited to elementary statistics teachers and students (A/B level targeted at grades 6-9), and the latter was suited to high school and Advanced Placement Statistics (AP Statistics) teachers and students (B/C level targeted at grades 10-12).

To complete this activity, participants were instructed to perform a three-part task. In the first part, the MOOC explained that the assessment contained 30 questions and it could be focused on middle school or high school content. It also informed participants that the assessment would take about 25-35 minutes in duration and participants would need to complete it in one sitting. Although not explicit in the instructions provided by the MOOC, any person could use the public link of the LOCUS test to re-take the test if he or she desired to. Since the LOCUS test is hosted outside of the MOOC platform and is provided by a third party, the MOOC also informed participants that they would receive their scores by email.

In the second part of the activity, participants had to point out their perceptions of their performance in the LOCUS test by choosing one of the four options:

(a) I scored pretty well on these items, but I only feel somewhat prepared to teach students in a way that would ensure their success on these items.
(b) I scored pretty well on these items, and I feel well prepared to teach students in a way that would ensure their success on these items.
(c) I missed more items than I had hoped, but I feel well prepared to teach students in a way that would ensure their success on these items.
(d) I missed more items than I had hoped, and I feel only somewhat prepared to teach students in a way that would ensure their success on these items.

For the third part of this task, participants were expected to engage in a specific forum that had the prompt: “Consider the students that you work with. How well prepared are they to
answer the items in this investigation? What would be needed to assist students in preparing to answer these types of questions?” Following the prompt for this discussion forum, participants shared their views about their performance in the LOCUS test. Participants’ engagement in forums regarding their performance in the LOCUS test resulted in the creation of 103 discussion threads, 320 posts, and 4900 discussion views as shown in Table 6-1, with an average of three posts per discussion thread. Results of qualitative analysis of these posts revealed two opposite perceptions regarding participants’ engagement with the LOCUS test.

The diagram in Figure 6-1 illustrates participants’ posts grouped together in two big themes: participants who perceived they did well on the LOCUS test (left side), and participants who did not perceive they did well on the LOCUS test (right side). I first present the content of posts in forums of participants who perceived they did well on the LOCUS test. Their forum posts were centered on confirmations of their perceptions of their own knowledge about statistics content (Figure 6-1, (a)). Then, I present the content of posts in forums generated by participants who did not perceive they did well on the LOCUS test. Their posts were centered on their perceptions of lack of preparation regarding statistics content, shown as (b) in Figure 6-1.

Both groups of participants stated their need to improve their preparation in statistics (Figure 6-1, (c)), which is presented next. The analysis will also show that some participants from both groups used forums to expose their frustration and insecurities regarding the gap between their perceptions of their current knowledge and their perceptions of the knowledge that is required to teach statistics well (Figure 6-1, (d)). An outcome of these frustrations was participants requesting extra resources regarding the assessment such as detailed solutions to the questions presented in their LOCUS test. Both groups of participants also used forums to talk about how students would perform if taking the same assessment (Figure 6-1, (e)). In the next subsections, I present evidence on each piece of the nature of the content of participants’ posts with respect to the Locus test represented in Figure 6-1.
Figure 6-1. Nature of the content of participants’ posts with respect to the Locus test.

(a) Confirmation of their perceptions of their own knowledge. In forums, participants shared their perceptions about their performance on the LOCUS test. In general, for these participants, their posts in forums seemed to indicate that their high score on the LOCUS test matched their perception of their own knowledge of statistical concepts. In their posts, participants tended to share elements that could justify their satisfactory performance, as in the case of participant 3859, a preservice teacher who seems to attribute her success in the LOCUS to the statistical content she was learning at the moment at college; as she said “I also scored high on the LOCUS test. I enjoyed the unique way of asking questions, and thought it was very
interesting how these questions were focused at a middle school level, yet they are similar to questions we are doing at a university”.

In a different discussion, participant 3128, an instructional technologist with 35 years of experience, shared that although she had scored high on the LOCUS test, she still saw a need to further improve her understanding of statistical concepts, “I probably understand the basics of statistics pretty well, though there are always gaps. I did get a high mark in the LOCUS test”. Participants 3128’s and 3859’s posts can be understood by the nature of LOCUS assessment, which is known to provide questions that require statistical conceptual understanding from its test takers (Whitaker, Foti, & Jacobbe, 2015). Thus, it is possible that the assessment presents questions that resembles topics being covered in introductory statistics at the college level, for example a question at level C of the assessment presented in Whitaker, Foti, and Jacobbe (2015, p. 7):

Lee wants to answer the question, “What proportion of sophomores at my high school plan to take a foreign language class during the next school year?” Which of the following methods would best allow Lee to answer his question?
(A) Randomly select 50 students from the high school and ask them if they intend to take a foreign language class next year. (20%) 
(B) Randomly select half of the foreign language teachers in the high school and ask them how many students are taking their classes this year. (8%) 
(C) Randomly select half of the sophomores taking Spanish this year and ask them if they intend to take Spanish next year. (10%) 
(D) Randomly select 40 sophomores from the high school and ask them if they intend to take a foreign language course next year. (62%)

According to Whitaker, Foti, and Jacobbe (2015), this item “addresses the use of random sampling in a survey design to help answer a question about a population of interest” (p. 7).

Random sampling is aligned with CCSSM (S-IC.1), in which students are required to understand when random sampling is needed. Random sampling is also common content in college introductory statistics courses.
Since the assessment exposes a continuum “maturation in understanding across the levels” of statistical understanding (Whitaker, Foti, & Jacobbe, 2015, p. 2), it is possible that the assessment taken by preservice teacher 3859 presented statistical content that she is seeing at a college level (as for instance, the notion of sampling). Participant 3128’s post illustrates this “maturation in understanding across the levels” (Whitaker, Foti, & Jacobbe, 2015, p. 2) as she states that she still has some gaps in her own knowledge. The importance of understanding statistical concepts gets more evident on the rest of participant 3128’s post, as she used forums as a space to state a question about what means to understand statistical concepts such as confidence intervals.

I still find myself gaining understanding and insights as I go. Because statistics is contextual, so much depends on the area in which it is being applied. […] But what does it mean to "understand confidence intervals", for example. To me it is mostly about knowing why they are needed and what they mean.

Participant 3128’s post is aligned with others posts in which other participants report the importance of understanding statistical concepts to be able to teach students as illustrated by participant 4537 (a college professor with 7 years of experience) who posted “I did the middle school assessment […]. The questions definitely addressed conceptual understanding over being able to do calculations. […] This assessment has made me think that I should include more of these conceptual questions on my students' tests, and what they might look like”. The concern about development of statistics conceptual understanding was also presented in posts of other participants who scored high on the LOCUS, as participant 3706 who stated:

What I took from completing the LOCUS test is that it is helpful to try and explain concepts in several different ways and that we need to check the students' understanding at several points as we go along to tackle misconceptions (possibly our own as well as the students') at an early stage.

Participants (experienced and novice teachers) who scored high on the LOCUS test seemed to point out in their forum posts the importance of conceptual statistical knowledge. Posts like that of participant 3128 may suggest that the development of robust statistical knowledge
may take time, since even experienced teachers such as participant 3128 might still find gaps in their own statistical knowledge. Posts like that of participant 3859 may indicate that to be in touch with statistical content similar to the content covered in the LOCUS test may have helped this novice teacher to get a good test score as well as gain confidence in their own ability to deal with statistics, as participant 3859 stated, “unique forms of questioning, assessing, and teaching statistics is crucial to gain confidence in this subject”. In synthesis, even for participants who scored well in the LOCUS test, there is still a feeling that they need to master some statistical concepts indicating a potential sense of incompleteness regarding to their own knowledge. A quote from participant 4093, a classroom teacher with 20 years of experience exemplifies this feeling.

I personally believe that it does not matter how much statistics we know. There is the fact that we do not know it all. Some of us may be great statistics teachers, however, it is important that we continuously learn about all the resources, websites, technology, etc. that are out there for us to incorporate in our classrooms.

The use of resources as sources of learning is clear from the post of participant 4093 and it will become more evident through this section as participants who perceived their performance on LOCUS test as satisfactory and as not satisfactory will ask for extra resources about the test as a way to address their need to improve their statistical knowledge. In the next section, I focus on participants’ perceptions of their lack of preparation regarding to statistics content.

(b) Perceptions of lack of preparation regarding statistics content. Participants (e.g., 5166, 3915, 5048) who did not perform according to their expectations in the LOCUS test, used forums to express their perceptions of their lack of preparation regarding statistics and its teaching (Table 6-1). For example, participant 5166, a high school mathematics teacher with 14 years of experience, said “As a first-year high school statistics teacher, the assessment further
showed me how much I will need to prepare and review well ahead of when I present it to my students”. For some participants, their interactions with the LOCUS test helped them to reflect with others in forums about the gap of statistics content knowledge they felt to have after completing the test. As stated by participant 3915, a high school teacher with 18 years of experience, “It [the LOCUS test] showed me how much I have to learn”. Similarly, in a different discussion, participant 5048, an elementary teacher with 4 years of experience stated, “I could answer the questions from the assessment that we have covered in class but struggle with the ones that we haven't touched upon yet”. For participant 4044, a high school teacher with 12 years of experience, her experience with the test seems to have revealed expression of some statistical content that was not provided to her during her preparation as she stated

> I also got 67% and I'm wondering which are the areas I have to improve. Most of the topics that I have taught in school are related to finding the mean, median, mode, range and standard deviation. We also discuss Gauss function and the Normal Curve, but some of the topics evaluated in the test were new for me. I would like to know at least the number of the question and the topic to look for you tube presentations that might help me improve or a review provided by the MOOCs-Ed team.

Participants’ intention to improve their own knowledge about statistics content as well their intention to better understand the questions and topics presented in the LOCUS test seems to have made them ask for more resources where they could further access in order to fulfill a potential gap (e.g., participants 4404, 4256). Post of participant 4044 shown previously is an example of it. Participants asking for more resources will show up in the next section.

Similar to high school teachers (e.g., participants 5166, 3195, 4044), some pre-service teachers (e.g., participants 3823, 3794, 3161, 4593, 4116) also shared their perceptions that they might not be well prepared to teach statistics. As participant 3823, a pre-service teacher stated, “I have never taken a statistics class, so it was interesting to see how much I need to learn in statistics especially if I want to teach it one day”. Most of these pre-service teachers restated the
need to be competent with statistical concepts in order to be able to teach. Some of them declare that they may still have some misconceptions that in some cases weren’t perceived by them before taking the LOCUS test, as participant 3794 stated:

> I feel the same way. I thought I had done much better on the exam than I actually did, which means that I have some misconceptions about statistics that I am not even aware of! I need to become much more versed in statistics so I don't inadvertently pass those misconceptions on to my future students.

Participants 4664’s (college teacher), 3915’s (high school teacher), and 3808’s (pre-service teacher) reflections in forums exposed the importance of undergraduate students having good statistical preparation in college that embraces not only mathematics but also statistical content, which is exemplified by participant 4664’s post:

> It seems that people have even less experience with statistics than with math. Our undergraduate math teaching degrees require much calculus but so little statistics. We must begin preparing teachers of all grade levels to teach the concepts of statistics, not just the procedures.

**c) Reinforcing the need of preparation in statistics.** When still discussing their experience with the LOCUS test, participants’ posts expressed a pressing need to be prepared to teach statistics successfully to their students. Statements from expert high school teachers (participants 4409, 4700, and 3915, all with more than 15 years of experience), below exemplify their need to acquire statistics knowledge to be able to teach their students. As participant 4409 stated “I myself feel that I need to have, and learn the very basic of Statistics concepts”, participant 4700 said “I also have a great deal of preparation and study ahead of me before I teach statistics next semester”, and participant 3915 said “It [the LOCUS test] showed me how much I have to learn”. For participant 4327 (a high school teacher with 2 years of experience), the assessment exposed her need to be statistically well equipped in order to teach statistics concepts.
to their students, as she stated “[…] [the LOCUS test] made me realize how much more I still have to learn before I can confidently teach higher level statistics”.

Similar perception of lack of solid statistical background and urgency of learning more statistics to be able to teach future students was noticed in posts of pre-service teachers. As participant 3823 stated, “The test was challenging for me and I know if I ever want to teach statistics in the future I have a lot more learning to do in order for my future students to comprehend the math”. For participant 3766 (a pre-service teacher) her apparent non-success on the LOCUS test may be product of some misconceptions that she might have, as she stated

Seeing as how I didn't get 100% on the Middle School assessment, I think it's safe to assume that my students would probably also not score 100%. This is most likely due to some misconceptions that I have, and which I would then pass on to my own students. Something I learned from this was that if I don't have a strong understanding of the mathematics, I won't be able to help my students develop their own strong understanding.

In a different discussion, participant 3838 (a pre-service teacher) stated that pre-service teachers should have more contact with high school statistics during their preparation, so that they would feel more comfortable in facing an assessment such as LOCUS; as she stated, “[…] the things that we do in class, and the assessment we just took I would say that having more high school exposure to stats would better prepare us for these questions”. In other posts, participants’ urgency of learning statistical content is related to their need of teaching statistics to their future students, a post from participant 4409, a high school teacher with 18 years of experience, who shared his feeling in forums

That confirmed how low my statistics knowledge and competence is. There were several questions that have answers that were almost similar and were very tricky. I felt not wanting to answer either any of those because I was not really sure which one would be the best answer. I am then very much concerned about my competence and readiness to prepare a statistics curriculum. My main concern is, if I don't understand it that much, how would I be able to teach it and explain it to my students? I do not want to pretend in front of them. This is either I get this or I'll tell my immediate supervisor that I am not the man to prepare the statistics curriculum, nor the man to teach it. I'd be honest, and not fool myself and my students.
In summary, qualitative analysis on posts of this section seems to indicate that participants’ interactions with the LOCUS test may have challenged their perceptions of their understanding of statistics content as well as what content they were supposed to know in order to teach statistics. Their interactions in forums were also a space to vent their frustrations related to their lack of preparation regarding to statistics content in order to teach statistics, which is presented in the next section.

(d) Exposing their frustration and insecurities after taking the assessment. Some participants who perceived their performance in LOCUS test as poor, exposed their frustration regarding the test in the forums. As seen in the previous section, after taking the test, participant 4409 started a discussion thread by posting his frustrations about his own statistical knowledge. Participant 4753, a college professor with 10 years of experience replied to him giving solace by expressing his support to participant 4409. Participant 4753’s post suggested to participant 4409 to see his experience through a positive lens in which the result of LOCUS test could motivate him to develop himself as a statistical teacher,

Hi 4409, […] I believe several of my students would struggle with the questions from this quiz because the focus is on a conceptual understanding of the fundamentals of research design and statistics. I believe good teachers regularly have doubts about their understanding and ability to effectively teach their students. Often this motivates them to learn more and become better teachers. It also helps us to remember the perspective of our students. (Participant 4753 post in the discussion 5586).

As the discussion thread evolved, it became a space in which participants manifested their affective expressions of sensitivity toward the owner of the initial post (participant 4409), as seen in the piece of discussion thread 5586 below,

4409, I agree with 4753, your struggles with the content now will make you a much better teacher for the typical student (Participant 3353 post in the discussion 5586).
I think that's the goal of this course. We come to learn together and better ourselves to teaching statistics meaningfully (both conceptual understanding and procedural fluency). Hope you find this course helpful in both building your knowledge and a community of educators to learn together (Instructor F post in the discussion 5586).

Thanks, Instructor F. I definitely look forward to learning from this course, especially from our colleague's shared discussions (Participant 4409 post in the discussion 5586).

Thanks 3533 for the very positive support. I do intend to put a positive spin on my current struggles. Hopefully, I'd be able to break down the concepts of Statistics while teaching to my students, keeping in my mind how and what means I did to try to understand the concepts myself (Participant 4409 post in the discussion 5586).

This piece of discussion thread shows that after their interaction with materials, their further engagement in forums displayed the above participants engaging in affective flows. It seems that their interaction with the LOCUS test aligned with the prompt offered by the MOOC provider for this discussion forum had stirred their feelings up and those feelings were manifested in the discussion forums as presented above. In this sense, these participants also became ‘stirrers’ of each other’s emotions by providing solace or empathy to each other’s situations, such as when participant 3533 wrote a post to participant 4409, and the latter replies by expressing appreciation for participant 3533’s comment and feedback.

After this wave of affective sensitivity toward each other, their interaction with others in forums regarding their performance in the LOCUS test also sparked further interactions asking for the test solutions and requests for detailed explanations about potential questions missed by them. Participant 4189, a mentor teacher with 28 years of experience, posted her disappointment and stated her desired to know the questions she did wrong, “I was disappointed when I saw just my score...I want to know exactly which problems I got wrong. To make sure that I'll be able to teach the concepts correctly to my students”. A similar feeling was shared by participant 3753, a high school teacher with 3 years of experience, “I too would like to see my mistakes. I like to
know what I did well in answering so I can know what I need to work on so I can help my
students. This feeling was also echoed in the comment of a pre-service teacher, participant 3774
who posted, “It's easier to know where to focus and study when I know what it is I need to study
(when we can see more detailed results than a percentage). […] I'm not sure which areas I should
study to adequately answer and teach the concepts”.

In cases in which participants asked for clarification about their performance in the
LOCUS test, they received a forum reply from a member of the instruction team informing that
the MOOC could not provide individual and detailed solutions on the assessment regarding each
participant’s performance. The instruction team informed participants that the LOCUS platform,
by default, provided to participants their score per section of the test and a website for further
consultation about the structure and types of the questions used in the assessment.

Analyzing the posts of participants who asked for more details about their assessments,
they seemed to be frustrated since there was no way to get more details about the test they just
had taken. It seems to be very difficult for them to take action to address their flaws in statistical
understanding that were highlighted by the test without having a detailed solution for the
assessment. In a broad view, the assessment solutions seemed to be a way those participants
could handle the problem of their perception about not knowing enough statistics. Their posts
may also represent a way for these participants to deal with their insecurities and an implicit
intention to review concepts that they did not know well when taking the test.

In synthesis, their performance on the LOCUS test brought to light what was not visible
before, bringing participants’ insecurities regarding statistics and its teaching to the surface of
their interactions with others in forums. As their complaints and frustrations about the test
increased, these complaints and frustrations seemed to act as a bond, making participants closer to
each other. In other words, their interactions with materials and later in forums were a vehicle for
collectiveness and trust that emerged among participants.
(e) *Talking about how students would perform in that test.* Stemming from their interaction with the LOCUS test and reinforced by the forum prompt (i.e., “Consider the students that you work with. How well prepared are they to answer the items in this investigation? What would be needed to assist students in preparing to answer these types of questions?”), participants reflected in forums about how prepared their students would be to perform the same assessment. Results showed complementary perspectives from participants when discussing students’ envisioned performance in the test. For participant 4451 (a high school teacher with 22 years of experience) the questions in the LOCUS test resembled the questions presented in the AP Statistics test. Thus, he believed that students from an AP Statistics course would not have problems with the LOCUS test, as he stated

> I found the questions to be very similar in style to the AP Stats questions, so I feel that the students at the end of the course should be able to answer the questions fairly confidently. However, my students who are not in Stats would not have a clue for most of the questions.

For participants 4256 (a high school teacher with 10 years of experience) and 5916 (a college professor with 4 years of experience), both high school and college students might not be prepared to answer the questions presented in the LOCUS test. As participant 4256 stated “My students are not at all prepared to answer the questions in the investigation. They are all sophomores in high school and haven't had much interaction with statistics”. Likewise, participant 5916 stated, “I think that my students will not be prepared well to answer the questions asked in this investigation. I think lot more engagement in statistical investigations would help them to answer the questions well”.

It seems that in these participants’ point of view, the first barrier for students to achieve a good performance on the LOCUS test was students’ lower level of statistics conceptual understanding. According to their posts, this seems to happen due to students having little access to statistics content while in school. When statistics is accessible to students, these statistical
classes tend to mostly focus on basic statistics concepts such as measures of central tendency as stated by participants 1265 and 3411 in different discussions,

[…] The level of statistical understanding in the Indian education scenario is pretty limited to reading from the textbook and doing the questions at the end. The central tendency questions are easy as long as they are straight forward and direct. Any application-based questions will pose a challenge to a majority. (Participant 1265)

I feel that coming into statistics that my students would not be prepared to answer these questions or be able to reasonably think about answers to some of them. The only statistics that my students seem to have coming into statistics is the basic measures of central tendency. (Participant 3411)

Participant 4854, a high school teacher with 15 years of experience used forums to point out that most of the time students have difficulties in understanding the text of a statistical question as presented by LOCUS as she stated, “I realize that my students will need a lot of practice on these type of questions. Questions regarding designing a study or an experiment are quite challenging for them. One of the things that affect them the most is their reading comprehension abilities”. Access and domain of statistics vocabulary were highlighted by participants 3402 and 3400 as students’ issues in their understanding of statistical concepts. As participant 3402 stated “I don't think students at my school would be prepared to answer all of the questions in the investigation. Vocabulary would be a big barrier”, and participant 3400 replied “I feel the same. The vocabulary is key. Most students don't understand the math language, therefore they don't understand the concepts being taught. I spend a lot of time before a lesson on vocabulary and still get puzzled looks from students when teaching about a topic”.

In a different discussion, participants 5210 and 3827 raise the same idea of students’ vocabulary deficiency informing that as non-native English speakers the process of understanding statistical problems may be a challenge to some students. In their point of view, intimidation and the need for extra time presents constraints when non-native English speakers take a test such as the LOCUS test, as stated by participant 5210’s post and participant 3827’s reply,
As a non-native English speaker I can also say that there is a language barrier. It took me quite some time to read the question in order to understand them correctly. I say this because I think it can be a regular issue for foreign students in any one country” (Participant 5210).

I am a non-native English speaker as well, taking the test was a little intimidating. I hope to gradually gain a better feel of terminology and content. (Participant 3827)

**Summary of the Nature of the Content of Participants’ Posts with Respect to LOCUS Test**

When posting their perceptions of their experiences with the LOCUS test in forums, participants’ posts were split in two main groups: the ones who shared that they had good experience with the assessment, and the ones who shared that they did not have a good experience with it. These different perspectives of their experiences with the LOCUS test may be related to the fact that these participants are coming from different environments and academic backgrounds such as pre-service teachers, high school teachers, teacher educators, and college instructors. When referring to their perceptions of their performance in the assessment, the discussions were broad in scope, providing space for participants to express their worries and frustration about being (or not being) prepared to teach statistics, as well as to reflect about how prepared their students would be to perform well on a test like this one.

Although the LOCUS test may have been perceived as a hard task for some participants, their posts did not highlight interactions related to statistics concepts or statistical reasoning embedded in the assessment. The absence of discussions regarding statistics content embedded in the LOCUS test may have happened for different reasons. One reason for this absence might be related to the fact that participants did not have the assessment questions to review once they finished the test. It is possible that the discussions could have developed differently if participants
had a chance to review the questions and/or the solutions of the test before or during their interactions in forums.

The fluidity of MOOCs allowed these different participants to open themselves to strangers. It allowed them to bond with others in this MOOC in the name of a cause that was to be better prepared to teach statistics. In their posts, participants did not mention sharing the link of this assessment with other teachers, despite the fact that the LOCUS test is a free assessment tool of statistical conceptual knowledge that could be further used with their students. Next, I present the nature of the content of participants’ posts with respect to Gapminder.

**Nature of the Content of Participants’ Posts with Respect to Gapminder**

Gapminder is an independent Swedish foundation that has created webtools “to make the time series statistics of global development in economics, health, environment, education, demography and energy easily understood and freely accessible to users” (Rosling & Zhang, 2011, p. 11). One of their most popular tools is called *Gapminder World*, which “enables interactive animations of more than 400 socio-economic indicators” (Rosling & Zhang, 2011, p. 11). Unit 1 of this professional development introduced to its participants a video of K-8 students interacting with Gapminder World. This video was one of the resources comprising the essential materials of the unit.

According to the MOOC page, the selected Essentials for Unit 1 were “designed to help [participants to] think about the discipline of statistics and how students may engage with data in a classroom”. The video with length of 3.5 minutes presents 13-14-year-old students in a computer laboratory classroom interacting with Gapminder World. In the video, students make use of multiple variables from a real-world data set in a dynamic way. On the MOOC page, along with the link for the video, participants were asked as they watch the video to “think about how
the context of the data and the multivariate dynamic display allows students to think deeply about world issues”.

Different from the LOCUS test in which the MOOC provider dedicated one forum from Unit 1 for participants to discuss their experience with the assessment, when interacting with the Gapminder video, participants were not specifically prompted to discuss their experiences with this resource in forums. Although not prompted, participants’ engagement with Gapminder video generated the creation of 17 new discussions, 144 posts, and 1482 discussion views as presented in Table 6-1. Although these numbers are relatively less when compared to the interactions about the LOCUS test, they are evidence that participants were somehow interested in this resource.

The nature of the content of participants’ posts in forums with respect to Gapminder can be found in Figure 6-2. Participants were very enthusiastic about the potential of Gapminder World, a tool that students were using in the video. As shown in Figure 6-2, participants stated their reasons why the tool was great. These reasons were grouped by similarity in three themes: it is great because teachers can do things in their classes, it is great because students can do things in class, and it is great because students will enjoy it. Represented respectively as (a), (b) and (c) in Figure 6-2. The majority of participants involved in these discussions about Gapminder stated their desire to use the tool in their class. Some participants used discussions forums to share their worries about using Gapminder tool, while others stated that they were going to share this resource with other teachers (Figure 6-2, (d) and (e)). Some participants stated that they would like to use Gapminder in their classroom (Figure 6-2, (f)). Below, I examine the nature of the content of participants’ posts with respect to Gapminder as synthesized in Figure 6-2.
(a) It is great because… Participants interacted with the MOOC resource (i.e., Gapminder video) and later voluntarily shared in forums their views about the video and their experiences with the Gapminder tool. When talking about the video, participants demonstrated enthusiasm regarding Gapminder. This enthusiasm can be evidenced by the language used by participants as they talked about this resource. In their posts, participants made use of words such as ‘love’, ‘amazing’, ‘fascinate’, ‘awesome’, ‘eye-opening’, etc., which express enthusiasm about the tool being used by students in the video. I underscored these words on participants’ posts so that the reader can easily identify them.
After watching the video provided by this MOOC, participant 2755, a middle school teacher with 16 years of experience, posted that she loved seeing the video in which students were discussing and dealing with data using Gapminder in class. She stated, 

I absolutely loved the rich discussion the students were having towards the end of the video. I love that the data displayed in Gapminder is at the touch of the students’ fingertips as well as the incorporation of technology within the lesson.

Participant 1265, a high school teacher with 22 years of experience, also posted that she was fascinated with the potential of Gapminder, “I am fascinated with all that can be done with Gapminder!” In a different discussion, similar feeling was also presented as the comment of participant 3631, a college professor with 15 years of experience, who reported being amazed with the data embedded in Gapminder, as he stated “As I explored the Gapminder videos, I was amazed with the data it contained”. Participant 4621 (a high school teacher with 14 years of experience) and participant 5087 (a pre-service teacher) also highlighted the potential of Gapminder for students to see data in action. As they stated: “The Gapminder video is an amazing way for students to see data in action and to be able to understand how data can be used to explain events or vice versa” (Participant 4621) and “I thought that this Gapminder tool was amazing too!” (Participant 5087).

It seems that participants’ enthusiasm about the potential of Gapminder seen in the video may have prompted them to try the tool. As they shared their perceptions about these experiences with others in forums, it is possible to notice in their comments that they continued praising the Gapminder tool for its envisioned potential inside classroom. However, their posts revealed that the reasons for their enthusiasm about the potential of the tool to be used inside in class varied among participants’ posts. These reasons were grouped in three main themes that emerged from the data when they talked about using Gapminder inside their classrooms. They were: what students can do with Gapminder, what teachers can do with Gapminder in classroom as teachers, and how much students would enjoy working with this tool. Represented respectively as (b), (c),
and (d) in Figure 6-2. In the next paragraphs, I detail each of these reasons and present evidence of participants’ comments.

(b) What students can do with Gapminder. Some participants shared their enthusiasm about Gapminder relating it to what students could do in class. For a college professor with 15 years of experience, participant 3631, “[Gapminder] forces students to think critically and analytically about the data presented in the simulation”. In participant 1265’s point of view, a high school teacher with 22 years of experience, student can gain by dealing with the temporal series presented in Gapminder, as she stated, “The experience the students will gain will be so much more enriching, especially the comparisons [of data between countries] which are possible over time”. Participant 3817, a pre-service teacher, highlights that by using Gapminder students have opportunities to pose questions and to gain knowledge about the data that is displayed in the tool, as she said, “I like Gapminder because students begin to formulate their own questions and become interested in the reasons why there are trends in data”. For two other middle school teachers, participants 4891 and 4318, Gapminder could help students to ask more sophisticated questions when dealing with data: “I also think the students would generate some interesting questions that could be explored with additional research. Love the tool!” (Participant 4891), and “I see how this tool can help the students focus more on the higher level thinking” (Participant 4318).

Other participants, also highlighted the potential of Gapminder for students to work on interdisciplinary projects, as stated pre-service teacher participant 4791, “Gapminder is a great way to connect statistics with other subjects. Students more interested in history can try and pinpoint historical events that would lead to the data changing. Gapminder shows how statistics is applicable to real life”. Likewise, participant 1478 (high school teacher) and participant 4867 (middle school teacher) believed that Gapminder would be a great tool for cross-curricular collaboration, as they stated: “The information on Gapminder could help students use the
statistics to find an area for a project. This would also be a wonderful tool for some cross-curricular collaboration” (Participant 1478) and “I think it is a great way to peak [sic] students’ curiosity about data and have them ask their own questions. […] It would be a great way to link to social studies and current events” (Participant 4867).

(c) As teachers, what they can do with Gapminder in classroom. Still related to interdisciplinary projects, some participants also commented about this possibility but through the point of view of teaching, instead focusing on students. For instance, participant 4838, a high school teacher with 22 years of experience who said, “I thought Gapminder opened the door for a lot of cross-curricular conversation and research and would be a great springboard for a deep dive into cause and effect and historical context as partners for statistical analysis”. Similarly, participant 4318, a middle school teacher with 20 years of experience who stated, “A teacher can also design a project that combines math/stats with history or health or geography using Gapminder”. Instructor B, a graduate student, also shared her experience with Gapminder stating,

In many of the datasets, you can see the effects of historical events (e.g., the effect of AIDS, WWI, WWII), and there is a democracy score showing how to democratic each country is: I think there’s a lot of potential for using Gapminder for interdisciplinary studies

(d) How much students would enjoy working with this tool. Few participants highlighted in their posts that students would be delighted by using Gapminder. For instance, participant 4854, a high school teacher with 15 years of experience who stated, “I found that tool really awesome and I am sure my students will love it too”. In a different discussion, participant 4593, a pre-service teacher stated, “It's so cool where education is going—being able to use resources like this is going to make students excited to learn about statistics and allow them to see the real-world application”. In another discussion, participant 1275, a college student shared to others that a teacher she is working with has used Gapminder in class to raise awareness of politics, as she
posted “I'm currently volunteering with a social studies teacher who used Gapminder this year to get her students excited about politics”.

In general, participants who engaged in discussions about Gapminder seemed to have enjoyed interacting with this new tool and got very excited about the possibilities of using it in their classrooms. Although the main reasons for using Gapminder may vary as presented above, it seems that there is something in Gapminder that grabbed the interest of many participants. On the other hand, other participants used forums to share their concerns about the incorporation of Gapminder in the classroom.

(e) *I worry about it.* Time, availability of computers, and teachers’ preparation were the main concerns of these participants regarding implementing Gapminder tool in their classrooms. For instance, participant 4854, a high school teacher with 15 years of experience said, “I found that tool really awesome and I am sure my students will love it too; however, I am wondering about the time constraint. I have to teach my curriculum, plus the resources available to my students”. The concern about resources to use Gapminder, more specifically availability of computers in the school seems to be a concern not only to participant 4854 but also to participants 5166 (high school teacher) and 5729 (middle school teacher). In distinct discussions, both participants indicated availability of computers in the school as a constraint to the use of Gapminder, as they stated “[…] I spent some time experimenting with the different variables on the x and y axis. My challenge is how to incorporate it in my lessons and lack of availability of computers for the students to use” (Participant 5166) and “I am in the same boat of not having computer access for each student, but I can at least project it on my screen and allow the students to interact with the program that way” (Participant 5729). In both discussions, Instructor B provided three alternatives to overcome the limitation of not having computers for students to use Gapminder, as she stated
One option would be to take screenshots of the videos as you play them using the 'print screen' key. You could collect the screenshots in a document and print that out. Also, if you brought one computer into the classroom and projected the presentation onto a larger screen, then you could tweak the lesson so that the whole class is involved in looking at the data on Gapminder using just one computer. There is an offline version of Gapminder that you can download onto your desktop if internet access is a problem at school.

Besides computer availability, participant 5166 also felt challenged about how to incorporate Gapminder in his lessons. A similar feeling was noticed in other participants’ posts. For instance, participant 3285, a high school teacher with 7 years of experience, stated:

Has anyone shared their actual lesson plan with Gapminder? The idea of using Gapminder is fantastic. I have been playing around with it for over a week. However, to get a concrete lesson, is a bit challenging. The lesson that is provided in Unit 1 provides a start of course, but I would love to see what students actually came up with. For example, if one uses exactly the lesson provided in Unit 1, I have found it easy to come to "dead ends." Have students been successful? If so, can someone share exactly what they used and some student work if that is allowed? […]

Participants 5166 and 3285 seemed to not feel comfortable about incorporating Gapminder tool in their class. This feeling was also shared by participant 3928, a high school teacher with 22 years of experience, who said:

I found Gapminder as intriguing as you all have and I spent a lot of time trying to understand what I was seeing. […] I feel like such a novice. I printed out the activity and I was intimidated. There is so much to look at, that I don't know where to begin or what question to ask

Interestingly, although some participants demonstrated concern about the use of Gapminder, majority of participants who engaged in these discussions about Gapminder tool declared that they would like to use it at their classroom and they would like to share this tool with other teachers from the same school or district.

(f) Participants would like to use Gapminder tool in their classroom. Some participants stated in the forums that they would like to implement Gapminder in their classes, as the case of participant 4854, a high school teacher with 15 years of experience who took some time to
explore Gapminder and shared in forums how she envisioned its implementation as well the connections with statistics topics that she would have to teach, as she stated,

Hello everyone! I was practicing with the Gapminder tool and I will definitely use it with my students. Next week I will start the chapter on bivariate data where the students work with the least squares regression line. I am planning on using this for them to identify the variables as explanatory or response, the strength of the correlation, the association, we can even discuss causation versus association.

Envisioning an implementation of Gapminder in class was also shared by participant 4514, a high school teacher with 25 years of experience, who posted she could use Gapminder in her calculus class by using exponential or polynomial regression of some variables over time, a feature available in Gapminder. She also envisioned her students using it to learn about predictions, by using regression equation and to explain the potential differences between predicted values and real values as she stated,

LOVE the Gapminder site!! […] I could see how Gapminder might even be used in my calculus classes. For example, you could do an exponential or polynomial regression of some variable over time (e.g. CO2 emissions in the US) and make predictions for future years using both the regression equation AND tangent line approximations (if current rates of change remained constant). Students could explain the differences between their predictions and also explore whatever other variables interested them.

The intention of using Gapminder in class was not only a trait of veteran high school teachers as presented above. College instructors and pre-service teachers also shared in forums their intentions of using Gapminder in their classrooms. For instance, participant 4611, a college instructor with 8 years of experience, stated “I also found Gapminder very interesting and I can't wait for an opportunity to try it with my students. I'm sure my computer-savvy students would love to see their own data move and ‘talk’ to them”. Participant 4593, a pre-service teacher also expressed her desire to incorporate Gapminder in her future student teaching, as she posted “I thought that Gapminder was an awesome resource that I plan to use in my student teaching next semester!”.
(g) **Participants would like to share this tool with other teachers from the same school or district.** Collaboration with other teachers seems to be another ignition for potential use of Gapminder tool. For instance, participant 3486, a high school teacher with 12 years of experience who stated “At our school we are looking at doing more collaborative teaching between different subjects. I can see using Gapminder would be ideal for doing a unit of work with collaboration between Maths and Social Studies (or Geography)”. Participant 3495, an instructional coach with 40 years of experience replied to participant 3486 stating “This is great. I shared Gapminder with a Biology teacher. She immediately recognized the value of the data sets that were directly applicable to her course and has begun to discuss its integration”. In a different discussion, participant 4639, a technology integration coach with 25 years of experience stated that she will share the tool with Social Studies teachers as she said, “I was also struck by the cross-curricular nature of Gapminder. I had seen the tool before, but after exploring it a bit more again for this course, I decided to share it right away with the Social Studies folks I support”. She also stated how she envisioned this implementation,

So, my idea was to start a lesson about that time period by showing students this particular data set and allowing them to "discover" that spike on their own and see what questions it might generate. Then give them some time to explore to see if they could find out why it might have been. The following days would be the instruction/reading/lecture etc. about that time period in general. Hopefully that interaction with data analysis would build some interest that might not have otherwise been there.

While some teachers saw value in the use of Gapminder in their classrooms as well in collaborative projects with other disciplines, participants 4973 and 3615 stated that they already used Gapminder in class. Participant 4973, a high school teacher with 6 years of experience said

I love Gapminder! I had my junior students do a project using Gapminder last year. It was so successful that this year I am looking to try and create a cross curricular project with the Social Science department. The students were so passionate about it!
Participant 3615, a college professor with 21 years of experience, shared in forums that she already uses Gapminder and provided some steps for others to introduce Gapminder in their classes too, as she stated:

Dear all, Gapminder is a fantastic tool for all grades especially as I found for my students in the University. First, you have to explain several matters for your students before you start. No1 you have to explain how many dimensions we have (they are 4 dimensions or we can say variables) on the same graph. No2 to explain all contents located on the top right corner, where just stop on any content using the mouse and see the light flash. No3. chose an example and prepare it well for your students and you can save it in above menu bar. No4 reduce the speed before click play so you can explain what is going on while the play is working. I hope these simple, basic and so easy instructions can be useful for some of you.

Others used forums to also share extra resources related to Gapminder tool, as participant 3556 and participant 4854. Participant 3556, a high school teacher with 25 years of experience shared a link for a Ted talk about Gapminder as she stated “There are also some Ted Talk videos related to Gapminder data that I have used in my classes. One of them makes the point that the world is really not like it used to be in terms of infant mortality and income.” In a different discussion, participant 4854, a high school teacher with 15 years of experience shared a link to an activity that uses Gapminder, as she posted:

I wanted to share with you that I have found an activity to introduce students to Gapminder. If you are interested in this, you’ll find it on http://www.teacherspayteachers.com on the search box type Introduction to Gapminder.com. The download is free and it allows you to modify the document if you want.

Summary of the Nature of the Content of Participants’ Posts with Respect to Gapminder

When posting in forums their experiences with Gapminder, participants shared an enthusiasm about this resource. It seems that watching the video of K-12 students dealing with data and making inferences about data may have shown them that it is possible to develop
statistical literacy with their students. I wonder if the complexity of Gapminder tool that synthesizes five variables varying at the same time in a graph, all presented in one screen, may have been a feature of the enthusiasm seen throughout participants’ posts.

Participants used forums to share their personal reasons for potential use of Gapminder in their classrooms. As the section shows, their reasons varied among three themes: what they could do with the tool, what students could do with this tool, and how much students would enjoy dealing with the tool. When talking about what students could do with Gapminder, participants highlighted its potential for students to think critically and analytically about the data they were engaging with. Participants also highlight Gapminder as a vehicle for students to formulate their own questions and understand the reasons for trends in data. When talking about what they as teachers could do with Gapminder, participants highlighted the potential of the tool for cross-curricular collaboration, although they did not elaborate much on how these interdisciplinary projects would happen.

With regard to statistics, participants’ posts did not present thorough discussions about the statistical content they could develop with their students when using Gapminder tool. Only two participants (4854 and 4514) shared their views about the potential of using this tool to teach correlation and regression. On the other hand, participants shared their affectivity towards their students upon potential use of Gapminder. Based on their comments, it seems that Gapminder could act as a motivating tool for students to enjoy their statistics class.

Forums were also spaces for participants to vent their concerns about implementing this new tool in their classroom. Time, availability of computers, and their own preparation were the main concerns of these participants, as previously presented in section (e). When posting in forums their experiences about Gapminder, it was possible to notice their envisioned action about their practice as their foresaw the implementation of the tool. In this sense, forums were spaces
for them to project reflections about how to do this implementation as well their concerns about it.

Participants also stated in forums their intentions of sharing this tool with colleagues since they perceived value in Gapminder for collaborative projects with other disciplines. Participants also shared back to the network (feed-forwarding) extra resources related to the use of Gapminder in classrooms such as Ted Talks and lesson plans. Next, I present the nature of the content of participants’ posts with respect to high school and middle school tasks.

**Nature of the content of participants’ posts with respect to tasks**

In Unit 2, the MOOC made available to participants two sets of Statistical Tasks, one focused on middle school teaching and another one focused on high school teaching. Each set comprised three tasks at different levels of statistical investigation. Participants had to choose a set and analyze the tasks according to a task guide (Tran & Lee, 2015b) as showed in Figure 6-3.
Figure 6-3. Written statistics task guide guidelines for developing, adapting, and analyzing Statistical Tasks (Tran & Lee, 2015b).

To complete this activity, participants were supposed to perform its three parts. In the first part of the activity, the MOOC provided guiding questions to help participants to analyze the tasks and to make connections with the content already presented in Unit 1 (i.e., statistical habits of mind and the SASI framework). The guiding questions were:

1. What learning goal(s) could this task be used for students’ learning? 2. Is this task worthwhile to engage students in statistics through all or parts of an
investigation cycle? 3. Could this task promote productive statistical habits of mind? 4. What would you change about this task to make it more worthwhile? why?” In the second part, participants had to answer question by informing which set of tasks they chose (middle school or high school) or if they chose to work with both sets.

In the second part of the activity, participants had to inform others about the tasks they would be working further (i.e., middle school or high school tasks). The third part of this activity comprised participants engaging in forums. Differently from Gapminder discussion forums, this forum was guided by a prompt as below

**Statistical or Mathematical Tasks:** For the collection of tasks you analyzed, discuss how the tasks could promote statistical habits of mind, and if there is anything you would change about a task to make it more worthwhile. You can also share other tasks you think are worthwhile statistical tasks, or ones that you would like help in adapting to be more worthwhile for engaging students in statistics.

Following the prompt for this discussion forum, participants shared their views about the tasks. Participants’ engagement in forums regarding these tasks (high school and middle school) generated the creation of 70 new discussions, 300 posts, and 3119 discussion views. These numbers are evidence that participants were interested in discussing these resources. Participants’ posts present some form of enthusiasm regarding some tasks from middle school and high school sets. Although participants’ enthusiasm was in a certain sense present in both middle school and high school tasks, the nature of the content of their posts in forums about these tasks were a bit different when they shared their views about high school and about middle school tasks. Below, I first present the nature of the content of participants’ posts who engaged with high school tasks. Next, I present the nature of the content of participants’ posts who engaged with middle school tasks. At the end of this subsection, I compare the nature of the content of participants’ posts from both groups with respect to these two resources.
**A - High school statistical tasks.** Three high school tasks were provided to participants. Although it was possible to find posts about each of these three tasks, the majority of discussions were centered in one of these activities, which is called the “Pepsi and Coke Activity”. Since participants produced a higher quantity of posts related to this task when compared to other high school tasks, I concentrate on the “Pepsi and Coke Activity” to analyze the nature of the content of participants’ posts in forums. I use participants’ posts about this task to present evidence to support the claims regarding the nature of the content of their posts about this material.

The high school task in which participants engaged most in this forum refers to a real blind test done by students with Pepsi and Coke beverages. In this task, students would have to blindly pour both beverages in different cups and figure out the whole class preferred beverage. In terms of statistics, the task relates to confidence interval for proportions and to hypothesis test.

The nature of participants’ interactions in forums regarding their interaction with the Pepsi and Coke task can be found in Figure 6-4. Participants were very enthusiastic about the potential of the task. As shown in Figure 6-4, participants stated their reasons why they thought the task was great. These reasons were grouped by similarity in two themes: this task is great because it will interest my students (a), and this task great because it engages students in the investigation cycle (b). While still talking about the Pepsi and Coke task, participants presented two opposite perspectives as they engaged with others in forums. For a group of participants, the Pepsi and Coke task has statistical potential and can be further modified (c). For another group of participants, the task presents many issues that made these teachers worried about its implementation. They were: students do not pose their own questions (d), the task takes too much time (e), and the task is not healthy (f). Below, I unpack the nature of the content of participants’ posts regarding their interaction with the Pepsi and Coke task as synthetized in Figure 6-4.
Figure 6-4. Nature of the content of participants’ posts with respect to the “Pepsi and Coke” task (high school task).

When posting about this task, participants demonstrated enthusiasm in their posts. This enthusiasm can be evidenced by the language used by participants as they talked about this resource. In their posts, participants made use of words such as ‘excellent activity’, ‘best activity’, ‘actual investigation’, ‘enjoyable’, ‘engaging’, ‘love’, etc., which express enthusiasm about the proposed high school task. I underscored these words on participants’ posts so the reader can easily identify them.

After engaged with the tasks, participant 3231, a high school teacher with 4 years of experience stated, “I loved the Pepsi vs Coke activity”. In the same discussion participant 4513, a college professor with 21 years of experience stated, “The Pepsi v. Coke is an excellent activity, especially by comparison to the other two choices in the high school section”. Complementing
the discussion, participants 5048 and participant 4963 also expressed their enthusiasm for the Pepsi and Coke activity. For participant 5048, a high school teacher with 4 years of experience, the Pepsi v. Coke was the best task from the set, as she said “100% on board with the Pepsi vs. Coke experiment being the best one”. Participant 4963, a pre-service teacher added to forums “I also like the Coke vs. Pepsi problem because it is an actual investigation rather than just a worksheet for them to go through”. In a different discussion, participant 3631, a college professor with 15 years of experience stated “I found task 2: Pepsi vs Coke activity most engaging as classroom activity. it involves all the members of the class”.

As participants shared their perceptions about this task, their posts also revealed the reasons for their enthusiasm about the potential of this task to be used in their classrooms. These reasons varied among participants’ posts and were grouped in two main themes that emerged from the data when they talked about high school tasks. They were: this task is great because it will interest my students (a), and this task great because it engages students in the investigation cycle (b). In the next paragraphs, I detail each of these reasons and present evidence of their comments.

(a) **This task is great because it will interest my students.** Some participants shared their enthusiasm about the Pepsi and Coke task relating it to a potential interest that it would raise among their students. For participant 5776, a high school teacher with 10 years of experience, the task “connects better with their experiences [referring to students] than the car problem does [referring to another high school task provided by this MOOC]”. Likewise, for participant 3706, a statistician with 4 years of experience, the task is something that engage students, as she stated “[…] the Coke vs Pepsi challenge is likely to be the topic that engages students the most”. In a different discussion, participant 4963, a pre-service teacher posted that the Pepsi and Coke task is indeed a statistical investigation, as she said, “I also like the Coke vs. Pepsi problem because it is an actual investigation rather than just a worksheet for them to go through”.

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The text provided is a comprehensive analysis of participant responses to a high school task involving the comparison of Pepsi and Coke. The key themes identified are the potential interest among students (a) and the engagement of students in the investigation cycle (b). The analysis delves into the factors contributing to participants' enthusiasm, highlighting the practical and educational benefits of the task.
(b) This task engages students in the investigation cycle. Some participants got attracted to the Pepsi and Coke task because it was designed for students to collect their own data, as said participant 4044, a high school teacher with 12 years of experience,

[… ] the Pepsi vs Coke [is an] interesting activity to make students think about the importance of the process for collecting the data. Teachers might ask students about the factors that might affect the data collection using the method described by this task.

According to participant 4044, teachers could use the period in which students are collecting data to ask them about factors that could affect the experiment design. In a different discussion, participant 5733, a novice high school teacher also made a similar post stating that the Pepsi and Coke task affords students to own their learning as they perform the experiment, “It allows students to actually gather their data, and then analyze it. In this experiment, they are active participants in their own learning.”

Participants 5733, 5527, 4814, 4426, 4409, and 4814 also emphasized the potential benefits of involving students in data collection, as exemplified by the post of participant 4409, a high school teacher with 18 years of experience who stated

When students are involved in an activity, they make it their own and really would make it worth their while. Hence when they actually made the data happen, being instrumental in not only choosing which brand to anonymously be named and tasted, to collating the results, the students learn how to make data collection impartial, objective and representative. Also, they see the process of good data collection by the randomness it was done, such that whatever result would really represent a preference for a brand without any prior bias.

For these participants, to give their students opportunities to perform data collection as the case of the Coke vs Pepsi task was to give them a chance to have ownership over the activity, allowing them to make decisions and helping them to experience the whole process of investigation. Other participants (e.g., 6064, 4059, 3346, 3631, 4191, and 4514) also highlighted the potential of the task for students to perform the whole investigation process. As participant
3346 a high school teacher with 8 years of experience said, “I like the Coke vs Pepsi as an activity - would definitely engage the students in their learning and they can follow the Statistical enquiry cycle (PPDAC in NZ Problem, Plan, Data, Analysis, Conclusion)”. Similar to participant 3346, participant 4191, a high school teacher with 6 years of experience highlighted that the Coke vs Pepsi task is an activity which supports students in performing all phases of a statistical investigation. According to participant 4191, students are more apt to participate in an activity like the Coke vs Pepsi task since tasting soda beverages seems to be something natural to students, which according to participant 4191 may foster their interest in the task, as he stated:

This was by far the most relevant and interesting topic to the students. I agree with the notion that the students could experience the range of pose, collect, analyze, interpret with this project. […] Here, is where I really feel is the key, the students are more apt to participate, make the learning their own, pair and share with the Pepsi vs Coke challenge. That alone would make it the most meaningful task to engage the students in the subjects, and then everything else is icing on the cake. Pose the question on who can use their data, how these experiments are done in the outside world, who would pay for this data. Let the collection phase be fun, exciting, and a treat for the students. Analyzing and Interpreting the data can allow for as much rigor as is called for, the experiment can be modified for Middle School as well as High School students.

(c) The Pepsi and Coke task has statistical potential and can be further modified. When sharing their views about the Pepsi vs Coke task, some participants highlighted the statistical potential of the task and further modifications they would make on the task. Participant 4963, a pre-service teacher stated, “I think [the Pepsi vs Coke task] it’s something that will interest the students and it can demonstrate nicely how confidence intervals and hypothesis tests can reflect real life data”. Participants’ interest in this task was also noticed on the posts from other discussion threads, for instance participant 3217, a graduate student who stated “[…] students might find it interesting to investigate the preference by gender. Perhaps, looking at a 2X2 table”:
Other participants suggest some modifications in the task, such as participant 5680, a high school teacher with 9 years of experience, for whom the task could be a good start, but it would need some modifications as she stated:

[...] Students could pose a question in their own words using their own understanding. They could come up with the data collection method and have to explain why it the data collected is fair and unbiased, why it takes care of any what if's, etc. Then they could do a lot with the data they collected. They could then come up with a final statement/inference based on their data with description of some of the what if's and uncertainties.

Likewise, participant 4514 noticed that the Pepsi vs Coke task proposes using a small population (i.e., students in a classroom) and did not explore the notion of uncertainty since it focused on the beverage preference of the whole class. According to participant 4514 (a high school teacher with 24 years of experience), students were not using the idea of sampling since they were focusing on results from their own classroom, and thus collecting data only in that classroom. Below, she shared some questions that could extend the Pepsi vs Coke task:

I keep hearing in this MOOC that statistics is all about dealing with uncertainty, and in this activity, you were finding out the preferred soda of every person in the class. So you really aren't using a sample, since you are surveying the entire population of the class. It seems to me there is no uncertainty if "everyone" is part of the data collection. This activity could definitely be extended to address the more challenging question of "What is the preferred cola brand in our school? In our town? In our county?" What different types of data could be collected to answer those questions, other than just doing taste tests? How would the sampling methods be different for each region (school, town, county)? How would you organize the data differently for each scenario? Also, if students are at the beginning phases of designing statistical investigations, it would be a good idea to share some samples of "gold standard" designs and some flawed designs (without telling which is which), so they can discuss the potential merits/flaws of each design.

On the other hand, participant 6064, an instructional coach with 19 years of experience, stated that she would use the Pepsi and Coke task to raise awareness of students about when they should use sampling, “I might also use it as part of a discussion about when sampling is appropriate and when it is not.” Differently from others, participant 3231 (a high school teacher
with 4 years of experience) stated that she has done an activity similar to the Pepsi and Coke task with her students when teaching probability, as she posted “[…] I already do an activity similar to this when in our probability unit. However, I loved adding the confidence interval aspect to it. […] You could add to the activity by letting the students do other drinks as well”.

Although the task was perceived by many participants as a good task that affords students opportunities to perform data collection with potential to perform all phases of a statistical investigation affording room to be modified and expanded as above, some participants also used the forums to discuss their concerns about the task. These concerns were grouped in three main themes: (d) students do not pose their own questions, (e) the task takes too much time, and (f) the task is not “being healthy”.

(d) Students do not pose their own questions. Some participants raised the fact that the Coke and Pepsi task already provided context and a question to start the statistical investigation, which may limit students’ participation regarding the complete cycle of statistical investigation as highlighted in the post of participant 4891, a curriculum specialist with 21 years of experience who bought attention in the discussion to the fact that the task, in fact, was already posing the question. As she said “I also preferred the Coke vs Pepsi task. I do think that it lacked student choice with regards to questioning”. She also shared with others in her post how she would modify the task to allow students to first create a criterion to define the study about whether Coke or Pepsi tastes better, as she stated

Here's how I would modify the task: For example, instead of telling students "Today we are going to test whether Coke or Pepsi tastes better" (a task imposed on the students). Why not introduce with: You may have seen the competition in tv commercials between Coke and Pepsi. Each company claims their product tastes best. What does it mean for a cola product to "taste great" and how can we represent that/quantify that/test that?; i.e. have students first create a criteria. Beginning with this discussion might also bring out some bias. It is important for students to take ownership by establishing what it is that they will collect data on and how it might
be represented and analyzed. This might make the task “messier” but does allow students more freedom and ownership.

According to her post, this task modification would allow students to take ownership of the activity since its beginning in which students would have posed a question that matters to investigate, collect data and later take conclusions based on their experimental decisions. She also contended that modifying the task as she suggested would make the activity less structured, which could make it messier than its original version. In a different discussion talking about the fact that this task already stated an investigation question, participant 3966, a pre-service teacher, said that “[…] It would be interesting and engaging to make a hypothesis before, to see which soda the entire class prefers. The class would be engaged, interested and their focus will be around inquiry”. She also suggested that a teacher could “[…] ask the class if this sample would be a proper representation of the population [of] the school. For her and others (e.g., participants 4963, 3217, 5680, 4726, 5009), the Coke vs Pepsi task could be used to illustrate many important ideas in statistics.

(e) the task takes too much time. Some participants (e.g., participants 5527, 3814, 4409, 3814, 4921, 3709, 4700) highlighted time as caveat of this task. For them, the task takes too much of class time to be performed, like the statement of participant 5527, a high school teacher with 8 years of experience who said

The only issue that I have with these things is the time issue in a class. It can become very easy for a teacher (like myself) to feel the crunch of time, and just throw data at them to do problems because it is so easy. I really want to make sure to use activities like this to really engage my students. It is a simple and easy way to look at a problem. It is something that I am striving to do and get better at.

In replying to participant 5527, participant 3814, a pre-service teacher, shared her concerns that besides time consuming, the soda tasting could overshadow the statistics concepts that students are supposed to build by doing this task, as she said “I agree that the time is an issue
with this particular task. I am also wondering if the actual soda in the investigation could overshadow the statistics and the data analysis in the task”. Time also emerged as a concern for other participants, as participant 3709 a college instructor with 3 years of experience who stated, “Time was my major concern as well, I cannot imagine actually using this task”. Time was also an issue under the point of view of participant 3557, a statistician who stated, “I agree with most--especially with the trouble of how much time is involved [in this task]”.

(f) The task is not healthy. Some participants (e.g., 3709, 3706, 3609, 4513, 3928, 5378) exposed their concerns that the task wasn’t a healthy activity to do with students because they would have to taste sodas. The common reason for this concern was that some teachers work in schools that strive to promote healthy habits in their kids, as represented by the post of participant 3706 who stated, “The Coke vs Pepsi challenge may not go down too well in the UK however, due to schools trying to promote healthy eating among the pupils!” Similar concern was expressed by participant 3709, a college professor with 4 years of experience who said,

I also teach in public health so a soda taste test wouldn't be very popular! I'm sure there is a better way to generate a similar dataset within a class (to solve a genuinely interesting question) that wouldn't be so time consuming or unhealthy.

These participants made alternative suggestions to modify the product used in this task in order to make it healthier. They suggested instead using Coke and Pepsi teachers could use orange juice (participant 4513), different brands of water (participant 3928), vegemite and marmite—New Zealand food products (participant 3609), and different brands of peanut butter (participant 3609).

B - Middle school statistical tasks. Three middle school tasks were provided to participants. Although it is possible to find posts about each of these three tasks, majority of discussions were centered in one of these activities, which is called the “The Old Faithful
Since participants produced a higher quantity of posts related to this task when compared to other middle school tasks, I am going to concentrate on the “The Old Faithful Activity” to analyze the nature of the content of participants’ posts in forums. I am also going to use participants’ interactions about this task to present evidence to support the claims regarding the nature of their interactions with this material.

The middle school task that was the subject of most of posts refers to wait times between successive eruptions (blasts) of geysers that were first collected by the National Park Service and the U.S. Geological Survey in Yellowstone National Park. In this task, students would have data from the Old Faithful geyser, and they had to conjecture about the time that someone might expect to wait for the Old Faithful to erupt, as well some factors that could affect that waiting time. In terms of statistics it relates to students’ use of a variety of graphical displays to discover trends in the data, and to the use those graphs to support predictions of the Old Faithful’s eruptions. According to Groth (2015), the Old Faithful activity was “designed to encourage students to engage in transnumeration-type activities” (p. 9), since its main goal is for students to generate and analyze best graphical representations of data sets showing the numbers of minutes between eruptions of the Old Faithful geyser. Transnumeration is a term a coined by Wild and Pfannkuch (1999) which means "changing representations to engender understanding" (p. 227).

The nature of the content of participants’ posts in forums regarding their interaction with The Old Faithful task can be found in Figure 6-5. Participants were very enthusiastic about the potential of the task. As participants stated their reasons why the task was great, these reasons were grouped by similarity in four themes: this task is great because it will interest my students (a), and this task great because it is interdisciplinary (b), and this task great because it has a lot of potential (c). While still talking about The Old Faithful task, participants presented concerns related to students not posing their own questions and not collecting data (d). In the following
paragraph, I unpack the nature of participants’ interactions in forums regarding their interaction with The Old Faithful task as synthesized in Figure 6-5.

![Diagram of Nature of participants’ interactions with respect to The Old Faithful Task]

Figure 6-5. Nature of the content of participants’ posts with respect to The Old Faithful task (middle school task).

When posting about this task, participants demonstrated enthusiasm in their posts. This enthusiasm was evidenced by the language used by participants as they talked about this resource. In their posts, participants made use of words such as ‘best’, ‘stood-up’, ‘go boom’, ‘good’, ‘interesting’, etc., which express enthusiasm about the proposed middle school task. I underscored these words on participants’ posts so the reader can easily identify them.

For participant 4622, a curriculum specialist with 22 years of experience, “[The] Old Faithful definitely was the best [activity] using the ‘Written Statistics Task Guide’”. For
participant 5260, a middle school teacher with 10 years of experience, when analyzing the three middle school tasks, The Old Faithful was the one that presented more information to students, as she said, “I thought that there was most substance to the Old Faithful task”. Other high school teachers, in different discussions also shared their opinions about The Old Faithful task as participant 4191, a high school teacher with 6 years of experience, who said the task “was by far the most relevant and interesting topic to the students”. For the high school teachers, participant 3348 and participant 4921 (both with more than 5 years of experience), the Old Faithful task stood-up among the other tasks. In their words, “When I read through the three tasks ‘The Old Faithful’ task stood up for me for reflecting some of the important aspect of a good statistical task” (participant 3348), and “Most students in this age group like things that go boom which Old Faithful does. It evokes visual views and auditory effects. This task meets the components of the statistical task. It is nicely designed for work in small groups” (participant 4921).

Similar praise was also noticed in participants with different backgrounds such as participant 3414 (a college student) and participant 5052 (a college professor with 16 years of experience). For participant 3414 “Of the three middle school tasks, 'The Old Faithful' task is the only one which is of any interest”. For participant 5052, the task presents a clear goal and require students’ critical thinking as she stated, “The context and learning goal are clear. This task requires the students to apply mathematical skills to real-world applications. I really like this task because the students have to use critical-thinking skills to complete the assignment”.

As participants shared their perceptions about this task, their posts also revealed the reasons for their enthusiasm about the potential of this task to be used in their classrooms. These reasons varied among participants’ posts and were grouped in three main themes that emerged from the data when they talk about The Old Faithful task. They were: (a) this task is great because it will interest my students, (b) this task great because it is interdisciplinary, and (c) this
task great because it has a lot of potential. In the next paragraphs, I detail each of these reasons and present evidence of their comments.

(a) **This task is great because it will interest my students.** Some participants shared that the task would interest students in the investigation process, as participant 4653, a high school teacher with 17 years of experience, who stated “I think the Old Faithful gave the students more in depth thought processes. For the beginner, figuring out which display to use is fine but then let the students dig deeper”. For participant 3414, a middle school teacher with 16 years of experience, the class activity would allow students to compare results among groups, as she said “During a class discussion comparing students’ results it would be really interesting when they have to tackle the issue of potentially significantly different results that would occur due to variability.”

(b) **This task great because it is interdisciplinary.** Some participants highlighted in their posts the potential of the task for interdisciplinary work related to history, science, and geography. Posts of participants 5052 (a college professor with 16 years of experience), 4537 (a college professor with 7 years of experience), and 2755 (a middle school teacher with 16 years of experience) exemplify these suggested interdisciplinary connections. For participant 5052 the task can be integrated with history and science, although she doesn’t detail in her post how this integration process would be done, as she stated, “I also like this task because it can be integrated with history and science subjects”. Participant 4537 saw connection between this task and geography. She also shared how she would proceed with the activity in her classroom as she stated, “I like the connection to geography with this activity. […] I probably would not give students the paper with all of the rows of data, I would simplify it by just giving each group a different set of two rows”.

Participant 2755 also believed the task could be integrated with sciences and history. Related to sciences she stated that students would need to focus on the wait times between the
eruptions. Related to history, she stated that students could research the history of The Old Faithful geyser which could help them in understanding the data,

I chose to focus on the Old Faithful task because it can also become an interdisciplinary unit involving science. I like how the students need to focus on the wait times between the eruptions. […] Students can also research and incorporate the history of Old Faithful to assist in formulating an interpretation of the data. The learning goals and expectations are clear, thus, because this is real life data, additional activities can be conducted related to the same topic.

(c) This task is great because it has a lot of potential. Some participants (e.g., 4346, 3414, 3348, 6150, 4093, 4537) used forums to highlight the potential of the task for students to:

use real data, perform data checking before starting the activity, analyze different data sets, get introduced to the idea of sampling, and use technology to create graphical representations of the geyser’s eruptions. For participant 4346, a statistician with 16 years of experience, the task allows students to perform a hands-on activity by using real data,

This example provides the students with straight-forward hands-on experience with data analysis […] The geyser example also has real life applications that would seem to be real and not abstract to the students […] The example introduces the concept of performing data checking activities prior to analyzing the data--VERY important. The example also requires discussing the output with others. This introduces the topic of effective communication of data analyses in a manner that is understood by others.

In a different discussion, participant 3414, a college student, posted that by performing The Old Faithful task students would have to analyze different random sets and to interpret the results as a whole classroom, “I too like the way that students will randomly analyze different sets of data for the same task and this will force them to make their own unique interpretation”. For her, students would have a chance to observe and discuss the significance of different results due to variability, as she stated, “During a class discussion comparing students results it would be really interesting when they have to tackle the issue of potentially significantly different results that would occur due to variability”. In other discussion, participant 3609, a high school teacher with 14 years of
experience, posted that the task introduces the idea of sampling, “The Middle School geyser task is quite wordy but still useful as it introduces the idea of sampling. Students will get different answers depending on which row they use but they will tend to have similar magnitude”. For participant 3348, a college student, the task doesn’t focus on answers as do the other two middle school tasks proposed by the MOOC. It focused on developing statistical habits of mind on students, as she stated, “it does ask students to pick right measures/graphical representations, organize and look for patterns and relationships, and interpret the data according to the questions, which are crucial in developing habits of mind”. For participant 6150, a middle school teacher with 15 years of experience, this task has potential for students to use technology to create at least one type of graphical representation to display data from the geyser’s eruptions. In her words,

Regarding Old Faithful, I think this would be a great time to integrate technology. The data set is large. Many questions could be asked/answered if students could easily switch between their data subset and the full set as well as switch easily between different types of displays. […] If students could switch between data displays easily, they may be more willing to make mistakes and learn from them.

(d) Participants presented concerns related to students not posing their own questions and not collecting data. Participants 4346, 3414, 954,4537, and 3348 who engaged in discussions about the middle school tasks and most specifically about 'The Old Faithful' task were concerned the task already presented data, instead of allowing students to collect their own data as suggested in the SASI framework. As participant 3414 (college student) noticed, “None of the three tasks ask for students to collect their own data”. In the point of view of participant 3348 (college student), although students did not collect data in the Old Faithfull task, the task allowed them to make sense of data, as she stated “The Old Faithful task focuses on the investigation and sense making process. Even though the question doesn't fully reflect all the four phases of investigation cycle”. In a different discussion, participant 4346, a statistician with 16 years of experience, stated that the Old Faithfull task provided a ‘template’ for data analysis missing to present
guidance for data collection, as she posted, “I think that these type of ‘data-ready’ examples give the students a template for analyzing the data but that they don't provide guidance for how to gather the data”. For participant 3284, an instructional technology facilitator with 15 years of experience, the task can be boring to middle school students since the topic (i.e., geysers) may not be attractive to them, as he stated, “Where's the personalized data? With middle schoolers, I can see them getting bored quickly. Old Faithful, what is that?” He extended his argument saying that teachers could motivate students in this task and should make use of activities in which data is centered on students, which would be more engaging for students according to him, “Now granted, a teacher could motivate them once the activities started, but if there was some student-centered data, even if it was not their class, I think you could find more engaged students”.

Other participants (e.g., participants 3284, 954, 4537, and 3348) expressed their concern that this activity did not afford students opportunities to pose their own questions as suggested in the SASI framework. Instead, the question was already stated by the task (i.e., “the time that some might expect to wait for Old Faithful to erupt, as well about some factors that could affect that wait time”). Participant 4537, a college professor with 7 years of experience, explicit commented “None of the tasks allowed students to pose their own research questions”. In a different discussion, through the point of view of participant 4622, a curriculum specialist with 22 years of experience, although the task already provided data and a question to be investigated, the task allows students to make decisions when choosing the data set and deciding how to graphically represent it, as she said,

The students make MANY [emphasis given by participant] of the decisions in this task even though the main question already has been posed by the teacher and the data set chosen. I especially like that the students choose the graphical display, but then the displays of all of the groups are interpreted. What if everyone chooses the same?
Summary of the nature of the content of participants’ posts with respect to statistical tasks

When posting their experiences in forums about the Pepsi and Coke high school task and about the Old Faithful middle school task, participants shared enthusiasm about these resources. Their enthusiasm may be related to the fact that both tasks used real data that could be obtained from experimentation (as in the case of the Pepsi and Coke activity), and through observation (as in the case of the Old Faithful activity). Participants who engaged in these forums also stated that these tasks would interest their students.

In discussions about the Pepsi and Coke activity, participants highlighted the potential of this task to be related to students’ daily experiences in drinking soda and choosing a favorite soda. They also emphasized that the Pepsi and Coke activity allowed students to collect their own data and to perform an actual statistical investigation. In terms of statistics, participants saw potential in the Pepsi and Coke task for raising awareness in students about sampling, notion of uncertainty, randomness, and fair and unbiased data collection. They also saw value in the task for teaching confidence interval, hypothesis tests, notions of probability, and inference based on data.

In discussions about the Old Faithful activity, participants highlighted the potential of this task for students to perform a statistical investigation. Similar to Gapminder, participants saw potential in this task for interdisciplinary activities engaging mathematics, history, science, and geography classes. They also emphasized that the Old Faithful activity allowed students to use technology in choosing how to display data. In terms of statistics, participants saw potential in the Old Faithful task for students to deal with variability, sampling, randomness, and to effectively communicate their data analyses to others.

Participants shared in forums that both tasks had the potential to be modified to accommodate goals in their classes. They also used forums to share their concerns about both
tasks. The absence of students posing their own question in these statistical investigations emerged as their main concern about these two tasks. Different from their interactions with Gapminder, participants did not mention sharing this task with other teachers beyond the idea of potential interdisciplinary projects. In the next section, I present a summary about the nature of participants’ interactions with the materials.

Discussion about the Nature of the Content of Participants’ Posts with Respect to the LOCUS Test, Gapminder, and Statistical Tasks

The materials analyzed in this section can be classified into two distinct categories: materials that were fully open and materials that were partially open. To define fully open materials, I used The Hewlett Foundation definition of Open Educational Resources (OER) which states it as “teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use and re-purposing by others” (Bliss & Smith, 2017, p. 12). This MOOC is an example of a fully open resource. Within this MOOC there were many fully open resources such as the Statistical Tasks, videos, Gapminder, and Census at School. In this study, partially open materials were resources that resided in the private domain and provided some barrier to access. Examples of partially open resources are formal education systems and proprietary software. Within this MOOC there were examples of partially open resources such as statistical software StatCrunch and JMP, and the LOCUS test.

Interactivity happened in this MOOC when participants interacted with these resources and with each other in forums about these resources regardless of whether the resource was open or partially open. Interactivity is understood in this study as a process that occurs online and involves person-to-person or person-to-platform interactions. Although interactivity occurred, the
nature of the content of participants’ posts varied in some degree as the resource varied. Next, I contrast the nature of the content of participants’ interactions in forums regarding their interaction with open and partially open materials as shown in Figure 6-6.

![Nature of the content of participants’ posts with respect to materials](image)

Figure 6-6. Nature of the content of participants’ posts with respect to open and partially open resources.

When posting their experiences with open resources in forums, participants presented enthusiasm about the resources. This enthusiasm was perceived by the words they used, by the way they referred to the experience they had, and by the vision of the experience they would have if using or implementing that resource in their lessons. When referring to their experiences with open resources, participants seem to look forward to a further experience with that material. On
the other hand, when posting their experiences with partially open resources in forums, participants did not present enthusiasm in their posts about the resource. Lack of enthusiasm was presented in their posts and instead of referring to the experience they had with the resource, they referred to the perceptions of the experience they had with that resource. When referring to their perceptions of experiences with partially open resources, participants seem to look back to the experience they had with that material.

Based on the data, it is possible to hypothesize that participants did not present enthusiasm regarding one partially open resources because of the nature of the resource, which was an assessment. Moreover, participants referred to perceptions of the experience they had with the resource because they did not have free access to that resource (in this case the LOCUS test) which would allow them to better explore their own knowledge, potentialities and caveats of the resource as they did with open resources that they interacted with.

When posting their experiences with open resources in forums, participants referred to things/activities that they could do as well as their students could do with that resource. On the other hand, they only referred to themselves or what they could do when posting in forums about their perceptions of experiences with partially open resources. This again may be related to the fact that the resource wasn’t fully open, allowing these participants to revisit it, to reflect about it and to envision using it with their students.

Participants used forums to share their worries about their experiences with open and partially open resources. However, the nature of their worries differed. When referring to open resources, participants’ concerns were focused on ‘how I will do that’, in a sense of how they would incorporate that resource in their teaching regarding the constraints of the school environment. When referring to partially open resources, participants’ concerns were focused on things/knowledge that were missing, in a sense of what they don’t have already established yet such as robust statistical knowledge.
Finally, feed-forwarding, here understood as the statement of sharing the resource with others inside or outside of this MOOC, was an element that emerged only when participants posted in forums their experiences with open resources. Although surprisingly, it seemed that as they shared open resources with others, they were also sharing the benefits of these open resources. In this sense, resource sharing could be an element of teachers empowering others, as suggested by Kramer (2015). On the other hand, this fact seems to contrast with the data from The Hewlett Foundation presented by Kramer (2015, p.2) which states that only “ten percent of K-12 educators are using OER”. In the next section I present the forum prompts and an analysis of their embedded requests.

Forum Prompts and their Embedded Requests

To understand how the discussions of provided materials took place in forums it is important to know that each forum was designed by the MOOC’s instructor team containing a guiding question or statement, hereafter called prompt that seemed to have the purpose of making participants reflect upon a theme or topic from that unit and to engage participants with their peers in forums. These forums were designed using two types of prompts. The first type of prompt invited participants to share their experiences as teachers and their knowledge of their students in regarding to the materials previously offered by the MOOC. The second type of prompt contained directions for participants to discuss with others about anything they would like to share related to what they have learned from materials in a respective unit. Table 6-2 presents all forums prompts distributed throughout the five units of this MOOC. The left side of the Table 6-2 shows prompts of the first type (specific prompts) while the right side of the Table 6-2 shows prompts of the second type (generic prompts).
Table 6-2. Two types of discussion prompt used in the MOOC.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Forum with specific prompt (Investigation)</th>
<th>Forum without specific prompt (Discuss with your colleagues)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>Consider the students that you work with. How well prepared are they to answer the items in this investigation? What would be needed to assist students in preparing to answer these types of questions?</td>
<td>You can engage in the discussion by either: Building upon current discussion posts by supporting and extending thinking, introducing new ideas, or asking a thoughtful question. Starting a new discussion if your post differs from existing discussions. Use a descriptive title when making a new discussion post. Both forms of engagement are valuable and help the community to learn and grow. If you are pursuing a certificate of completion, please note that either a reply or a post is considered engaging with a forum for course completion.</td>
</tr>
<tr>
<td>Unit 2</td>
<td>Statistical or Mathematical Tasks: For the collection of tasks you analyzed, discuss how the tasks could promote statistical habits of mind, and if there is anything you would change about a task to make it more worthwhile. You can also share other tasks you think are worthwhile statistical tasks, or ones that you would like help in adapting to be more worthwhile for engaging students in statistics.</td>
<td>You can engage in the discussion by either: Building upon current discussion posts by supporting and extending thinking, introducing new ideas, or asking a thoughtful question. Starting a new discussion if your post differs from existing discussions. Use a descriptive title when making a new discussion post. Both forms of engagement are valuable and help the community to learn and grow. If you are pursuing a certificate of completion, please note that either a reply or a post is considered engaging with a forum for course completion.</td>
</tr>
<tr>
<td>Unit 3</td>
<td>Discuss what you observe about student thinking when they interact with the technology tool, how the tool affords them to develop statistical reasoning and statistical habits of mind in the Working with dynamic tool Tinkerplots video and what level of statistical sophistication of the SASI framework that students are at in the Multiple levels of sophistication video.</td>
<td>You can engage in the discussion by either: Building upon current discussion posts by supporting and extending thinking, introducing new ideas, or asking a thoughtful question. Starting a new discussion if your post differs from existing discussions. Use a descriptive title when making a new discussion post. Both forms of engagement are valuable and help the community to learn and grow. If you are pursuing a certificate of completion, please note that either a reply or a post is considered engaging with a forum for course completion.</td>
</tr>
<tr>
<td>Unit 4</td>
<td>What were your “aha” moments about students’ work in these videos that might impact your teaching with the investigative cycle? If your students were exploring the Census at School</td>
<td>You can engage in the discussion by either: Building upon current discussion posts by supporting and extending thinking, introducing new ideas, or asking a thoughtful question.</td>
</tr>
</tbody>
</table>
data to investigate a question of interest to them, what challenges do you envision they might have when posing questions, collecting data (including measurement issues in data), analyzing data, and interpreting results? Consider sharing some strategies that could be used in the classroom to help students progress to higher levels of statistical sophistication, or support them in working at lower levels that are more appropriate for where they are.

Starting a new discussion if your post differs from existing discussions. Use a descriptive title when making a new discussion post. Both forms of engagement are valuable and help the community to learn and grow. If you are pursuing a certificate of completion, please note that either a reply or a post is considered engaging with a forum for course completion.

<table>
<thead>
<tr>
<th>Unit 5</th>
<th>In what ways has your confidence changed for teaching statistics? How could you help a fellow educator become more confident?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>You can engage in the discussion by either: Building upon current discussion posts by supporting and extending thinking, introducing new ideas, or asking a thoughtful question. Starting a new discussion if your post differs from existing discussions. Use a descriptive title when making a new discussion post. Both forms of engagement are valuable and help the community to learn and grow. If you are pursuing a certificate of completion, please note that either a reply or a post is considered engaging with a forum for course completion.</td>
</tr>
</tbody>
</table>

Analyzing prompts of the first kind of forums entitled ‘investigations’ (left side of Table 6-2) it was possible to identify that these prompts proposed some form of action from participants as they engage in the forum. Table 6-3 shows the researcher’s highlights of the proposed action embedded in these prompts. We notice that these specific prompts were mainly asking participants to think about their practice as teachers and to think about their students as they interact in forums. Prompts for units one and four were asking for participants to think about their students as they engage in those forums. Prompts for units two, three, four, and five were asking participants to think about their role as a teacher as they engage in those forums. Analyzing the prompts of the second kind of forums entitled ‘discuss with your colleagues’ (right side of Table 6-2) it is possible to note that in all units these prompts provided directions of how to engage in
those forums. Aiming to growing the community of forum participants, these prompts implicitly invited participants to discuss anything related to the unit and/or to their practice as teacher. In all forums of Table 6-2, participants interacted with others by opening new discussion threads and/or by replying to each other’s posts.

Table 6-3. Analysis of the prompt requests.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Prompt</th>
<th>Prompt’s request</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>Consider the students that you work with. How well prepared are they to answer the items in this investigation? What would be needed to assist students in preparing to answer these types of questions?</td>
<td>Think about your students and interact in this forum.</td>
</tr>
<tr>
<td>Unit 2</td>
<td>Statistical or Mathematical Tasks: For the collection of tasks you analyzed, discuss how the tasks could promote statistical habits of mind, and if there is anything you would change about a task to make it more worthwhile. You can also share other tasks you think are worthwhile statistical tasks, or ones that you would like help in adapting to be more worthwhile for engaging students in statistics.</td>
<td>Think as a teacher and interact in this forum. + Share resources and/or adapt resources to engage your students</td>
</tr>
<tr>
<td>Unit 3</td>
<td>Discuss what you observe about student thinking when they interact with the technology tool, how the tool affords them to develop statistical reasoning and statistical habits of mind in the working with dynamic tool Tinkerplots video and what level of statistical sophistication of the SASI framework that students are at in the multiple levels of sophistication video.</td>
<td>Think as a teacher and interact in this forum.</td>
</tr>
<tr>
<td>Unit 4</td>
<td>What were your “aha” moments about students’ work in these videos that might impact your teaching with the investigative cycle? If your students were exploring the Census at School data to investigate a question of interest to them, what challenges do you envision they might have when posing questions, collecting data (including measurement issues in data), analyzing data, and interpreting results? Consider sharing some</td>
<td>Think as a teacher and interact in this forum. + Think about your students and interact in this forum.</td>
</tr>
</tbody>
</table>
strategies that could be used in the classroom to help students progress to higher levels of statistical sophistication, or support them in working at lower levels that are more appropriate for where they are.

<table>
<thead>
<tr>
<th>Unit 5</th>
<th>In what ways has your confidence changed for teaching statistics? How could you help a fellow educator become more confident?</th>
<th>Think as a teacher and interact in this forum.</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Units</td>
<td>You can engage in the discussion by either: Building upon current discussion posts by supporting and extending thinking, introducing new ideas, or asking a thoughtful question. Starting a new discussion if your post differs from existing discussions. Use a descriptive title when making a new discussion post. Both forms of engagement are valuable and help the community to learn and grow. If you are pursuing a certificate of completion, please note that either a reply or a post is considered engaging with a forum for course completion.</td>
<td>Directions for forum participation.</td>
</tr>
</tbody>
</table>

In the next section I analyze the embedded requests of the forums prompts vis-à-vis the content of participants’ posts in these forums.

**Forum Prompts and the Nature of the Content of Participants’ Posts**

Comparing the nature of the content of participants’ posts in discussion forums from units 1 and 2 (as presented in the previous section of this chapter) with the respective forums prompts offered by these units, it was possible to note that: (a) discussions generated by participants were bigger in scope than what was proposed by their respective prompts, (b) although not prompted, discussions of some materials naturally emerged in forums, and (c) participants discussed in forums about different features of the resource instead of discussing what was proposed by the prompt. To present evidence of the relationship between prompt and
real discussions, next I revisit the diagrams that describe the nature of the content of participants’ posts from three forums that were discussed in the previous section (i.e., LOCUS test, Gapminder, and Statistical Tasks). In those diagrams, I identified the content of discussions related to the given prompt within the nature of the content of participants’ posts generated at these forums. After that, I present a discussion about the importance/effect of prompts in this MOOC.

*Discussions Generated by Participants were Bigger in Scope than What was Proposed by their Prompts*

Evidence of this claim can be found on content of participants’ posts about their experiences with the LOCUS test in Unit 1, and on content of participants’ posts about the high school task Pepsi vs Coke in Unit 2. For the LOCUS test, the prompt asked participants to discuss how prepared their students were to take the assessment and what teachers could do to help their students to be equipped to answer questions such as the ones presented in the LOCUS test. The nature of the content of participants’ posts in forums regarding the LOCUS test is presented on the diagram of Figure 6-7. It shows that participants discussed how their students would perform if taking the same assessment as marked in gray in Figure 6-7 attending to the prompt request. However, the content of their engagement in discussion forums were not restricted to the prompt guidelines. In fact, the content of participants’ posts was broader in scope than what was asked by the prompt. Before approaching how their students would perform on the same assessment, it seemed that participants had the need to first reflect about their own performance on this assessment and the implications of their preparation on their teaching. In this process, some participants took space in forums to share their frustration with the assessment, for later to accomplish what the prompt was suggesting. This fact shows that participants tend to attend to
the suggested prompt anchoring their discussions around the main theme proposed by the prompt. However, they did not limit the content of their interactions to the prompt request.

**Figure 6-7. Identification of the content of participants’ posts related to the forum prompt of Unit 1 – investigation (gray).**

A similar result was found when analyzing the prompt for Statistical Tasks in Unit 2 in comparison to the nature of participants’ interactions with the high school task Pepsi vs Coke showing in Figure 6-8. Again, we see that their engagement in discussions forums were not
restricted to the prompt guidelines. The prompt asked participants to discuss in forums how those tasks could promote statistical habits of mind. It also asked if participants would change anything on those tasks, and invited participants to share their own tasks with others.

Although this prompt asked specific questions about participants’ engagement in this forum, the content of their engagement about the Pepsi vs Coke task were broad in scope and partially different from what was asked by the prompt. From the three high school tasks provided by the MOOC, Figure 6-8 shows that participants were interested in discussing the Pepsi vs Coke task with others in forums, and they attended to one of the requirements of the prompt when they discussed the statistical potential of the task and further modifications of it (marked in gray in Figure 6-8). However, participants virtually did not discuss how the task could promote statistical habits of mind, they shared neither their own exemplary tasks nor tasks to be adapted in order to potentially engage students in statistics. This shows that although a discussion had a prompt, participants elected a piece of this prompt to talk about in forums, aligned with other issues raised by them and anchored on the main theme of that forum.
Although Not Prompted, Discussions of Some Materials Naturally Emerged in Forums

Evidence of this claim can be found in participants’ interactions about their experiences with the Gapminder video in Unit 1. Although not prompted, participants’ engagement with Gapminder video organically created 144 posts distributed in 17 new discussions treads where participants shared their enthusiasm about the potential of the Gapminder World tool. As shown in Figure 6-8, participants selected their favorite task of the set. This task is great because...

- (a) This task will interest my students
- (b) This task engages students in the investigation cycle
- (c) Statistical potential of the task and further modifications
- (d) Students not posing their own questions
- (e) The task takes too much time
- (f) The task is not healthy
on Figure 6-9, participants seemed to have had the need to state their reasons about why the tool was great. Participants involved in these discussions used forums to share their interest in using the tool in their class. Others used discussions forums to share their worries about using the tool, while some participants stated their intention of sharing this resource with other teachers. These participants’ interactions indicate that if the resources provided by the professional development resonate in some way with their realities, they will share their perspectives and experiences about those materials despite the fact that these discussions were not prompted by the MOOC provider.

**NO PROMPT.**

**Nature of the content of participants’ posts with respect to Gapminder**

- **It is great because...**
  - Students can do
  - I can do
  - Students would enjoy it
    - I worry about it
    - I share resources
  - I want to use it

*Figure 6-9. Identification of the content of participants’ posts from non-prompted discussions about Gapminder in Unit 1 – discuss with your colleagues.*
Participants Discussed in Forums about Different Features of the Resources instead Discussing what was Proposed by the Prompt

Evidence of this claim can be found on content of participants’ posts about their experiences with the middle school task Old Faithful in Unit 2. The prompt asked participants to discuss in forums how those tasks could promote statistical habits of mind. It also asked if participants would change anything on those tasks and invited them to share their own tasks with others. Although this prompt asked specific questions for participants’ engagement in this forum, the content of their interactions in forums differed from what was proposed by the prompt. Figure 6-10 shows that participants were interested in discussing the Old Faithful task with others in forums, however instead of focusing on what was asked, participants used forums to share their enthusiasm about the potential of the task as they stated reasons why the task was great. They also used forums to share with others their concerns about the task as students not posing their own questions neither collecting data while performing this task. This shows that although a discussion forum had a clear prompt, participants moved the target of the discussion established by the prompt to what they wanted to share connected to the prompt.
Discussion about Forum Prompts and the Nature of the Content of Participants’ Posts

Results from this section show that participants in forums: elected and discussed only some part of the prompt, chose to discuss a resource that resonated with their interests without a prompt, and changed the discussion target initially established by the prompt to a new and not necessarily related target. Participants’ autonomy emerged as a common ground among these three reactions taken by participants as they interacted in forums. Autonomy of participants and
the openness of this MOOC help us in understanding differences between the embedded requirements of forum prompts and the content of participants’ posts in these forums. Autonomy allowed participants the option to join and leave forum spaces at their will. Openness in this MOOC granted participants the freedom to contribute to discussions with whatever content they wanted. Contributions that deviated from the target represented by the prompts were also welcomed by participants in this MOOC and may have created an environment that invited other participants to reflect upon ideas related to the prompt that might not have been originally planned by the MOOC provider.

Although participants made use of autonomy as they engaged in forums, the discussion prompts were designed by the MOOC provider for particular purposes. According to the main instructor, two different types of prompts were implemented in this MOOC,

[In each unit] One [discussion forum] is around the specific investigation that they are supposed to be doing. [...] We have another open forum in every single unit that is just discussed with your colleagues and it can be more general about anything that they read or watched or thought about with the materials in that unit (Interview – Main instructor).

For Thompson, DeNoyelles, Chen, and Futch (2016), effective discussion prompts are designed to generate in participants “a frame of reference through an associated shared experience or learning activity” (p. 1). According to these authors, discussion prompts can be pedagogically designed to foster: debate among participants, to encourage participants’ role play (in which participants speak from their point of view), and to elicit statements of participants’ knowledge about a topic. As shown on the left side of Table 6-2, the forum with specific prompts gave opportunities for participants to speak from their point of view of the resource as in role play type of prompt stated in Thompson et al. (2016). An example from Table 6-2 is the forum prompt of Unit 1 that invited participants to think about would be needed to assist their students in preparing to answer questions as presented in the LOCUS test.
Despite the fact that prompts had intentions through their design, the nature of the content of participants’ posts with respect to particular resources showed that the selection of instructional activities as the materials provided by this MOOC was paramount in shaping topics that were discussed by participants in this MOOC. Evidence includes the discussions about a Gapminder video in the absence of prompts. Participants’ election to discuss features of the Pepsi vs Coke and the Old Faithful tasks are other examples of participants’ selection of materials.

Whether the discussions were generated by an investigation followed by a prompt for participants to reflect upon or by an explicit direction for how participants were to act in forums, these prompts acted as forum guidelines for participants to start a conversation and to stay somehow connected to the topic of interest. Based on the data, it is possible to say that forum prompts such as those presented in the left side of Table 6-2 acted as anchoring features—features that aid in contextualizing the discussions and helping participants to decide whether they will engage in the discussion (Guzdial & Turns, 2000; Garrison & Cleveland-Innes, 2005).

In general, the discussion prompts in this MOOC intended to promote participants’ interest and discussion of practice in teaching statistics through data investigations. The questions embedded in the prompts were opened enough allowing participants’ reflection as they interacted with others in forums. Since the prompts did not separate or constrain participation based on professional experience of participants, they seemed to have acted as welcome signs inviting contributions from participants with diverse backgrounds and experiences.

Research has stated that participants’ contributions in discussion forums improve by providing topics (discussion prompts) that are relevant to them (Du et al., 2008), by asking participants to engage in practical applications (Koh, Herring, & Hew, 2010), and by anchoring the discussions with reflective questions (Garrison & Cleveland-Innes, 2005). Based on participants’ engagement in forums in this MOOC, it is possible to say that the specific prompts in the discussions (such as those listed on left side of Table 6-2) provided topics that were
relevant to participants such as the LOCUS assessment and the Statistical Tasks. These prompts were asking for participants to engage in practical applications such as adapting tasks and checking their own statistical knowledge. These prompts were also asking participants reflective questions such as how prepared their students would be to take the same assessment, and how these teachers could help their students in a task. In the next section, I present participants who started most of the discussions in forums.

**Who Started the Discussions in Forums?**

In addition to analyzing the content of discussion prompts as shown at the beginning of this chapter, it is important to know who initiated discussions in forums. From the nature of the content of participants’ posts with respect to the three resources presented at the beginning of this chapter (LOCUS test, Gapminder, and Statistical Tasks), discussion forums were initiated by MOOC participants whose posts usually presented their feedforwarding of their remixing and repurposing of materials provided by this professional development. This feedforwarding mainly consisted of participants’ reflection, point of view, feelings, and opinions about the resources provided by this professional development. Participants created discussions in forums that had specific discussion prompts and in forums that had generic discussion prompts.

From a total of 646 discussion threads created by participants in this MOOC, it was possible to notice that a high number of discussions threads were created by only few participants and these participants had different professional roles. These participants acted as discussion starters, opening threads in which they and others could engage in discussions. Although this study did not investigate participants’ reasons for opening new discussions, it sheds light on who these discussion starters were and their importance to the network in this professional development setting.
In this study, a participant who opened ten or more discussions is a discussion starter. The choice for a cutting point of ten discussions is based on the number of units available in this MOOC. The MOOC had a total of 12 discussion forums, distributed as two forums in each of the five course units (i.e., five units, ten forums) plus a forum for participants’ introduction and a forum for participants who would like to submit a project as part of a 25-hour professional development certificate. The choice of only ten discussions allows participants who did not introduce themselves and who did not engage with a project to be eligible as a discussion starter. Although the choice of ten as the number of discussion threads represents two threads in each unit, a participant could be considered a discussion starter if he or she started at least ten discussion threads regardless of whether the threads were distributed across the twelve forums or concentrated in only some of the five units. Table 6-4 shows the discussion starters, participants who initiated at least ten discussions threads throughout the MOOC.

Table 6-4. Number of discussions initiated by discussion starters.

<table>
<thead>
<tr>
<th>Participant Numbers</th>
<th>Professional role</th>
<th>Number of discussions initiated by participant</th>
<th>% of total discussions</th>
</tr>
</thead>
<tbody>
<tr>
<td>4346</td>
<td>Others - Statistician</td>
<td>15</td>
<td>2.32%</td>
</tr>
<tr>
<td>4514</td>
<td>Teacher, K-12</td>
<td>14</td>
<td>2.17%</td>
</tr>
<tr>
<td>3631</td>
<td>College Professor- Mathematics/Statistics</td>
<td>13</td>
<td>2.01%</td>
</tr>
<tr>
<td>4409</td>
<td>Teacher, K-12</td>
<td>11</td>
<td>1.70%</td>
</tr>
<tr>
<td>4513</td>
<td>College Professor- Mathematics/Statistics</td>
<td>10</td>
<td>1.55%</td>
</tr>
<tr>
<td>4921</td>
<td>Teacher, K-12</td>
<td>10</td>
<td>1.55%</td>
</tr>
<tr>
<td>5052</td>
<td>College Professor- Teacher Educator</td>
<td>10</td>
<td>1.55%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>83</strong></td>
<td><strong>12.85%</strong></td>
</tr>
</tbody>
</table>

The discussion starters were mainly from the United States, with one participant from the Philippines and another one from the United Kingdom. Their gender was distributed as 57%
female and 43% male. All of them had a masters’ degree or a doctoral degree. They have 17 years of experience on average and they work as k-12 teachers or college instructors.

Regarding their importance to the network, discussion starters were pioneers in feeding forward the network by posting content that they had previously engaged with from this professional development. Evidence of this feedforwarding can be seen in the quantity of discussions created by these participants. Discussion starters initiated 12.85% (83 discussions) of all discussions in this MOOC. By doing so, these participants helped to created new venues (discussion threads) for the flow of information through the network, as their discussion threads hosted 113 posts and generated 979 discussion views throughout the MOOC.

As discussion starters, these seven participants (as described in Table 6-4) contributed to what was going to be discussed in those threads by introducing a topic for a discussion that was being formed (as shown in discussions about Gapminder). They seemed to not have had problems in being the first to imprint their observations and reflections in forums. They expressed their understanding of the materials in a written format and connected their understanding to their reality. For example, the prompt of discussions in Unit 1 read: “Consider the students that you work with. How well prepared are they to answer the items in this investigation? What would be needed to assist students in preparing to answer these types of questions?” Participant 4514 opened discussion thread number 6177, entitling it “Assessment items so different from what we've been teaching”. He opened the thread with the following offering,

These assessment items were sooooo very different from the kind of stats tasks we've been asking our students to do in NY state for the past several years. Up until now, the students only had to understand types of bias, how to generate and interpret a normal curve, etc. They never had to understand confidence intervals, p-scores, or what it means for differences in results to be "statistically significant. Having never taken any college level stats myself, I feel pretty intimidated about having to explain these ideas to my students now that we have adopted the Common Core. I did better on the test than I thought (80%) but a lot of my answers were based on a gut feeling rather than something I could explain effectively to students. I have a lot of growing to do, but I am actually excited about learning so many new ideas. I found the questions compelling even though I didn't understand
all of them. I think it would be worthwhile even to discuss the incorrect answers, as well as the correct ones.

His post attracted four additional people to discuss the LOCUS test items and to learn about participants’ common misunderstandings. The forum prompt asked for/about how prepared were participants’ students to answer the questions on the LOCUS test, and participant 4514’s comment that some statistical contents presented on the LOCUS were not part of the New York state curriculum, and that he wasn’t confident to explain these statistical concepts to his students. He finished the post suggesting a discussion about the incorrect answers obtained in the LOCUS test. This suggestion attracted other four participants who echoed his voice in the need of discussing the LOCUS questions. The discussion thread initiated by participant 4514 generated 60 views from other participants who seemed to be interested in the topic but who did not directly contribute to this discussion by posting. Participant 4514’s discussion opening as quoted above is only one example of how discussion starters influenced what was discussed in the threads they initiated.

Not all discussion starters opened a thread by posting their remix or repurpose of the materials they had previously engaged with. Sometimes they started a new thread with an opinion that seemed to afford opportunities to others for sharing their repurposing by stating their understanding about the material they previously interacted with and/or sharing their own practice. For instance, participant 4513, who opened discussion thread number 6822 in Unit 2, expressed his opinion by posting “The Pepsi v. Coke is an excellent activity, especially by comparison to the other two choices in the high school section.” After that, participant 5009 replied,

By far the best activity as a whole was Pepsi vs. Coke. However the data set was qualitative with minimal variables and I was not impressed with the method for conducting the investigation. I think that it would be more valid for students to develop their own investigative proposal (including posing a question that they want to answer within the confines of Coke vs. Pepsi). After watching the
presenter's videos, I see a much greater correlation between scientific processes and statistical methods. The entire investigative process needs to be modeled at each step and students need to learn through experimenting with their own investigations. We are attempting to do this with all of our Chemistry Labs this year.

By agreeing with participant 4513, participant 5009 relied on his experience to state his understanding of the activity as the one using a dataset that “was qualitative with minimal variables”. He suggested that students should develop their own investigations instead of using an investigation proposed by a teacher such as the one from the MOOC materials. As he revised the Pepsi and Coke activity, he suggested something different by recalling his own experience as a teacher and informing others that he and his colleagues were planning to implement something similar to what he suggested in his post. Overall, the post of discussion starter participant 4513 generated 43 replies from 38 distinct participants who actively engaged in sharing their understanding of the Pepsi vs Coke task, discussing its features and potentially connecting this task to their practice.

A new discussion thread was also a place for discussion starters to share their practice with others. An example can be found on participant 4513’s post who started discussion thread number 6826 by posting an activity he did with his students to address students’ understanding of correlation using simple materials as such pasta,

I try something different just about every year I teach, but one that I use most of the time is setting up a simple experiment to gather data for multiple regression (one of the problems with basic statistics is that we lead most students to the misconception of correlation is causation because we only use bi-variate data...). Research topic: what is the predictable relationship between mass, distance, and multiple strands of spaghetti? Supplies: desks, ruler, paper cups, string, pennies, raw spaghetti noodles. Procedure: pair students and supply them. Have students poke holes in cups and thread string to create loop. Have students start with one spaghetti noodle and desks 5cm apart. Load pennies until the noodle breaks and record data. Add a noodle and repeat until five noodles. Move desk to 10 cm and repeat. Repeat until noodle no longer reach. Analyze data.

This discussion generated 8 replies from 4 distinct participants who engaged in it.
The post of participant 4409 is another example of a participant learning ideas from his peer’s experience to implement in his classroom as he stated,

Thank you so much for this thread and all the others that commented and contributed to the continuation of this thread. As I previously divulged, I haven’t had much chance to work with Statistics. Now, reading through this thread, it is giving me a good idea of what a Statistics class could possibly look like. It is giving me a lot of ideas on how to start, and/or maintain the interest on the class.

Looking at the numbers presented on Table 6-4, one may wonder if discussion starters were cultivators or choppers of interactivity in this MOOC. Considering the average of posts per discussions created by them, approximately 1.4 posts per discussion, it seems that discussion starters were choppers of interactivity in this MOOC, diluting participants’ interactions by creating many discussion threads. However, a deep analysis of their patterns of engagement in forums shows that four of these discussion starters were also super-posters in this MOOC (Bonafini, 2018), which make them cultivators of interactivity because they posted in discussions created by others, and thus assisted with the engagement in forums.

The term “super-posters” was originally coined by Huang, Dasgupta, Ghosh, Manning, and Sanders (2014). They used super-posters to label participants who were the “highest-volume contributors” in forums (p. 1). Huang et al. (2014) collected data from 44 MOOCs and defined the top 5% of participants with respect to their average number of posts as super-posters. To identify super-posters in this online professional development, the total number of forum posts were cleaned by excluding posts from the instructional team. The sample of participants’ posts consisted of 2095 posts generated by 328 active participants. Due to sample size effect, in this study super-posters were defined as a set of participants comprising the top 10% of forum participants as represented on Table 6-5.
Table 6-5. Super-posters participants classification.

<table>
<thead>
<tr>
<th>Participant Numbers</th>
<th>Number of posts</th>
<th>Percentage of the total posts (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4409</td>
<td>76</td>
<td>3.63%</td>
</tr>
<tr>
<td>3631</td>
<td>48</td>
<td>2.29%</td>
</tr>
<tr>
<td>4346</td>
<td>46</td>
<td>2.20%</td>
</tr>
<tr>
<td>4513</td>
<td>37</td>
<td>1.77%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>207</strong></td>
<td><strong>9.88%</strong></td>
</tr>
</tbody>
</table>

By also acting as super-posters, participants 4409, 3631, 4346, and 4513 were the leaders in cultivating interactions in this MOOC. Note that participant 4409 presented a much higher number of posts (i.e., replies to others) than the other super-posters (Table 6-5). Due to his number of posts to other participants, participant 4409 acted as a leader of engagement when compared to the quantity of contributions (total discussion creation plus posts) of the other super-posters who were also discussion starters.

**Summary of Who Started the Discussions in Forums**

Discussion starters were highly educated and experienced professionals. They acted as network expanders as they opened new threads that were later populated by posts of other participants and themselves. Their actions were vehicles to produce more interactivity among the community members, yielding (113 posts and 979 discussion views). By opening new discussions, the discussion starters contributed to the definition of the topic and content of 12.85% of all discussions in this MOOC. They contributed to the network by creating new nodes in it as they shared their reflections, feelings, and opinions about the resources provided by this professional development. By creating new discussions, they also opened venues for other participants to aggregate content embedded in their messages, which could be later repurposed and fed-forward by other participants.
Analyzing their posts, four of seven discussion starters also acted as super-posters in this MOOC. By replying to posts of others, they demonstrated commitment in contributing back to the network, and the content of their contributions was aligned with the goal of the MOOC (teaching through statistical investigations). Through their contributions by creating discussions or posting in discussions created by others, discussion starters repurposed the content learned in this MOOC by sharing their experiences with others in forums. Discussion starters exercised presence in this MOOC, contributing to social learning that was being created though interactions of participants in the network.

**Structure of Participants’ Interactions in Forums with Respect to Three Resources**

In previous sections, qualitative content analysis was used to gain deep information about the content of participants’ posts. However, qualitative content analysis falls short in depicting the structure of the network that was formed by participants as they interacted in forums. In order to fully understand the nature of participants’ interactions in forums with respect to resources, Social Network Analysis (SNA) was used to capture the structure of the network created by participants through their interactions in MOOC forums. Results from this section will give a broad picture of who were involved in the discussions, and who acted as active participants when engaging in discussions with respect to three resources (the LOCUS test, Gapminder, and Statistical Tasks). The choice of presenting the structure of participants’ interactions (network) with respect to these three resources is related to the fact that these resources generated a high number of participants’ interactions in forums, and it may help the reader in gaining deep knowledge about what participants shared in forums and how they connected to each other when interacting about each of these three materials in forums.
As described in the methodology chapter, discussion threads referring to these three materials were automatically extracted from the MOOC forum Excel database through Excel macros by using the parenting function generated by the MOOC provider. The discussions related to LOCUS test, Gapminder and Statistical Tasks were analyzed separately to expose the networks created by participants as they interacted with each other about those resources.

**Structure of the Network of Participants’ Interactions in Forums about the LOCUS Test**

In order to learn about participants’ interactions in forums with respect to the LOCUS test, the network of their interactions in forums was created by using NodeXL. Figure 6-11 shows the network of participants’ interactions with respect to the LOCUS test. The nodes (dots) in the figure represent the participants and were labeled with their ID number. The edges (arrows) represent one or more posts provided by one participant in response to a post from another participant. The loops (circular arrows) indicate that a participant created a discussion and no one replied to it or that a participant replied to him/herself, perhaps adding more context to his/her previous post.

The tip of the edges in Figure 6-11 visually represent the direction of the messages exchanged between the two distinct participants. For instance, the main instructor (participant 296) sent a message to participant 4513, this action is reflected on the network by an arrow from participant 296 towards participant 4513 (i.e., 4513 ← 296). Participant 4513 replied to participant 296, this action added another tip to the previous arrow between both participants (i.e., 4513 ↔ 296) which represents a reciprocal communication. Reciprocal communication means in this case that participant 4513 and 296 exchanged messages, it does not necessarily mean that the messages exchanged between them were about the same topic or in the same discussion thread. The edges in Figure 6-11 do not visually represent the quantity of messages exchanged between
two distinct participants. In the case above, if participants 4513 and 296 have exchanged multiple messages, the graph would show only one arrow with two tips (↔) for one or for multiple exchanges between these two participants. Although not represented graphically, NodeXL retrieves the total duplicated edges in the software for future use.

Figure 6-11. Structure of the network of participants’ interactions in forums with respect to the LOCUS test after multiple interactions using Fruchterman and Reingold interactive algorithm.

**Overall metrics.** The overall metrics produced by NodeXL are presented on Table 6-6. From Table 6-6 we learned that the discussions had 199 nodes and 430 unique edges. We also learned there were 21 participants who posted and did not received any reply or posted to him/herself in order to clarify or add something to their original posts. The arrows shown in Figure 6-11 are a not true representation of participants’ interactions with each other since there were 69 duplicated edges as shown in Table 6-6. Recalling that density is the proportion of existing ties over all possible ties, the LOCUS test network was not dense as we can visualize through Figure 6-11, and through its density measure (graph density = 0.0112) on Table 6-6. The network presents a fair modularity score = 0.4685. Recall that modularity values fall between the
range of $-1/2$ and 1, and that graphs with high modularity have dense connections among the vertices within the same group but sparse connections among vertices in different groups.

Table 6-6. NodeXL overall metrics for the network of participants’ interactions in forums with respect to the LOCUS test.

<table>
<thead>
<tr>
<th>Graph type</th>
<th>Directed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertices</td>
<td>199</td>
</tr>
<tr>
<td>Unique edges</td>
<td>430</td>
</tr>
<tr>
<td>Edges with duplicates</td>
<td>69</td>
</tr>
<tr>
<td>Total edges</td>
<td>499</td>
</tr>
<tr>
<td>Self-loops</td>
<td>21</td>
</tr>
<tr>
<td>Graph density</td>
<td>0.0112</td>
</tr>
<tr>
<td>Modularity</td>
<td>0.4685</td>
</tr>
</tbody>
</table>

**Individual centrality metrics.** Analyzing the centrality measures of participants who engaged in discussions about the LOCUS test as shown in Table 6-7, we learned that the MOOC main instructor node (participant 296) was the most prestigious one in this network, since this node presented the highest in-degree measure (number of arrows that link other people to the main instructor’s node). By having more arrows (edges) leaving the main instructor’s node, she was considered an influential node in this network. The main instructor worked as bridge in discussions about the LOCUS test (betweenness centrality = 24907.61). The main instructor was also the nearest node to all other nodes in the LOCUS network (closeness centrality = 0.003), and the most important node in this network (eigenvector centrality = 0.067).

Table 6-7. NodeXL individual centrality measures for discussions about the LOCUS test.

<table>
<thead>
<tr>
<th>In-Degree</th>
<th>Participant 296 had the highest in-degree = 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out-Degree</td>
<td>Participant 296 had the highest out-degree = 58</td>
</tr>
<tr>
<td>Betweenness Centrality</td>
<td>Participant 296 had the highest betweenness centrality = 24907.61</td>
</tr>
<tr>
<td>Closeness Centrality</td>
<td>Participant 296 had the highest closeness centrality = 0.003</td>
</tr>
</tbody>
</table>
Participant 296 had the highest eigenvector centrality = 0.067

Discussion about the Structure of the LOCUS Network

The metrics provided by SNA showed that the network created by participants who engaged in discussions about the LOCUS test relied heavily on the presence of the MOOC main instructor. The measures of degree centrality shown in Table 6-7 presented evidence of the popularity of the main instructor in the LOCUS network. The main instructor was the one with the highest in-degree and out-degree in the network demonstrating that she was the most connected person within the LOCUS network as shown by arrows in bold on Figure 6-12. The centrality measures evidence that that the main instructor was the most prestigious and the most influential participant in this network. As the main instructor also took the position of the highest betweenness centrality individual in this network, this is additional evidence that if we remove the main instructor node (that has a high betweenness of centrality), the subnetworks could become disconnected. The eigenvector centrality measure reinforces the main instructor’s importance in this network.
Structure of the Network of Participants’ Interactions in Forums about Gapminder

In order to learn about participants’ interactions in forums with respect to Gapminder, the network of their interactions in forums was created by using NodeXL as shown in Figure 6-13.

Figure 6-13. Structure of the network of participants’ interactions in forums with respect to Gapminder after multiple interactions using Fruchterman and Reingold interactive algorithm.
Overall metrics. The overall metrics produced by NodeXL are presented on Table 6-8. From Table 6-8 we learned that the discussions had 108 nodes and 136 unique edges. We also learned that the discussions presented only one participant (participant 5395, a classroom teacher), who created a discussion and did not receive any reply. The arrows showed on Figure 6-13 are not true representations of participants’ interactions with each other since there were 9 duplicated edges as showed on Table 6-8. The network was not dense as we can see on Figure 6-13 and through its density measure (graph density = 0.0120). The network presents modularity = 0.6270.

Table 6-8. NodeXL overall metrics for the network of participants’ interactions in forums with respect to Gapminder.

<table>
<thead>
<tr>
<th>Graph type</th>
<th>Directed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertices</td>
<td>108</td>
</tr>
<tr>
<td>Unique edges</td>
<td>136</td>
</tr>
<tr>
<td>Edges with duplicates</td>
<td>9</td>
</tr>
<tr>
<td>Total edges</td>
<td>145</td>
</tr>
<tr>
<td>Self-loops</td>
<td>1</td>
</tr>
<tr>
<td>Graph density</td>
<td>0.0120</td>
</tr>
<tr>
<td>Modularity</td>
<td>0.6270</td>
</tr>
</tbody>
</table>

Individual centrality metrics. Analyzing the centrality measures of participants who engaged in discussions about Gapminder as shown on Table 6-9, we learned that instructor B (participant 3131) was the most prominent node in this network, since this node presented the highest in-degree measure (number of arrows that link other people this node). The MOOC main instructor was the most influential vertex, presenting the highest out-degree. The main instructor also worked as bridge in this network, connecting six groups (betweenness centrality = 5844.91). The main instructor was the nearest node to all other nodes in the Gapminder network (closeness...
centrality = 0.003) and was the most important node in this network (eigenvector centrality = 0.098).

Table 6-9. NodeXL individual centrality measures for discussions about Gapminder.

<table>
<thead>
<tr>
<th>Centrality Type</th>
<th>Highest Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-Degree</td>
<td>Participant 3131</td>
</tr>
<tr>
<td>Out-Degree</td>
<td>Participant 296</td>
</tr>
<tr>
<td>Betweenness Centrality</td>
<td>Participant 296</td>
</tr>
<tr>
<td>Closeness Centrality</td>
<td>Participant 296</td>
</tr>
<tr>
<td>Eigenvector Centrality</td>
<td>Participant 296</td>
</tr>
</tbody>
</table>

Discussion about the Structure of the Gapminder Network

The metrics provided by SNA showed that the network created by participants who engaged in discussions about Gapminder relied on the presence of instructor B (participant 3131). The main instructor also plays an important role in the Gapminder network being the participant with the highest out-degree centrality, which represents her ability to access other nodes in the network and quickly disseminate information. The main instructor is again the most prestigious tile positioning as the most prominent node in the network. Her direct contact with many nodes in the network (i.e., highest out-degree centrality) makes her a crucial gear in the interlaced structure of this network.
In order to learn about participants’ interactions in forums with respect to Statistical Tasks, a network of their interactions in forums about middle and high school statistical tasks (combined) were created as shown on Figure 6-14.

Figure 6-14. Structure of the network of participants’ interactions in forums with respect to Statistical Tasks after multiple interactions using Fruchterman and Reingold interactive algorithm.

**Overall metrics.** The overall metrics produced by NodeXL are presented on Table 6-10. From Table 6-10 we learned that the discussions had 126 nodes and 298 unique edges. We also learned that the discussions presented participants who created discussions that did not receive any reply (self-loops = 21). The arrows showed on Figure 6-14 are not true representations of participants’ interactions with each other since there were 18 duplicated edges as shown in Table 6-10. The network was not dense as we can see on Figure 6-14 through its density measure (graph density 0.0182). The network presents modularity = 0.4355.
Table 6-10. NodeXL overall metrics for the network of participants’ interactions in forums with respect to Statistical Tasks.

<table>
<thead>
<tr>
<th>Graph type</th>
<th>Directed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertices</td>
<td>126</td>
</tr>
<tr>
<td>Unique edges</td>
<td>298</td>
</tr>
<tr>
<td>Edges with duplicates</td>
<td>18</td>
</tr>
<tr>
<td>Total edges</td>
<td>316</td>
</tr>
<tr>
<td>Self-loops</td>
<td>21</td>
</tr>
<tr>
<td>Graph density</td>
<td>0.0182</td>
</tr>
<tr>
<td>Modularity</td>
<td>0.4355</td>
</tr>
</tbody>
</table>

**Individual centrality metrics.** Analyzing the centrality measures of participants who engaged in discussions about Statistical Tasks as shown on Table 6-11, we learned that participant 4513 (a college professor) was the most prestigious one in this network, since he presented the highest in-degree measure (number of arrows that link other people to him). The MOOC main instructor was the most influential vertex once more, presenting the highest out-degree. Participant 4513 worked as bridge in this network, connecting six groups (betweenness centrality = 5844.91) as shown in Figure 6-15. Participant 4513 was also the nearest node to all other nodes in the Statistical Tasks network (closeness centrality = 0.004). The eigenvector centrality confirms that the main instructor was the most influencer node in this network.

Table 6-11. NodeXL individual centrality measures for discussions about Statistical Tasks.

<table>
<thead>
<tr>
<th>In-Degree</th>
<th>Participant 4513 had the highest in-degree = 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out-Degree</td>
<td>Participant 296 had the highest out-degree = 17</td>
</tr>
<tr>
<td>Betweenness Centrality</td>
<td>Participant 4513 had the highest betweenness centrality = 4387.83</td>
</tr>
<tr>
<td>Closeness Centrality</td>
<td>Participants 4513 and 296 had the highest closeness centrality = 0.004</td>
</tr>
<tr>
<td>Eigenvector Centrality</td>
<td>Participant 296 had had the highest eigenvector centrality = 0.051</td>
</tr>
</tbody>
</table>
Figure 6-15. Participant 4513 connections with all groups in the Statistical Tasks network (thick arrows).

Discussion about the Structure of the Statistical Tasks Network

The metrics provided by SNA showed that the network created by participants who engaged in discussions about Statistical Tasks heavily relied on the presence of participant 4513. He shared the closeness centrality role with the main instructor in the Statistical Tasks network, meaning that both nodes were near to all other individuals in this network. Although participant 4513 was a prominent node in this network with the highest in-degree (receiving many replies from his posts), the main instructor’s influence is still expressed in this network. This influence is represented by her out-degree (replying posts of others), betweenness centrality (her position on paths of communication between nodes), and eigenvector centrality (her connection with other important nodes in the network) as shown on Table 6-11.
Summary of the Structure of Participants’ Interactions in Forums with Respect to Three Resources

In terms of overall metrics, when comparing the networks produced by discussions about the LOCUS test, Gapminder, and Statistical Tasks, it is possible to note that the LOCUS test network was the network that engaged the most and the one who had the highest quantity of exchange communications (duplicates edges = 69). The LOCUS network and the Statistical Tasks network were the ones that presented the highest number of self-loops, meaning that 21 posts or discussion creation within these networks did not receive replies. Conversely, Gapminder network had only one participant who did not receive a reply. It is interesting to note that although organically created by participants, the Gapminder network seems to be more cohesive with only one participant without a reply and high modularity compared to the other two networks presented in the study, meaning that participants had dense connections among the ones within the same group but sparse connections among the ones in different groups.

Regarding the individual metrics when comparing the networks produced by discussions about the LOCUS test, Gapminder, and Statistical Tasks as shown in Table 6-12, it is possible to note that the main instructor and instructor B were the most prestigious node in the LOCUS and Gapminder networks, respectively. Participant 4513 (a super poster and a discussion starter) emerged as the most prestigious node in the Statistical Tasks network. The main instructor was the most influential participant within the three networks (highest out-degree measure). In line with Russo & Koesten (2005), the main instructor’s out-degree represented her ability to connect and potentially influence others in these three social networks.

Participant 4513 worked as a bridge in the Statistical Tasks network establishing connections with all groups in this network. He shared the closeness centrality role with the main instructor in the Statistical Tasks network, meaning that both nodes were near to other individuals in this network. In both LOCUS and Gapminder networks, the main instructor arose as the node
holding the highest betweenness centrality, this suggests that the main instructor had the possibility of controlling the flow of information and/or resources that went through this network. As the node with the highest betweenness centrality in those networks, the main instructor had chance to work as a broker (Everetta & Valente, 2016, Kim & Hossain, 2008), meaning that she could connect two separate groups in those networks. To exemplify the concept of brokerage, here is a post from the main instructor in the LOCUS test network informing participant 2755 that others are discussing the LOCUS assessment elsewhere, stating, “[Participant 2755] You are NOT alone! Many others are discussing the assessment and want to improve themselves. For example, read this thread of posts, including the one I contributed with a link in it I think you will find useful [she gives the discussion URL]”.

By having the highest betweenness centrality in these two networks, the main instructor positioned herself in between connections as an example in Gapminder network (Figure 6-16), in which for participant 3304 to connect to participant 5094, this connection had to pass through the main instructor (participant 296).

Table 6-12. NodeXL individual centrality measures for LOCUS, Gapminder, and Statistical Tasks networks.

<table>
<thead>
<tr>
<th>Individual centrality metrics</th>
<th>LOCUS network</th>
<th>Gapminder network</th>
<th>Statistical Tasks network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant 296 had the highest in-degree = 30</td>
<td>Instructor B (participant 3131) had the highest in-degree = 13</td>
<td>Participant 4513 had the highest in-degree = 29</td>
<td></td>
</tr>
<tr>
<td>Participant 296 had the highest out-degree = 58</td>
<td>Participant 296 had the highest out-degree = 14</td>
<td>Participant 296 had the highest out-degree = 17</td>
<td></td>
</tr>
<tr>
<td>Participant 296 had the highest betweenness centrality = 24907.61</td>
<td>Participant 296 had the highest betweenness centrality = 5844.91</td>
<td>Participant 4513 had the highest betweenness centrality = 4387.83</td>
<td></td>
</tr>
<tr>
<td>Participant 296 had the highest closeness centrality = 0.003</td>
<td>Participant 296 had the highest closeness centrality = 0.003</td>
<td>Participant 4513 had the highest closeness centrality = 0.004</td>
<td></td>
</tr>
</tbody>
</table>
Participant 296 had the highest eigenvector centrality = 0.067  
Participant 296 had the highest eigenvector centrality = 0.098  
Participant 296 had the highest eigenvector centrality = 0.051

The main instructor also had the highest closeness centrality in the LOCUS and Gapminder network, meaning that she was near to other individuals in this network (i.e., geodesic distance). The main instructor’s central positioning in these networks may have helped her in monitoring the flow of information in the network. The closeness centrality aligned with the eigenvector also are indicators that the main instructor was ‘close’ to everyone in the network and had the “best visibility into what is happening in the network” (Dey & Roy, 2016, p. 243).

Figure 6-16. Example of main instructor (participant 296) betweenness in Gapminder network.

Nature of Participants’ Interactions with Others in Forums

To fully understand the nature of participants’ interactions in forums it is important to understand the distribution of forum posts (active participation) as the MOOC progresses, what participants share about themselves, and how they interact with others. This section will show
that although participants’ posts declined as the MOOC progressed, the number of posts by active participants was marginally constant as participants went through the MOOC. In terms of the content of their posts, participants not only shared their perspectives about materials in forums, but also shared their views about themselves, their perceptions of their learning from this MOOC, and their vision of potential implementations in their practice. With respect to how they interacted with others, this section will show that participants expressed concordance to the ideas of others and treated others with camaraderie as they engaged in forums.

**Distribution of Forum Posts as the MOOC Progresses**

In Chapter 5, Figure 5-11, I presented the total number of participants’ logs displayed by week throughout the period the MOOC platform was opened. From Figure 5-11, one can observe that participants’ engagement had its peak in the first week of the course (official starting date September 28th) with 19,435 course logs, and decreased as the professional development progressed. By observing participants’ course logs in Figure 5-11 one might wonder about the pattern of participants’ posts through this MOOC. Questions such as the follow come to mind:

- What are the pattern of participants’ posts throughout the MOOC?
- Do participants’ posts also follow the same trend as their logs to the course platform previously showed in Figure 5-11?
- More specifically, how is the pattern of engagement of K-12 teachers, target audience of this professional development?

Figure 6-17 shows the quantity of participants’ posts by unit as this professional development unfolds. By analyzing the distribution of forum posts throughout the MOOC units, it is possible to see that the quantity of participants’ posts declines as the MOOC progresses. The graph in Figure 6-17 presents a similar trend as the graph of participants’ logs shown in Figure 5-11. Figure 6-17 shows that the MOOC starts with participants posting 567 times (i.e. quantity of
posts in Unit 1) and finishes with participants posting 190 times (i.e. quantity of posts in Unit 5). This difference represents a decrease of 374 posts when comparing participants’ posts from Unit 5 to participants’ posts from Unit 1. This decreasing trend in the pattern of participants’ posts aligns to the pattern of engagement previously documented in the MOOC literature (Fini, 2009; Onah, Sinclair, & Boyatt, 2014; Brinton et al., 2013; Kizilcec, Piech, Schneider, 2013; Thomas, 2002) meaning that this decreasing trend is not a particular feature of this MOOC.

![Quantity of Posts by Unit](image)

Figure 6-17. Quantity of participants’ posts by unit.

Besides looking at the quantity of posts generated in each unit of this MOOC, it is important to know how many active participants engaged in each unit, thus generating the posts presented in Figure 6-17. Figure 6-18 shows the quantity of unique participants compared to the quantity of participants’ posts by unit. Figure 6-19 shows the quantity of posts by unique participants in this MOOC. From Figure 6-19, it is possible to notice that participants posted an average 2.7 of times per unit (represented in Figure 6-19 by a dotted line). Figure 6-19 shows that the quantity of posts per unique active participant (i.e., participant who created a discussion and/or replied to a post of others) marginally varies as the MOOC develops.
Figure 6-18. Quantity of unique participants and quantity of participants’ posts by unit.

Figure 6-19. Quantity of posts by unique active participants.
Observing the quantity of posts generated by the active participants in this MOOC as shown in Figure 6-17 the reader might be wondering how many of them were, in fact, K-12 teachers, the target audience of this professional development. Table 6-13 shows that, on average, 60% of active participants in this MOOC were comprised of the target audience of this professional development. Three hundred and twenty-seven K-12 teachers out of 561 active participants in this MOOC engaged in forums by creating a new discussion and/or replying to a post of someone else. The trend on quantity of posts of K-12 teachers also follows the general trend presented in Figure 6-17, showing a decrease in the quantity of posts generated by K-12 teachers as they went through this professional development as shown in Figure 6-20.

Table 6-13. Quantity of unique K-12 teachers compared to quantity of unique participants.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Quantity of Unique K-12 Teachers</th>
<th>Quantity of Unique Participants</th>
<th>% of Unique K-12 Teachers/Unique Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>104</td>
<td>199</td>
<td>52.26</td>
</tr>
<tr>
<td>Unit 2</td>
<td>71</td>
<td>120</td>
<td>59.17</td>
</tr>
<tr>
<td>Unit 3</td>
<td>56</td>
<td>92</td>
<td>60.87</td>
</tr>
<tr>
<td>Unit 4</td>
<td>47</td>
<td>75</td>
<td>62.67</td>
</tr>
<tr>
<td>Unit 5</td>
<td>49</td>
<td>75</td>
<td>65.33</td>
</tr>
<tr>
<td>Total</td>
<td>327</td>
<td>Total: 561</td>
<td>Average: 60.06</td>
</tr>
</tbody>
</table>
The analysis presented in this section excluded participants’ introductory posts (i.e., Unit 0 with 478 posts). These introductory posts were excluded from this analysis because the focus here was to see the trend of engagement throughout the MOOC units, and posts from Unit 0 occurred before participants truly engaged with the MOOC content that starts in Unit 1. The discussion forum from Unit 0 was asking participants to introduce themselves and to talk more about their interest in this professional development. Examples of posts classified as introductory posts and excluded from this analysis are:

Greetings All! I am 3546, former college professor and current high school math teacher (all levels). I love teaching statistics and learning new technologies and methods for conveying my love of statistics and its usefulness to my students. I look forward to working with everyone. (Participant #3546)

Hi 3546! I am very excited to learn with people like you who enjoy teaching students as well as learning themselves! (Participant #4319)
Discussion about the Distribution of Forum Posts as the MOOC Progresses

This section showed that the quantity of posts decreased as the MOOC developed. This decrease in the quantity of posts goes along with the decrease in the number of active participants in forums as shown in Figure 6-18. When exploring the quantity of posts by unique active participants in forums, it was possible to notice that the quantity of posts per unique active participant marginally varied as the MOOC developed. Although some participants were not active in forums, the ones who were active kept their posting activity almost constant in forums throughout the MOOC.

The issue of decrease in the quantity of forum posts as a MOOC develops has been documented by many authors (e.g., Fini, 2009; Onah, Sinclair, & Boyatt, 2014; Brinton et al., 2013; Kizilcec, Piech, Schneider, 2013; Thomas, 2002). Some of these authors have taken initiatives to explore the patterns of participants’ posts when using different MOOC forums setups, as the case of Onah, Sinclair, and Boyatt (2014) who investigated the patterns of participants’ engagement in peer support discussion forums and in tutor-monitored discussion forums. Onah, Sinclair, and Boyatt (2014) concluded that tutor-monitored discussion forums generated a higher number of participants’ posts than peer support discussion forums. However, most of these posts were participants asking technical questions about the MOOC content to the tutors, which may resemble a question and answer forum (i.e., Q&A forum). In peer support discussion forums, the authors reported that some participants did not provide correct answers to others, making engagement less productive among participants.

The MOOC of this study made use of peer support discussion forums in which participants could share their experiences and learn from the experience of others. Different from regular MOOCs in which participants’ focus in forums is to understand the subject content, in this MOOC participants’ focus in forums was to enhance their own professional learning. Thus,
participants used forums as spaces to get acquainted with the MOOC resources, to reflect before and/or after their teaching practice, and to share with others their expectations about potential implementation of what they learned from this professional development. As participants engaged in forums throughout this MOOC, their posts could not be classified as right or wrong answers as described in Onah, Sinclair, and Boyatt (2014). Forums posts in this MOOC expressed participants discussing: the MOOC materials, the issues of teaching statistics to their students, extra resources sharing, etc. By doing so, their participation in forums represents participants attempting to enhance their own professional learning about statistics teaching.

In this MOOC 60% of its active participants identified themselves K-12 teachers, the target audience of this professional development initiative. What does it mean to have an online professional development for teachers in which 60% of its active participants were K-12 teachers? There are many ways to interpret this piece of data, and next, I present an interpretation that goes along with the theoretical perspective that guides this study.

This MOOC presenting 60% of its active audience made of K-12 teachers indicates that 327 out 561 active participants were teachers actively engaging with others in forums. When analyzing the number ‘60% are K-12 teachers’ it is important to consider that participation in this professional development was voluntary and diverse. Voluntary means participants were exercising autonomy and coherence by choosing which resources they wanted to learn from and choosing with whom they wanted to interact throughout this professional development experience. Diverse means this MOOC embraced participants from different locations, with different professional roles, and with different levels of experience. Moreover, this professional development did not have any entry barrier such as an entry test to select and/or to group participants by their experience in this MOOC. Thus, to have 60% of active participants as K-12 teachers means that 327 K-12 teachers were voluntarily investing into their own professional knowledge by engaging with others in forums. These participants were aggregating materials
from MOOC pages and aggregating materials shared by others in forums. They were reflecting on their teaching practice of statistics, and they were feedforwarding to the network with their perspectives and experiences.

A question that comes to mind is: How can a MOOC for teachers attract and retain a higher number of K-12 teacher active participants? The action of attracting and retaining more K-12 teachers as active participants in a MOOC for professional development should be approached at least in two ways. In one way schools should give more autonomy to their teachers to choose a professional development tailored to their individual needs. Schools should also provide support for teachers to dedicate themselves to their online professional development as well as support for them to implement what they learned from their professional development. In another way, MOOC providers should establish partnerships with school districts to make this form of professional development known to teachers. By being in contact with school districts MOOC providers could provide tracks in MOOC content that would be even more tailored to the need of those teachers. It is important to mention that there are many other actions that both schools and MOOC providers could take in order to increase attraction and retention of K-12 teachers in MOOCs for professional development. The recommendations above are only initial suggestions and are not intended to be a comprehensive list of actions.

**What Participants Share about Themselves**

Besides engaging in forums to share their perspectives (feedforwarding) about materials offered by this professional development and shared by others, participants in this MOOC also used forums to share their views about themselves. These personal views were classified by the researcher as: (a) participants’ qualifications and weakness, (b) participants’ perceptions of their learning from this MOOC, and (c) participants’ envisioning of potential implementations in their
practice. Below, I present evidence of the content of participants’ posts with respect to these three themes.

*Participants’ Qualifications and Their Perceptions of Weakness*

Participants used forums to share their qualifications and perceptions of weakness. In terms of qualifications, they shared in forums their credentials and their professional experience. In terms of weakness, they shared in forums their insecurities with respect to statistics knowledge and to statistics teaching. Instances of participants sharing their qualifications and their professional experience were concentrated at Unit 0 (course introduction) where participants were asked by the forum prompt to introduce themselves and to talk more about their interest in this professional development. Instances of participants sharing their insecurities with respect to statistics knowledge and to statistics teaching were concentrated at Unit 0 and at Unit 1.

With respect to participants’ qualifications, after engaging with the introductory video from Unit 0 and following the discussion prompt, participants joined forums and introduced themselves mainly following two types of post structure: by sharing their credentials and/or by sharing their professional experience. Examples of participants who introduced themselves by sharing their credentials can be seen on posts of participants 3576 and 4358 that occurred in different discussions threads: “Hi I am a Statistical Analyst working in the Statistical Education team at Statistics New Zealand (NZ's Official Statistics Agency)” (participant 3576), and “Hello all! My name is [participant 4358] and I am a quality engineer in upstate New York” (participant 4358). Other participants also introduced themselves through their qualifications as represented by the examples above.

Other participants introduced themselves by sharing their professional experiences instead of using their credentials. Examples of participants who used this structure were:
participant 3547 who introduced her name and added, “This will be my sixth year teaching AP Statistics”, participant 3486 who introduced herself as “Hi my name is [participant 3486] and I teach at a small area school which covers students from 5 years old to 18 years old. I am sole charge of Maths for students from 12 years to 18 years”, and participant 4205 who introduced himself as “Greetings friends, my name is [participant 4205], and I teach in the Department of Mathematics at the University of Southern Indiana”. Other participants introduced themselves through their professional experiences following a similar structure as the examples above, including the main instructor.

With respect to potential weakness, participants used forums to share with others their insecurities with respect to their academic preparation in statistics, statistics content, and statistics teaching. Instances of participants sharing their insecurities about their academic preparation in statistics were manifested multiple times in forums from Unit 1. Examples of this perception can be evidenced on post of participant 4256 (high school teacher) who stated, “I haven't taken a statistics class for at least 10 years and feel it's time to brush up”. Similarly to participant 4256, participant 5009 (high school teacher) posted in a different discussion, “The last statistics course I took was 3 decades ago, so I too feel a little like a fish out of water!”. The sense that they may need more preparation in statistics was reinforced on participant 3492’s (high school teacher with 4 years of experience) post who said, “I also need the very basic introductory statistics in order to proceed with this course [referring to this MOOC]”.

Besides sharing their perceptions of not having enough academic preparation in statistics, participants also used forums to share their insecurities with respect to their statistics content and statistics teaching. Instances of these insecurities emerged when they engaged with the LOCUS test in Unit 1. These insecurities were also presented at the beginning of this chapter in the section about the content of their posts referring to the LOCUS test. Other instances of their insecurities
were concentrated on their introductory posts at Unit 0. Since their insecurities with the LOCUS test were already covered at the beginning of this chapter, this section complements participants’ perceptions of their insecurities about statistics content and to statistics teaching by using data from participants’ posts in Unit 0 (course introduction).

Participants used forums to talk with others about their insecurities with respect to statistics content. An example was the post of participant 4059 (high school teacher with 11 years of experience) who stated, “I always struggled with statistics as a student myself”. In a different discussion, participant 4409 (high school teacher with 18 years of experience) expressed his lack of confidence on his statistical knowledge by saying, “I say my Statistics knowledge and ability to practice will not hold water to any of you”. The feeling of not being versed on statistics content was present on posts of other participants coming from different discussion threads such as participants 5947, 3794, 5052, and 3950.

Participant 5947 (middle school teacher with 1 year of experience) used forums to state that he doesn’t feel knowledgeable in statistics, “I lack proficiency in the subject”. In a different discussion thread, participant 3794 (middle school teacher with 5 years of experience) stated a similar feeling “I need to become much more versed in statistics”. In another thread, participant 5052 (middle school teacher with 16 years of experience) posted that she was taking the professional development because she did not feel competent on statistics when compared to other skills as she said, “I'm the one to go to for Reading skills and strategies, definitely not statistics. So, here I am”. The post of participant 3950 (high school teacher with 8 years of experience) seems to synthesize this apparent collective feeling of participants not being competent with statistics subject, “It also worries me that so many math teachers seem to be deficient in statistical knowledge (myself included)”. 
Besides their insecurities with respect to statistics content, participants also stated their low confidence in teaching statistics. The examples ahead are representative of participants’ posts with low confidence about teaching statistics classes. Examples of participants who expressed high confidence with respect to their statistics content and their statistics teaching were presented at the beginning of this chapter in the section about the content of participants’ posts with respect to the LOCUS test.

Participant 3853 (middle school teacher with 23 years of experience) stated, “I have always found statistics a difficult topic to teach”. Similarly, participant 5498 (high school teacher with 1 year of experience) stated, “I'm beyond stressed about how to teach this [referring to high school statistical content]”. These two posts show that statistics still seems to be a challenge to teach for both novices and expert teachers. Post of participant 4059 (high school teacher with 11 years of experience) corroborates with this perception of lack of confidence of participants regarding their statistics teaching, “I have been teaching math for 11 years now, and statistics has always been one of my weaknesses”.

The vocabulary used by participants (underlined on their quotes) shows their struggle of not having sufficient academic preparation about statistics content, nor the pedagogical preparation to teach statistics in middle school or high school. Thus, teaching statistics seems to be an act of braveness that demands courage from these participants as expressed by the post of participant 4444 (high school teacher with 20 years of experience) who stated,

Although I have been teaching for twenty years I just recently got up the courage to teach statistics. Statistics was not my strongest in college, I felt like I was not very good at it and was always behind everyone else since my high school did not offer a statistics course. These feelings of inadequacy kept me from attempting to teach this course for far too long.

New curricular demands, as the Common Core (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) seems to have made this lack
of confidence even more apparent, as stated by participant 4932 (middle school teacher with 24 years of experience),

> It’s a little strange; I consider myself a reasonably strong teacher/mathematician, and I’ve been teaching math for over 20 years, but CCSS instantly escalated what I need to know (and to teach) about statistics to the extent that I actually need to supplement my field of knowledge.

Posts as these ones resemble the concerns presented on the rationale of this study where researchers have pointed out the importance of a statistics professional development for teachers since many mathematics teachers don’t feel confident with the subject of statistics and consequently with its teaching (e.g., North & Zewotir, 2006; Wessels, 2011; Giambalvo & Gattuso, 2008; Batanero, Godino & Roa, 2004).

**Discussion about Participants’ Qualifications and Their Perceptions of Weakness**

Through their introductions, participants attended to the forum prompt by saying their name, where were they from, and sharing something about themselves. As they shared ‘something about themselves’, participants posted their qualifications expressed by their credentials and/or their professional experience. The forum prompt also asked participants to state the reasons for taking this professional development (their interest in the course). From their posts, participants were interested in improving their skills with respect to statistical content and to statistics teaching.

The novelty here was participants sharing upfront with others at the first forum of this MOOC their insecurities with respect to their statistics content and their low confidence in teaching statistics. Their posts showed a level of personal information that was not required by the prompt to join in the forum. Somehow participants felt the need to voluntarily share their
struggles with lack of academic preparation, and their vulnerabilities about statistics content and statistics teaching right away as they started this MOOC.

As participants joined the forum and shared with others their personal perceptions of their knowledge and practice of statistics, they took risks and trusted the network in receiving and keeping this information within the group. This meant that these participants were also trusting others, as members of the network. They were trusting on participants they did not know fully yet to keep this information as part of the content that was shared within this professional development.

On the other hand, as they shared their personal perceptions of their knowledge and practice of statistics with strangers in this network, they were also sending a message to others, a cue that they were open to receive messages with similar content from others. On a large scale, as participants shared their insecurities with others in forums, they created a movement of trust among them that was established upfront, before they fully knew each other. In this sense, participants in this MOOC made use of swift-trust which is a type of trust “activated in a context where temporary groups with little or no prior history have to work together within a short period of time in order to achieve certain projects” (Talboom & Pierson, 2013, p. 90).

Since there was not enough time for participants to establish relationships with each other first, and then, trust on each other as in the most common use of trust (i.e., person-based trust, Lewicki & Bunker, 1996) they behaved as if trust was already present as stated by Talboom and Pierson (2013) when talking about swift-trust. The cues for participants’ swift-trust to emerge were their insecurities with respect to statistics content and to statistics teaching as underlined in their posts. Thus, by “seeing oneself as similar to other people (or as part of a common group or category) provides a basis for assuming that these individuals have similar values and will therefore behave in similar and predictable ways” (Adams, Waldherr, Sartori, & Thomson, 2007,
p. 2). In this sense, interactions of participants in forums with respect to their insecurities created a common group in which they might have perceived themselves as similar to others.

Participants’ Perceptions of Learning from this MOOC

As participants interacted in forums throughout all five units of this MOOC, they voluntarily shared their perceptions of learning from this professional development. These perceptions of learning were not prompted by the MOOC provider and emerged in forums 116 times, with some participants posting their perceptions of learning more than once in the same or in different forums and units. A common element among all posts in which participants self-reported their perception of learning was the importance of the resource provided by the MOOC in their learning (underlined on their quotes). In this section, I present participants’ posts containing the self-reporting of their learning.

In Unit 1, participant 5382 (college professor with 8 years of experience) referring to the LOCUS test posted in a forum, “From the assessment [LOCUS test] I have learned that being able to interpret the results is as important as learning how to compute them”. Participant 4318 (middle school teacher with 20 years of experience) also posted in a different forum her perception of learning as she stated, “I think my biggest take from Unit 1 is knowing about Gapminder”.

In Unit 2, Participant 4191 (high school teacher with 6 years of experience) posted that learning the differences from mathematics and statistics as presented on the materials at that Unit was important for him as he stated, “The most interesting point I got from the lesson was that one of the big differences between the two [mathematics and statistics] are variability, and uncertainty of conclusions”. Participant 3348 (college student) also used forums to share her perceptions of
learning from the video with experts available at Unit 2. She stated, “[Expert 1’s] discussion was also one of the big lessons that I got from this unit”.

In Unit 3, participant 5481 (high school teacher with 15 years of experience) also used forums to share what she learned with the videos available at Unit 3, especially the video with experts as she stated, “The videos and panel discussion are all helpful, learning how to pose questions, generate class discussions, engage students, and how to teach statistical concepts using 21st century tools at three different levels”. In Unit 4, participant 4514 (high school teacher with 24 years of experience) shared in forums that the LOCUS test from unit1 and the CAOS test (Comprehensive Assessment of Outcomes in a first Statistics Course) from Unit 4 helped her with the notions of statistical literacy, statistical reasoning and statistical thinking.

As an inexperienced stats teacher, I really appreciate the sample assessment items found at the LOCUS website and at the ARTIST website. The sample assessment items help me understand the levels of statistical literacy, reasoning and thinking I need to develop in my students (and myself). [...] The resources on these websites will certainly help guide my instruction and develop my own questioning techniques.

The CAOS test is a free tool and it can be found at https://apps3.cehd.umn.edu/artist/caos.html. Participant 3348 (college student) also highlighted the tools provided in Unit 4, “All the tools, and especially videos provided me with a great experience to practice my skills in statistics”.

In Unit 5, participants had chance to retake the Self-Efficacy to Teach Statistics (SETS) Survey took by them at the beginning of this MOOC. The SETS is a survey that measures “teachers’ self-efficacy to teach topics at GAISE levels A and B as well as K–8” (Harrell-Williams, Sorto, Pierce, Lesser, & Murphy, 2015, p. 1). With respect to SETS survey, participant 3235 (middle school teacher with 3 years of experience) posted in a forum of Unit 5 that her confidence in teaching statistics has increased since she took the survey at the beginning of this
MOOC, “Yes, my confidence has increased a little and I really like the idea of using more 
simulations. Hopefully it will work!”

Other participants used forums in Unit 5 to voluntarily provide a feedback of their 
learning with respect to the whole course instead of referring to a specific resource. For instance, 
participant 4409 (high school teacher with 18 years of experience) who stated, “This course was 
greatly a big booster to my confidence in both learning and readying myself to teach Statistics. 
[...] I hope to save several of the resources available here to guide me through”. In a different 
discussion, participant 3225 (high school teacher with 30 years of experience) stated in a different 
discussion thread “This course was a great booster for me in resources and confidence”.

From the ones who volunteered their perceptions of learning in forums, some participants 
explicitly mentioned their interaction with others as important element of their learning. It was 
the case of participant 5731 (college professor with 15 years of experience) who stated, “It was a 
unique opportunity for me and I have learned a lot specifically from your classroom experience”, 
referring to the experience of her colleagues in this MOOC. Participant 3225 (high school teacher 
with 30 years of experience) also highlight the contribution of others in her own learning as she 
compared her experience in this professional development with previous experiences she had, 
“[...] I took an in-person course and spent a week feeling not very bright, here [at this MOOC] 
each person is taking time to explain and answer questions. This is much more comfortable and 
so I am learning more”.

**Discussion about Participants’ Perceptions of Learning from this MOOC**

Among 116 instances of participants’ volunteering their perceptions of learning from this 
MOOC, there were 90 instances of participants sharing their perceived value on specific
resources provided at each unit. There were eight instances in which participants perceived value in their discussions with others (forum interactions), and 18 instances in which participants were more general in their comments expressing that the whole course was important for their learning.

Although these comments were in nature participants’ self-reports of their perceptions of learning from this MOOC, they were evidences that reinforce the notion proposed by connectivism (Siemens, 2005; Siemens & Downes, 2011) that participants learn as they establish and experience connections through the network, in this case with materials and with people. From participants who volunteered their perceptions of learning, materials emerged as a salient feature in their self-report of learning. The novelty of some resources presented by this MOOC such as Gapminder, LOCUS test, SETS survey, etc., might have accounted for their mentions of resources as they volunteered their perceived learning. The abundance of open resources available in this MOOC might also have accounted for participants mentioning these resources in their comments.

The nature of materials available in this MOOC allowed participants to aggregate resources that could be used for their own learning, for future reference and/or for future use in their classes. The possibility of saving these resources for moments of need seems to be one of the reasons for participants’ aggregation of resources. Evidence of this fact can be seen in the posts of participants 3136, 4814, and 3722 who made explicit their reasons in their posts. Participant 3136 (college professor with 15 years of experience) stated that he stored the materials for future reference, “I like it very much reviewing and reading the materials posted and so I saved them all for future references”. Participant 4814 (high school teacher with 25 years of experience) posted in a different thread that the materials stored by her could be used in time of need, as she stated, “I have lots of links and bookmarks to revisit when time permits or when I find myself a bit lost”. Participant 3722 (high school teacher with 8 years of experience) valued
the resources since she could explore them in her class, “[...] I do appreciate gaining more resources to continue to explore as I'm teaching my AP course”. In terms of connectivism (Siemens & Downes, 2011) participants aggregated most of the resources, repurposed some of them by expressing how they would use that resource in their practice, and fed-forward their perceptions about these resources back to the network. The aggregation of resources virtually happened by all kind of participants (i.e., high/middle school teachers, college professors, college students, etc.).

**Participants’ Envisioning Potential Implementation in Their Practice**

As participants interacted in forums throughout all five units of this MOOC, some made public their intentions of implementing in their classes some tool, approach or activity provided by this professional development. In terms of discussion prompts, none of the prompts asked participants to think about implementation in practice. Thus, participants’ sharing of potential implementations in their classes emerged as they interacted in forums. In this section, I present participants’ posts containing their envisioning of potential implementation in their practice.

Starting at Unit 1, participants used forums to voluntarily share their intentions of implementation of materials they had engaged with throughout this MOOC. Examples of participants sharing their intentions of implementation were seen in participants who replied to a discussion thread created by participant 4533 (college professor with 30 years of experience) who asked “Has anyone ever used Gapminder? It looks very interesting”. This thread generated 31 replies where participants reflected about the Gapminder tool and their personal teaching practice. Seven of these 31 replies referred to participants who shared their intentions to implement Gapminder in their classroom or their intentions to share the tool with other teachers. Table 6-14
synthesizes these posts. The evidence of their expression of potential implementation or share with colleagues are underlined in their posts on Table 6-14.

Table 6-14. Posts of participants who volunteered their intentions to implement Gapminder or to share Gapminder with their colleagues.

<table>
<thead>
<tr>
<th>Forum Post</th>
<th>Participant ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>I had never used it before, but <em>I'm going to introduce it to my students next week!</em> The discussion topics seem endless.</td>
<td>4513 (college professor with 21 years of experience)</td>
</tr>
<tr>
<td>At our school we are looking at doing more collaborative teaching between different subjects, <em>I can see using Gapminder would be ideal for doing a unit of work with collaboration between Maths and Social Studies (or Geography).</em></td>
<td>3486 (high school teacher with 12 years of experience)</td>
</tr>
<tr>
<td>This is great. I shared Gapminder with a Biology teacher. She immediately recognized the value of the data sets that were directly applicable to her course and has begun to discuss it's integration.</td>
<td>3495 (instructional coach with 40 years of experience)</td>
</tr>
<tr>
<td>I am thinking that I too will use it sometime this week. The lesson plan included might be a great way to introduce it to the students. I think that they could definitely find something in there that would pique their interest.</td>
<td>4451 (high school teacher with 22 years of experience)</td>
</tr>
<tr>
<td>Definitely looks like a good resource. I look forward to sharing it with some of the middle school teachers I work with. I think some of you mentioned bias, but I wanted to bring it out even further. In the video on the site, students definitely went ahead and made some hypothesis about reasons for lower income/age expectancies. I would want to make sure my teachers also explored these and discussed/researched them further, so as not to further strengthen student bias.</td>
<td>3284 (instructional technology facilitator with 15 years of experience)</td>
</tr>
<tr>
<td>I found Gapminder compelling, also. I have not used it before, but plan to use it for warm-ups in my Statistics class in the spring. I plan to present some of the data from the spreadsheets and ask students to develop questions from the data to solve. I think it will help with conceptualizing statistics.</td>
<td>3309 (college professor with 34 years of experience)</td>
</tr>
<tr>
<td>It's perfect for middle school students! My Grade 7 students would love it. My students come from all over the world so bringing this access to global data will be engaging. The types of questions alone will be interesting and revealing (biases, misconceptions, etc.) I just have to figure out how to engage them with it using just my laptop and data projector. It would be awesome to have 1:1 access to computers or at least 1 per pair.</td>
<td>3991 (middle school teacher with 14 years of experience)</td>
</tr>
</tbody>
</table>
Still on the same discussion thread, five participants informed that they had already used Gapminder in their classes, as shown on Table 6-15. Evidence of their references about using Gapminder are underlined on their posts on Table 6-15.

Table 6-15. Posts of participants informing their use of Gapminder.

<table>
<thead>
<tr>
<th>Forum Post</th>
<th>Participant ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>I've used Gapminder-- what's great is when you can have students come to an interactive board, and move the data and variables around, themselves! Gapminder has data of great interest to high school students. I think it could be used in middle school, too, where (at least where I’ve taught) instruction can be interdisciplinary, so kids could focus on a continent, say, that is currently in the social studies curriculum.</td>
<td>3323 (high school teacher with 20 years of experience)</td>
</tr>
<tr>
<td>I regularly use it, but I haven’t required students to interact individually with the data. After watching the video of the year 8 students, I am going to have my students watch that video and then find a country (besides Haiti or the Dominican Republic) to investigate and write a paragraph report.</td>
<td>3587 (college professor with 18 years of experience)</td>
</tr>
<tr>
<td>Dear all, Gapminder is a fantastic tool for all grades especially as I found for my students in the University. First you have to explain several matters for your students before you start. No1 you have to explain how many dimensions we have (they are 4 dimensions or we can say variables) on the same graph. No2 to explain all contents located on the top right corner, where just stop on any content using the mouse and see the light flash. No3. chose an example and prepare it well for your students and you can save it in above menu bar. No4 reduce the speed before click play so you can explain what is going on while the play is working. I hope these simple, basic and so easy instructions can be useful for some of you.</td>
<td>3615 (college professor with 21 years of experience)</td>
</tr>
<tr>
<td>I love Gapminder! I had my junior students do a project using Gapminder last year. It was so successful that this year I am looking to try and create a cross curricular project with the Social Science department. The students were so passionate about it!</td>
<td>4973 (high school teacher with 6 years of experience)</td>
</tr>
<tr>
<td>I'm a nonformal educator (teaching global and environmental topics) and have used Gapminder for a few years now. I also had the pleasure of attending one of Hans Rosling's talks 2 years ago when he was in DC. Students and adults alike, given the proper time to understand and digest the graphs, love it! (And him!) It might be worth mentioning that the data can also be pulled from Gapminder into Excel docs. We've found that useful in numerous way. Most recently we inputted it into ArcGIS and created a global heat map of fertility rates from 1950-2000 using this data.</td>
<td>4265 (Professional development with 6 years of experience)</td>
</tr>
</tbody>
</table>
Attention to students (posts of participants 4513, 4451, 3309, and 3991), to curriculum (posts of participants 3486 and 3495), and to other teachers (post of participant 3284) emerged as potential reasons in participants’ posts about intentions to implement Gapminder. Attention to students (posts of participants 3323, 3587, 3615, and 4973) and to further use of the tool (post of participant 4265) emerged as important elements for participants’ who have already used Gapminder. In this discussion thread, participants were very explicit about their intentions of implementing Gapminder in their practice. Although they don't make clear why they selected that resource to share in forums their envisioned plans about implementation of this tool.

In Unit 2, participant 4514 (high school teacher with 24 years of experience) created a discussion thread by posting that she had a “light bulb moment” while watching the expert video, in which the main instructor talks with statistics professional experts. In this video the instructor and professional experts were talking about the phases of a statistical investigation (posing a question, collecting data, analyzing data, and interpreting results) and the differences between mathematics and statistics. In her post participant 4514 stated that although she had worked several years as high school mathematics teacher she had never taught statistics as described by the experts on the video from Unit 2. After her interaction with the resource (watching the expert video), she shared that her practice was teaching statistics similarly as teaching mathematics without including opportunities for students to pose questions, look how the data was collect and analyze the data. She seemed to agree with the video in a sense that teaching statistics as mathematics may reduce the potential of statistics class. She shared in forums that she would like to encourage statistical habits of mind and the use of real data in her classroom as underlined,

While listening to the "expert panel" and reading the posted articles at the beginning of the unit, I had a "lightbulb moment". Although I have been teaching HS math for 24 years, I have never actually taught "statistics" as defined by the members of the expert panel. I have taught units that I THOUGHT were statistics, but I was merely providing students with a few mathematical tools that statisticians can use (e.g. - finding a mean, making a histogram, calculating a standard deviation, etc.). [Expert 1 in the video] said that math teachers often jump right to
the "analyze phase" with a given set of data without ever posing any meaningful questions, looking at how the data was collected, or even why it was collected. That sounds way too much like what is going on at my school for students who only experience "stats" in our Algebra 2 course, and don't go on to the college level course we offer. [Expert 2 in the video] added that this practice "trivializes" statistics. Ouch!! Guilty as charged!! I am looking forward to learning how to encourage the statistical habits of mind [a main instructor] listed in her article, and creating opportunities for meaningful engagement with real data in the classroom.

Her post generated 14 replies from other participants who also reflected about their practice of teaching statistics envisioning potential changes in their lessons. An example was participant 4726 (high school teacher with 10 years of experience) who replied to the discussion thread saying that she was considering trying to incorporate the statistical investigation cycle in her class as underlined,

I certainly can relate to spending a lot of time on the analysis phase. I definitely will try to do a better job with my students to go through all 4 parts of the cycle. That being said, I feel like a lot of time needs to be spent on each part individually and then put all of them together during different parts of the school year. In no way am I saying that we shouldn't strive to use the cycle frequently, but if our goal for the unit is to talk about how to conduct a study or experiment, then I will focus on the second phase. If our goal is to learn how to do inference, I'll have to focus on the third and fourth phase. Maybe I'll try to integrate 1 of these complete cycles each unit in my AP stats course. [...] 

Another example in the same discussion thread was participant 1478 (high school teacher with 20 years of experience) who also replied to participant 4514 saying she had the same realization with respect to her classes as participant 4514. In her post, she also stated her intention to include the habits of mind in her lesson as underlined,

I had the same "lightbulb". Currently, I teach online with a curriculum fully developed that I mostly facilitate and the data/statistics unit is really just looking at the mechanics of constructing the various types of graphs. When we get to the unit this year, I plan to expand it to include the habits of mind.

Posts from participants 4514, 4726, and 1478 in this discussion thread showed that through their interactions with materials available at this MOOC, they used forums to share their
teaching practice (for instance, teaching statistics lesson as mathematical lessons) and to consider potential changes and adjusts in their statistics lessons as a way to make these classes more investigative.

In rare moments, participants used forums to share the fact that they had implemented a change in their classes based on their interactions with materials from this MOOC. An example of this fact was participant 4514 (high school teacher with 24 years of experience) who opened a new discussion thread in Unit 3 expressing her appreciation to the video where the main instructor talks with Expert 1 about the GAISE framework (Franklin et al. 2007). In the video, Expert 1 explains the development of the concept of the mean for students at different levels of the GAISE framework. Based on her interaction with the video, participant 4514 stated,

I really appreciated [Expert 1’s] discussion of the mean at various levels of sophistication and the idea of variation as it relates to the mean. I think even high school students need to revisit the idea of the mean being a "fair share value". [Expert 1] did a great job explaining variation as the minimum number of "things" (e.g. - family members) to move so that every trial reaches the "fair share" amount. The line drawn on the block diagram at the mean level was a very effective visual.

Participant 4514 added to her previous post informing that she had used the approach presented by Expert 1 in the video to teach the concept of mean as underlined in her post, “I actually used [Expert 1’s] visual of the block diagram to teach "average value of a function" today in my AP Calc class. Thanks, [Expert 1]!” After this post, participant 4514 was probed by instructor B to share more about how her implementation. She shared with participants in that discussion thread that her students could understand the idea of average value of a function as suggested by the Expert 1 in the video (as underlined in her post),

It went great! The students totally "bought in" to the idea that the average value of a function was the height of a rectangle that spread the area under the curve over the interval in question. I told them to imagine that the area under the curve from \(x=a\) to \(x=b\) was composed of a single layer of tiny marbles, and then imagine reorganizing the marbles into a rectangle whose base was the interval \([a, b]\). The students figured out that the height of the rectangle was the average value without me having to do a formal proof.
Participant 954 (elementary teacher with 9 years of experience) also engaged in the same discussion thread to share her appreciation to the video similarly as done by participant 4514. In participant 954’s post, she also stated that she envisioned herself doing the same approach of the video to teach the concept of mean to her elementary students (as underlined in her post),

I also like [Expert 1’s] activity representing family members using stackable blocks. That really made a good visual and physical representation that made sense to me. I could see myself doing this with my 1st through 3rd graders, or at least something similar. The activity seems to be engaging and something hands-on that young students would like and learn from.

Discussion about Participants’ Envisioning of Potential Implementations in their Practice

Although not prompted by the MOOC provider, some participants made public their intentions of implementing in their classes some tool, approach or activity provided by this professional development, as examples from units 1, 2 and 3 presented in this section. Other instances of participants sharing their intentions of implementation also happened in units 4 and 5 and were suppressed here since they resemble the structure of the examples presented in this section.

When considering a potential implementation in their practice of some tool, approach or activity provided by this professional development, some participants directly stated that they were planning to incorporate the resource without sharing much of their reflexive process, as the participants who talked about implementing Gapminder. Other participants stated their reflections about the resource, their reflections about their current practice, and then stated some potential implementation of the resource in their practice, as presented in the discussions about the implementation of the SASI framework in Unit 2. In rare situations, a participant shared back to
the network that she/he interacted with the resource and already implemented an idea from the resource or the resource in their practice, as exemplified by participant 4514 who shared in forums her implementation of a more holistic approach to teach the concept of mean in Unit 3.

Participants sharing their envisioning of potential implementation in practice is evidence of their autonomy as they personalized the experiences provided by this professional development bringing them into their realities. Participants’ posts like the ones presented in this section suggest teachers’ ownership of the practices established in their classrooms, as well as a leadership with respect to their own initiative of improving their own teaching and consequently provide a richer experience to their students or colleagues.

The resources available in this MOOC acted as “triggers” making participants reflect about their current practice and envisioning a potential change that would benefit their students or their colleagues. As said in the previous results chapter, teachers’ implementation of their learning in their practice wasn’t focus of this MOOC by design. So, it is natural for the MOOC to fall short in anything with respect to participants’ implementation. This explains the lack of deepness in the conversations about teachers’ implementations and consequently teachers’ change of their practice. On the other hand, the discussions presented in this section emerged naturally from participants and were highly related to materials with which they had previously interacted. Based on results of this section it is possible to say that there is a lot of potential for MOOCs to be designed to assist teachers who manifest interest of changing their practice as the ones showed here.
How Participants Interact with Others

In order to fully understand the nature of participants’ interactions with others it is important to depict how participants treated others as they interacted in forums. As participants engaged with others in forums, they expressed concordance with the ideas of others and solace to each other. In this section, I present evidence of the content of participants’ posts with respect to concordance and solace among them.

In their posts, participants mainly expressed concordance with the ideas of others throughout all forums in this MOOC. An example was the discussion thread started by participant 4621 who stated that Gapminder video was “an amazing way for students to see data in action and to be able to understand how data can be used to explain events or vice versa”. Her post attracted 14 participants who also agreed about the potential of Gapminder in class. Evidence of participants’ statements of concordance are underlined in Table 6-16. Within Table 6-16 it is possible to see participant 4639 and participant 3915 agreeing with participant 4838 (in bold and underlined) about Gapminder cross-curricular nature as a mini-discussion embedded in a big discussion created by participant 4621 about Gapminder.

Table 6-16. Participants’ statements of concordance about the potential of Gapminder.

<table>
<thead>
<tr>
<th>Forum Post Body</th>
<th>Participants ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Gapminder video is an amazing way for students to see data in action and to be able to understand how data can be used to explain events or vice versa. […]</td>
<td>4621 (high school teacher with 14 years of experience)</td>
</tr>
<tr>
<td>I agree, I think my biggest take from Unit 1 is knowing about Gapminder. […]</td>
<td>4318 (middle school teacher with 20 years of experience)</td>
</tr>
<tr>
<td>I thought Gapminder opened the door for a lot of cross-curricular conversation and research and would be a great springboard for a deep dive into cause and effect and historical context as partners for statistical analysis.</td>
<td>4838 (high school teacher with 22 years of experience)</td>
</tr>
<tr>
<td>[Participant 4838,] I was also struck by the cross-curricular nature of GapMinder. […]</td>
<td>4639 (middle school teacher)</td>
</tr>
</tbody>
</table>
Yeap, I have already explored as I have downloaded it to my laptop...... and there are also other categories of data that could be utilized. thank you  

I agree. In addition, I found the interaction with Gapminder was so interesting that I spent (probably way too much) time just exploring. [...]  

I found Gapminder as intriguing as you all have and I spent a lot of time trying to understand what I was seeing. [...]  

Me too! I have lots of "real work" I should be tending to, but I really got sucked into using Gapminder.  

Hi, [Participant 4838], I also played with some United States data, and I was fascinated to know more about a drop in life expectancy for a couple of years in the 1800s. Gapminder is an exciting tool with lots of possibilities. [...]  

Yes, I really loved the video of the 8th grade students. [...]  

I agree. I absolutely loved the rich discussion the students were having towards the end of the video. [...]  

I too appreciated the Gapminder Tool. [...]  

I really loved this video as well. [...]  

Good stuff  

I agree that Gapminder has great potential. [...]  

Another example of concordance among participants happened when participant 4819 opened a new discussion thread in Unit 1 to talk about his perceptions of students dealing with the task “Jane’s age” on the video embedded as a resource in this MOOC. In his post, participant 4819 stated that Jane’s age activity could be a great task to introduce data collection and inferences. Four participants plus the main instructor engaged later in this discussion and expressed agreement with participant 4819’s point of view that Jane’s age activity could, indeed,
be a good approach to introduce data collection, as presented in Table 6-17. Evidence of participants’ statements of concordance are underlined in Table 6-17.

Table 6-17. Participants’ agreement about the use of Jane’s age activity.

<table>
<thead>
<tr>
<th>Forum Post Body</th>
<th>Participants ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>I thought this was a very interesting question and I’d love to see how other</td>
<td>4819</td>
</tr>
<tr>
<td>students would respond to it. I think it is a great intro to what data collection,</td>
<td>(curriculum specialist with</td>
</tr>
<tr>
<td>statistics, and inferences are all about. I also see it leading into discussions</td>
<td>15 years of experience)</td>
</tr>
<tr>
<td>about reliable uses of data.</td>
<td></td>
</tr>
<tr>
<td>I agree. I think this would be a great intro for this topic.</td>
<td>3402</td>
</tr>
<tr>
<td>[…]</td>
<td>(instructional coach with 23 years of experience)</td>
</tr>
<tr>
<td>I agree. [Participant 4819] that it is a good task that can lead into a</td>
<td>Main Instructor</td>
</tr>
<tr>
<td>discussion about different data collection methods, measurement issues, and</td>
<td></td>
</tr>
<tr>
<td>bias [...].</td>
<td></td>
</tr>
<tr>
<td>I agree. I would turn the discussion to sampling and sampling bias. [...]</td>
<td>4386</td>
</tr>
<tr>
<td>(high school teacher with 20 years of experience)</td>
<td></td>
</tr>
<tr>
<td>I agree with you. This question would be a great way to start a discussion</td>
<td>3348</td>
</tr>
<tr>
<td>about statistics and its components. [...]</td>
<td>(college student)</td>
</tr>
<tr>
<td>I agree. This is a real life question. [...]</td>
<td>5260</td>
</tr>
<tr>
<td>(high school teacher with 10 years of experience)</td>
<td></td>
</tr>
</tbody>
</table>

Discordances among participants were rare, and when it happened they were subtle and concentrated on ideas expressed by participants, as for example in the discussion thread created by participant 4921. Participant 4921 opened a new discussion thread expressing her understanding of students in the video dealing with data from Schoolopoly activity (a resource provided by this MOOC). She stated that the middle and high school students in the video were acting at different levels of sophistication, as shown on her post on Table 6-18. Participant 4409, disagreed with participant 4921, indicating that although students may be at different grades, their levels of reasoning were similar. Participant 4891 added a clarification to the discussion distinguishing levels of sophistication in the SASI framework from participants engagement with the Schoolopoly activity. Participants 4172, 3577, 3346, and the main instructor agreed with
participant 4891 that although high school students presented a higher level of sophistication in the SASI framework when compared to the middle school students, middle school students presented a higher engagement with the task (exploring hypothesis, trying different sample sizes, etc.). Evidence of participants’ statements of disagreement are in bold on Table 6-18.

Table 6-18. Participants disagreement about the levels of sophistication of students on the Schoolopoly activity.

<table>
<thead>
<tr>
<th>Forum Post Body</th>
<th>Participants ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>[...] These videos easily showed differences between middle and high school students. The middle school students used more visual evidence (charts). The high school used more sophisticated; statistical measures. [...]</td>
<td>4921 (high school teacher with 10 years of experience)</td>
</tr>
<tr>
<td>[Participant 4921], I surely do not have a very differentiated opinion with how elementary students work when compared to the grade 9s' or 10s' of my school. It seems that they think and act the same even though they are already in high school. [...]</td>
<td>4409 (high school teacher with 18 years of experience)</td>
</tr>
<tr>
<td>I think my interpretation of the question of &quot;sophistication level&quot; was a bit different than was intended. When I compared the engagement and reasoning among the groups, I felt that the middle school pair who ran 1000 trials engaged greater reasoning and were much more engaged. While the high pair had the right &quot;tools&quot;, I felt that they merely relied on what the &quot;formulas&quot; showed rather than engaging with the simulation in context and trying to interpret what was going on. [...]</td>
<td>4891 (curriculum specialist with 20 years of experience)</td>
</tr>
<tr>
<td>[Participant 4891], I agreed with you. I thought there was more meaningful discussion at the middle school level.</td>
<td>4172 (high school teacher with 20 years of experience)</td>
</tr>
<tr>
<td>I also agree with you [Participant 4891]. The lowest level students didn't equally understand statistics, as one continued to keep with the argument of &quot;fair&quot; and was a bit of a bully. The middle school kids showed some great thinking, and understanding. [...]</td>
<td>3577 (statistician with 4 years of experience)</td>
</tr>
<tr>
<td>This is a great discussion! I agree that using more statistically sophisticated tools like a formal test does not imply the highest level of sophisticated reasoning! [...]</td>
<td>Main Instructor</td>
</tr>
<tr>
<td>I also agree, my impression was that they thought that the die wasn't fair, but then just relied on the chi test rather than investigating further.</td>
<td>3346 (high school teacher with 8 years of experience)</td>
</tr>
</tbody>
</table>

Participants’ expression of solace towards others appeared throughout multiple forums in this MOOC with a higher concentration on posts related to the LOCUS test. As some participants
perceived they had not done well in the LOCUS test, they joined forums to share with others their experience with the assessment. Next, I present a discussion thread as evidence of participants providing solace to others.

After interacting with the LOCUS test, participant 4593 opened a new discussion thread (Table 6-19) stating that she was impressed with the complexities of the questions in the assessment and she was concerned about the risk of not being well versed to teach statistics to her future students. Participant 4726 replied to participant 4593 providing comfort by stating that she has taught Advanced Placement Statistics (AP Stats) for three years, and just now she started to understand the concepts that she has been teaching. By sharing her own experience to participant 4593, participant 4726 seemed to have given solace to participant 4593. Participant 4726’s solace was given by informing participant 4593 that learning to teach statistics is a process and it had also happened to her. As part of the sense of comfort provided by participant 4726, she still offered advice to participant 4593 by saying that participant 4593 should not feel incompetent because of her performance on the assessment. Participant 4726’s advice seemed to be also valuable to participant 3850.

The behavior of providing comfort and encouragement to one another was also appreciated by the main instructor as a positive contribution in forums, as shown on Table 6-19. The interaction of participants 4593, 4726, and main instructor may also have attracted participation from other two participants. Participant 6216 joined the discussion by replying to participant 4593 informing that if she decides to teach AP Stats, she could join the AP Teacher Community. Participant 6313 joined the discussion by reinforcing the statement made by participant 4726, saying that after her third year of teaching AP Stats she started to feel more comfortable with the content and with its teaching process. Statements of comforting and encouragement involved to this discussion are in bold on Table 6-19.
Table 6-19. Participants statements of comforting and encouragement about statistics teaching to participant 4593.

<table>
<thead>
<tr>
<th>Forum Post Body</th>
<th>Participants ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>As a pre-service teacher, my skills to assist students is only just beginning. And let me tell you, after this investigation- I am in awe over the complexity of statistic questions. [...] As a future educator, if I'm not able to understand what I am teaching, there is no way my students will be able to master the content. [...]</td>
<td>4593 (college student)</td>
</tr>
<tr>
<td>This is my 3rd year teaching AP stats - and I'm just now starting to feel like I kind of understand what I’m teaching. And I have a Stats minor! I'm not telling you this to discourage you - just the opposite. Just that you constantly learn as you teach. Don't feel incompetent because you don't know all the answers. Use the opportunity here to gain a group of colleagues you can ask when you need help. And don't forget - when you don't know the answers, ask the students to help teach it. You'll be amazed at how they can really help you understand better. Just remember, you don't have to have all the answers - ever. Certainly not at this point.</td>
<td>4726 (high school teacher with 10 years of experience)</td>
</tr>
<tr>
<td>That's really helpful. I'm a pre-service teacher, too, and in the same situation.</td>
<td>3850 (college student)</td>
</tr>
<tr>
<td>Great advice [Participant 4726]! Thanks for sharing from an experienced teacher's perspective that can help inspire and encourage our newest colleagues (preservice teachers)!</td>
<td>Main instructor</td>
</tr>
<tr>
<td>Also, if you end up teaching AP Statistics, you can join the AP Teacher Community at AP Central. It's a great place for information and access to resources. This is my 7th year teaching AP Stats and I am always learning... sometimes things I didn't even know I had questions about.</td>
<td>6216 (high school teacher with 20 years of experience)</td>
</tr>
<tr>
<td>I agree with advice [Participant 4726]. In my 3rd year of AP stats, I finally felt like I was &quot;getting the groove&quot; of not only the statistics, but how to help students make connections to the big ideas. [...]</td>
<td>6313 (middle school teacher with 16 years of experience)</td>
</tr>
</tbody>
</table>

Similar behavior of participants offering comfort or support to others also happened in 65 posts distributed through discussions about the LOCUS test. Since they resemble each other in structure they were suppressed here.
Discussion about How Participants Interact with Others

As participants interacted with each other in forums, they expressed high concordance with the ideas of others. Discordance or criticism among participants’ ideas was rare in forums. Participants’ behavior of high agreement among themselves resembles Gunawardena, Lowe and Anderson’s (1997) phase one of the Interaction Analysis Model (IAM), in which participants share or compare information, but do not explore dissonance or inconsistency among ideas, concepts or statements.

In terms of disagreement, participants seem to slightly disagree in isolated discussions in which the disagreement was expressed through their negotiation of the meaning of MOOC materials. This behavior resembles the beginning of phase two of the IAM proposed by Gunawardena, Lowe and Anderson’s (1997). As data presented in previous sections of this chapter, participants' posts were mainly focused on making statements about their perceptions of their interactions with MOOC resources, envisioning how these resources could be implemented by them in their practice instead of debating about particularities of any resource. This fact may help us to understand the lack of disagreement among participants as they interacted in forums. The high level of agreement and low level of disagreement among participants in MOOC forums seems to not be a unique characteristic of this MOOC. It was also detected by Bonafini, Chae, Park, and Jablokow (2017) when analyzing forums of a MOOC that was not designed for teachers’ professional development.

Participants also provided solace to each other expressing that they were part of the same group and had similar struggles with statistical content and statistics teaching. Their comments were of encouragement about what other participants have done and about opportunities that might be ahead of them as statistics teachers. In their posts, participants expressed a sense of care for the subject being discussed through the MOOC materials as well a sense of care for what
others were thinking about these materials. Participants’ focus on what was being discussed aligned with their support for each other can be described as caring dialogue in forums as suggested by Wegerif (2007). Their supportive messages to others aligned with their high level of agreement indicate that participants have created a safe environment in forums that could have encouraged others to open themselves and also to interact in forums. Thus, participants’ engagement in forums was a vehicle for a sense of belonging (Wenger, 1998; 2003) created among them.

Wenger (1998) suggests that engagement, imagination, and alignment are the three pillars of belongingness for individuals regarding the environment. Engagement occurred as participants interacted with materials and with others in forums, they engaged in activities related to statistics teaching that gave and/or reinforced their experiences with the subject. Imagination occurred as participants envisioned their actions as statistics teachers through their engagement with materials and with others in forums. Alignment occurred as they constructed their image of what means to be a statistics teacher and to teach statistics through data investigation. In terms of connectivism, supportive messages and a high level of agreement showed participants building and strengthening their network.

**Answering the Second Research Question about the Nature of Participants’ Interactions with Respect to Materials and with Others**

In answering the second research question of this study: *What is the nature of teachers’ and others’ interactions (with materials and with each other) in a MOOC designed for statistical professional development?*, this final section presents my considerations about participants’ interactions in forums with respect to materials and participants’ interactions in forums with respect to others.
Nature of Participants’ Interactions with Respect to Materials

Results show that materials (resources) were vehicles for participants’ interactivity in this MOOC. Interactivity is understood in this study as a process that occurs online and involves person-to-person or person-to-platform interactions. Interactivity happened in this MOOC when participants interacted with resources and when they interacted with each other in forums about the resources. Participants’ interactivity occurred regardless of whether the resource was open or partially open, and regardless of whether or not the discussions contained a prompt.

Participants interacted in forums about resources provided by this MOOC regardless of the type of access to the resource (open or partially open). When posting their experiences with open resources in forums, participants referred to things/activities that they could do as well things/activities their students could do with those resources. When posting their experiences with partially open resources in forums, participants referred only to what they (the participants) could potentially do with the resources.

Participants’ interactivity happened regardless of whether or did not contain a prompt. Participants interacted in forums by electing and discussing some part of the prompt. They changed the discussion target initially established by the prompt to a new and not necessarily related target. They interacted in forums by selecting and discussing resources that resonated with their interests, despite what the prompt may have asked for. As part of participants’ interactivity, they aggregated resources provided by this MOOC and shared open resources back to the network.

Discussion starters acted as network expanders opening new threads and amplifying interactivity among participants. Their actions vehicles to produce more interactivity among the community members. By opening new discussions these participants contributed to the network by creating new nodes in it. By doing so, they opened venues for other participants to aggregate
content embedded in their messages, which could be later repurposed and fed-forward by other participants. Interactivity was also fostered by discussion starters who acted as super-posters. Super-posters replied posts to others and contributed back to the network with content aligned with the resources embedded in this MOOC.

In terms of structure of the networks, results showed that discussions about some resources engaged more participants than others. Materials were essential for the creation of organic networks such as the Gapminder network. When analyzing the content of participants posts and the quantity of interactions in forums with respect to different resources, results indicate that participants’ interactivity was related to the nature of the resource that was available in this MOOC.

The main instructor acted as a steward of interactivity throughout this MOOC. As a participant with the most experience in creation and delivery of this kind of professional development, the main instructor took the leadership role for interactivity by being the most prestigious and the most influential node within the three networks presented in this chapter. By acting as a steward of interactivity, the main instructor ensured that participants were interacting with each other in the discussion threads. As an important node, the main instructor was near to other individuals in this network which allowed her to ensure that participants would not be without answers or guidance as they engaged in forums. By her position in the network and the level of interactivity she presented, the main instructor had influence on the three social networks presented in this study.

Materials were also mentioned by participants as they shared with others their perception of learning from this professional development. Although participants’ perceptions of learning were in the form of participants’ self-reports, they were additional evidence that reinforces that materials were indeed vehicles for their learning as they built a network through their interactions throughout this MOOC.
Considering that materials are vehicles for interactivity in this MOOC, it was up to each participant to interact or not with a selected resource. Thus, participants’ autonomy was the guidance for their interactivity in this MOOC. In this sense, results were aligned with the notion proposed by connectivism (Siemens, 2005; Siemens & Downes, 2011) that participants learn as they establish and experience connections through the network. The openness of most resources available in this MOOC aligned with the possibility of bookmarking resources for further use in their practice seem to have contributed in participants’ attribution of value and aggregation of resources throughout this professional development. In terms of feed-forwarding resources back to the network, participants shared with others only open resources, which reinforce once more the importance of openness.

**Nature of Participants’ Interactions with Respect to Others**

As participants interacted with others in forums, they shared not only their perspectives about the materials (resources) provided by this MOOC but also their qualifications expressed by their credentials and/or professional experience. They also shared their interest in improving their skills with respect to statistical content and to statistics teaching, and their insecurities with respect to statistics content and statistics teaching.

Participants shared their personal information and their insecurities even though it was not required by the forum prompts. By sharing their insecurities with respect to statistics content and statistics teaching, forum participants demonstrated trust in the network. At the same time, they sent a cue to others that they were also open to receiving this kind of message from others. This way, they established a movement of trust among them which is understood as swift-trust.

As participants interacted with each other in forums, they expressed high concordance with ideas and perceptions of others by comparing information without exploring dissonance or
inconsistency among ideas, concepts or statements. Discordance or criticism among participants’ ideas were occasional and when it did occur, the disagreement was expressed via their negotiation of meaning of MOOC materials.

Participants also provided solace to each other by expressing that they were part of the same group and had similar struggles with statistical content and statistics teaching. Their comments were of encouragement to other participants expressing a sense of care for the subject being discussed through the MOOC materials as well a sense of care for what others were thinking about these materials. Their supportive messages to others aligned with their high level of agreement indicate that participants have created a safe environment in forums which may have contributed to their sense of belonging (Wenger, 1998; 2003).

Although not prompted by the MOOC provider, some participants made public in forums their intentions of implementation of the resources in their classes. Their sharing of their envisioning of potential implementation in practice was evidence of their autonomy as they tailored the experiences provided by this professional development.
Chapter 7

MOOCs and Professional Learning: Implications and Possibilities

The purposes of this study were to investigate to what extent the characteristics of effective professional development hold in a MOOC designed for statistics development of secondary teachers, and to depict the nature of teachers’ and others’ interactions (with materials and with each other) in a MOOC designed for statistical professional development. In the results presented in Chapter 5, I described how this MOOC embodied all characteristics of effective professional development. However, these characteristics weren’t transferred in a straightforward fashion from face-to-face professional development literature into this MOOC. I also showed how differently these characteristics were depicted when a MOOC is used as venue for statistics development of secondary teachers. Participants’ autonomy was highlighted as a common element that modified all characteristics explored in that chapter.

In the results from Chapter 6, I showed that materials (resources) were vehicles for participants’ interactivity in this MOOC, in which participants’ interactivity happened regardless of whether the discussions contained prompts. In terms of structure of the networks, results showed that discussions about some resources engaged more participants than others, with materials being essential for the creation of organic networks such as the Gapminder network. Discussion starters acted as network expanders opening new threads and amplifying interactivity among participants, while the main instructor took the leadership role for interactivity and acted as a steward of interactivity throughout this MOOC. The chapter also articulated how participants interacted with others in forums, exposing that they shared not only their perspectives about
materials (resources) provided by this MOOC but also their qualifications and their insecurities with respect to statistics content and statistics teaching.

The findings from both chapters raise further questions and implications with respect to MOOCs as venues for effective professional development and participants’ interactions in these venues, which are presented in this chapter.

**Conceptualizing a Set of Characteristics for MOOCs To Be Designed as Venues for Teachers’ Professional Development**

A natural question that comes to mind after reading the findings of this dissertation is “what does a MOOC have to contain in terms of characteristics to be an environment for effective professional development for teachers?” Building on the findings from Chapter 5, I conceptualize a set of characteristics for MOOCs to be designed as venues of teachers’ professional development.

I start with content focus as the first characteristic of a MOOC as venue of teachers’ professional development. Content focus here is understood as what teachers have the opportunity to learn during a professional development (Kennedy, 1998). The content base for professional development for teachers can vary, and it can be focused on disciplinary content (e.g., mathematics, statistics), pedagogical content (approach of teaching), or a combination of disciplinary and pedagogical content. Literature on effective professional development (e.g., Garet et al., 2001; Birman et al., 2000) defends the idea that an effective professional development should focus in developing teachers’ knowledge of subject matter, and not only teaching practices as is the case with this MOOC. Although, results from this study showed that participants (teachers) valued the availability of new resources as well the new approaches to teach statistics to their students offered by this MOOC, it also showed that participants had
insecurities with respect to statistical content they would have to deliver to their students. Offering teachers opportunities to learn how to teach subject matter in an investigative way might not attend to gaps in teachers’ knowledge of subject matter. Teachers’ insecurities with the subject matter that emerged in this MOOC reinforce the need of designing a professional development that also presents some sort of focus on advance teachers’ knowledge of subject matter (Conference Board of the Mathematical Sciences, 2012; Ball, Thames, & Phelps, 2008; Phelps, 2009; Wu, 2009). Suggestions of developing teachers' knowledge of subject matter aligned with teaching practice could be ideal in the case of statistics since these teachers are in need to improve their knowledge about statistics content as well statistics teaching.

Flexibility emerges as the second characteristic of a MOOC as venue of teachers’ professional development. The MOOC setting brings a new conceptualization for the notion of duration of professional development described in the literature. Results showed that participants may engage with professional development in different intensities and for different amounts of time. Thus, flexibility carries the idea of fluidity in duration of a professional development meaning that the amount of time participants engage with a professional development does not need to be a fix number of hours and the same amount of hours for everyone. The duration of a MOOC for an individual teacher is more better determined by the teacher rather than predetermined by the MOOC author or professional development provider.

In terms of participation, MOOCs are expected to host a worldwide participation, and the same applies to a MOOC designed for professional development. Thus, variety in terms of geographic location, professional roles (e.g., pre-service teachers, high school teachers, and college teachers), and years of experience (e.g., novices and experienced teachers) highlights diversity of participants as a natural characteristic of a MOOC as professional development. Besides intrinsic diverse characteristics carried by participants, results showed that a MOOC has the potential to host diversity in participants’ interactions, welcoming participants’ interactions
with others who have different or similar profiles as them. The magnitude of diversity is not predetermined by the local teaching population.

Opportunities for active learning is the fourth characteristic of a MOOC as a venue of teachers’ professional development. However, opportunities for active learning offered by a MOOC should not be restricted to providing participants interactions with materials and with interactions with others in forums as presented in this study. It seems that MOOCs have potential to provide opportunities for active learning through cooperative and collaborative forms of interactions among them. In this sense, participants with common goals, social presence, and information sharing may join each other to create something (Bonk & Cunningham, 1998), for instance, an artifact to be used in their class. Social presence is the ability of learners to project themselves socially and emotionally as real people in an online learning community (Garrison, Anderson, & Archer, 2000). Participants learning from their cooperative and collaborative interactions would emerge from the process of join together, and give-and-take among participants towards of consensus building (Kirschner, 2001), which could expand the chances for participants to learn with and from others.

Autonomy and openness should be considered fundamental characteristics of a MOOC as a venue for effective professional development. Based on results presented in both previous chapters, autonomy was the feature that guided participants in this professional development. Then, failing to consider participants’ autonomy as an important feature of participants’ learning as they interact with materials and with others would be, in ultimate instance, a restriction on participants’ interactions in an open environment as a MOOC. Regarding openness, results from this study showed an example of how participants’ interactions with open materials emerged organically in forums and were richer than their interactions with partially open materials. Thus, if one wants to boost participants’ interaction in a MOOC for teachers’ professional development,
openness of resources should be considered an important feature of this form of professional development.

**MOOCs as Spaces for Professional Learning and their Potential for Teachers’ Communities of Practice**

Teachers’ professional learning happened in this MOOC as participants sought knowledge about teaching statistics through data investigation and connected to other participants in forums by reflecting upon their practice and discussing resources with which they had interacted previously, as shown in both results chapters (Chapter 5 and 6). The way this MOOC was designed allowed participants’ autonomy regarding their learning process as they engaged with materials that were pertinent to their interests. It also allowed interaction with people who would share similar interests as them such as their interest of being more prepared to teach statistics to their students.

When a MOOC opts to foster collaborative interactions among participants it opens opportunities for participants to go beyond posting their views of materials in asynchronous online discussions, developing a teacher community of practice (CoP). According to Wenger (2006), “communities of practice are formed by people who engage in a process of collective learning in a shared domain of human endeavor”. In this sense, participants’ intention to learn can be a catalyst to establish a CoP (Wenger, 2006) as in the case of this MOOC. In connectivism, “a community is the clustering of similar areas of interest that allows for interaction, sharing, dialoguing, and thinking together” (Siemens, 2003, p.03). In a MOOC for teachers’ professional development, communities could be created to promote participants’ learning, in which participants would “work together” (Dillenbourg, 1999, p. 08) towards common learning goals, producing and sharing knowledge as a group.
CoPs (online or face-to-face) are characterized by three main structural elements: domain, community, and practice (Wenger, 1998; 2006; Wenger, McDermott & Snyder, 2002). These elements are mutually constitutive, and they evolve regarding changes in each of the other (Arnold, Smith, & Trayner, 2010; Eckert, 2006). A domain is a shared interest to which members are committed. In the case of this MOOC as a CoP, the domain of the online CoP would be the focus on statistics teaching. Community is characterized by members engaging in a joint activity, sharing information, and building relationships through participation in the community. In the case of this MOOC as a CoP, community would be depicted by participants interacting with others in forums with the intent of working together (joint activity). Practice means that the community is formed by practitioners who together develop and share a repertoire of language, concepts and resources, making their practice discussable (Wenger, 2006). In the case of this MOOC as a CoP, teachers would be involved and contributing to the community by sharing and reflecting upon their practice with other participants regarding statistics teaching.

Online communities place the interaction between participants at the center of learning (Kohls & Schümmer, 2014), and nurturing interactions between teachers is critical for their collaboration in this professional development. Thus, indeed, this MOOC has potential to work as a CoP. However, some things need to be taken into consideration. Due to open access and free of charge nature of MOOCs, participation tends to be emergent, diverse, and fragmented (McAuley, Stewart, Siemens, & Cormier, 2010), with some participants joining in and some leaving, and with some just observing the professional development without interacting with anyone or anything. Although a community is expected to have some core participants, some less active contributors, and many observers, it is not possible to control the number of participants that will take each position on this CoP (core participants, less active contributors, and observers). Thus, the nature of participants’ interaction in MOOC may constrain the sense of community as a main
element of CoP. Asynchronous communication and participants joining in discussions threads as assemblages may also constrain this idea of community.

Fixed duration of MOOC professional development as the one studied in this dissertation, present another constraint inhibiting a MOOC from operating as a CoP. The official duration of six weeks as in this MOOC may not be enough time to support the building and consolidation of a CoP. For that, the MOOC should have to be designed to provide space for participants’ interactions through flexible periods of time, by offering different opportunities for teachers to try new approaches and share them back with the professional development group.

In synthesis, a MOOC for teachers’ professional development could be characterized as a CoP, in which participants share repertoires and explore ideas as they are working in groups in discussion threads. Both online CoPs and professional development MOOCs start with a group of participants seeking knowledge. In both of them, participants are voluntary and self-selective, have fluid goals and engage in cycles of learning and doing. Both foster mutual engagement (peer interactions), establishing and nurturing connections among participants. As said before, the MOOC in this study presents the CoP’s three elements: domain, community and practice. However, framing a MOOC for teachers’ professional development as a CoP will require some adjustments in the design of the MOOC to avoid potential constraints as described in this section.

**Enhanced Interactivity in MOOCs**

Based on the findings from previous chapters, in this section I approach the potential of resources and prompts in enhancing participants interactivity in MOOCS. Interactivity is understood as a process that occurred online and involved person-to-person or person-to-platform interactions.
Resources

With respect to resources, a fundamental finding presented by this study was that resources were vehicles for participants’ interactivity in this MOOC. A follow-up question that emerges from this finding is what kind of resources have the greatest potential to enhance interactivity in a MOOC for professional development? Enhanced interactivity in a MOOC can be seen in two ways: quantity of posts and alignment of these posts to participants’ practice. To think about the potential of resources enhancing interactivity in a MOOC for professional development is important since learning in this online environment is fundamentally a social experience (Wenger, 1998; 2006) that happens as participants experience connections through the network.

Findings from Chapter 6 indicated that participants’ interactivity happened in this MOOC when they interacted with both open and partially open resources. Open resources were open license materials that allowed participants free access, use, and the ability to repurpose, and partially open resources were materials that resided in private domains and provided some barrier to their access. When comparing quantity of posts with respect to each type of resource, a higher quantity of posts occurred when participants interacted in forums about partially open resources. Looking deeper into their interactions in forums about partially open resources it was possible to note that many of these posts were focused on participants asking for access either access or more information about the resource, and the instruction team clarifying the doubts of participants about the restricted access to that resource as well providing auxiliary materials to them. When looking at participants’ interactions with open resources the nature of the content of participants’ posts seemed to be focused on participants understanding and experimenting the free resource, as well as envisioning its implementation in their practice. Moreover, participants’ interactions with
open resources emerged naturally in this MOOC, indicating a potential value of open resources as object of organic interactions among participants in forums.

Although the quantity of posts was higher when participants referred to partially open resources, part of these posts (e.g., inquiring and complaining about access to a resource) does not seem to be the kind of interactivity we want to foster in MOOC for teachers’ professional development. On the other hand, participants’ posts about open resources were less in quantity but they were more connected to participants’ practice. From their interactions with open resources, participants naturally created discussions to talk about those resources indicating that: they were interested in the resource, they would like to try it for themselves, and they would like to try it with their students. It seems that this is the kind of interactivity that we want to foster in a MOOC for teachers’ professional development.

From the results of this dissertation it is not possible to talk about causality of resources generating more or less quantity of posts or posts referring to participants’ practice, and this was not my intention here. The goal was to use the results from this study with respect to participants interactivity to discuss the potential role of resources enhancing interactivity in a MOOC for teachers’ professional development and which kind of interactivity these resources were likely to stimulate.

Prompts

With respect to prompts, results in previous chapters indicated that participants’ interactivity was not always closely associated with the prompt that guided the discussions. This fact raised the need to discuss the role of prompts in anchoring and contextualizing the discussions as well helping participants with the decision of engaging or not in the discussion (Guzdial & Turns, 2000; Garrison & Cleveland-Innes, 2005).
The discussion prompts implemented in this MOOC aimed to establish a discussion of practice about teaching statistics through data investigations. The questions embedded in the prompts were open enough to promote participants’ reflection as they interacted in forums. As showed in the results chapter, the nature of the discussion prompts invited participants to react in forums about the materials they had engaged previously. Reacting to materials is helpful and proved to generate interactivity in forums as shown in this study. However, this kind of discussion prompts did not seem to be framed to foster opportunities for participants to effectively learn with and from others, going beyond displaying patterns of agreement in interactions established by participants in forums as seen in the results.

The literature of Computer Supported Collaborative Learning (CSCL) has developed strategies to structure peer interaction in discussion forums. Although these strategies do not focus on prompt creation, I believe some of them can be used by MOOC providers when framing prompts with the intention to enhance participants’ interactivity in forums. Inspired by the literature of CSCL (e.g., Stahl, Koschmann, & Suthers, 2006; Johnson & Johnson, 2005; Dillenbourg, 1999) as well as the literature of group work in MOOCs (e.g., Zhang et al., 2016; Berger & Wild, 2016; Manske, Hecking, Chounta, Werneburg, & Hoppe, 2015), below I present some suggestions to design prompts that might enhance interactivity in discussion forums for teachers’ professional development. Empirical research is recommended to check the effectiveness of the suggestions below.

Based on the work of Johnson and Johnson (2005), an idea would be creating prompts that foster participants’ social interdependence as they interact in forums. Social interdependence is “the degree to which students perceive their success as being affected by other students’ actions” (Peterson & Roseth, 2016, p. 148). By posting and replying to others in a MOOC, participants exhibited some form of positive interdependence, however, they did not combine efforts towards a common achievement. Prompts that require participants to work together by
posting a group view or posting a group creation of some artefact (material) has the potential to enhance their social interdependence as they interact in forums which may lead to a potential increasing participants’ interactivity in forums. An illustrative approach would be a prompt that require a group of participants to create a statistical task to teach scatter plots to high school students. The number of participants in a group should be three or four students so interactions among the group participants would be feasible. The statistical task should be created or adapted from their collective practice, and it should incorporate the SASI framework given by this MOOC.

Prompts that script participants’ interactions in forums might be another alternative to increase interactivity among participants. Studies (e.g., Peterson & Roseth, 2016, Fischer, Kollar, Stegmann, & Wecker, 2013) suggest that participants following rules and roles (script) as they interact in forums may raise effectiveness of the online discussion by allowing participants to focus on a task they have to solve or perform together. An illustrative approach would be a prompt that provides participants a situation in which a hypothetical teacher would like to implement a statistical task with a technology tool to teach line of best fit and introduce high school students to make predictions. This prompt would ask for one participant to analyze this lesson as a teacher and share in forums their perceptions, while other participants would analyze it as students as they share their views in forums. For the participant acting as teacher it would expected this participant to elaborate on statistics content and explanation of ideas and concepts embedded in the task as this person join forums. For participants acting as students, it would be expected those participants to produce thought-provoking questions that would make the group to think through students’ point of view.

Prompts that embedded the use of techniques such as think-pair-share (Sugiharti & Suyitno, 2015) or jig-saw (Azlina, 2010) may also be valuable in fostering participants learning from each other. An illustrative approach using think-pair-share technique (Sugiharti & Suyitno,
2015) would be the prompt requiring participants to individually think about the potential for students learning with the use of a MOOC resource. Then paired with a partner to discuss ideas about students’ use, and later share in forums the group ideas about students learning with the use of a MOOC resource. By using jigsaw technique (Azlina, 2010), a discussion prompt could state that each pair (or group) of participants should choose a statistical subject from a list of possible topics. In their interactions with others, each pair (or group) would have to recap the main points of the subject matter and construct an investigative task involving the subject. Other participants would interact by providing feedback to the material presented by the pair (or group) of participants. Then, participants’ roles would be exchanged so that at the end each pair (or group) of participants created something related to the course content and also provided feedback to others.

It is also possible to consider the implementation of more sophisticated type of prompts that require participants to try something out with their students (e.g., a task) and reflect with others in forums about the pre-during-post implementation. Or still, prompts that invite participants to react upon materials created and shared by other participants. At the end, to implement these ideas in a MOOC changes would have to be done in terms of duration of the professional development.

**Teachers’ Responsibility for Their Own Professional Development**

As shown in both results chapters, although participation in this MOOC was diverse comprising participants with different professional roles (classroom teachers, teacher developers, college instructors, college student, among others), their interactions in forums seem to have been driven by their intentions of being prepared to teach statistics to their students. Evidence of participants’ attention to their students was highlighted as their first goal in this professional
development as ‘strengthening their understanding of how to engage students in statistical investigations’, chosen as a first goal by 54% of participants as shown in Chapter 5. Participants’ attention to their students was also presented in the content of their posts referring to MOOC resources (e.g., LOCUS test, Gapminder, and statistics tasks), on posts describing their insecurities about statistical teaching, and on posts about their envisions of potential implementation of resources and approaches in their practice, all shown in Chapter 6. Discussion prompts and materials available in this MOOC were also in service to establish a discussion of practice about teaching statistics through data investigations, which may have allowed opportunities for participants to establish the connection between their learning from this MOOC with their intention of being prepared to teach statistics.

However, more can be done by both MOOC providers and by MOOC participants to connect even more participants’ engagement in MOOCs for professional development with their experiences (or lack of experience) in teaching statistics. From the MOOC side, the implementation of more sophisticated type of prompts that require participants to try something out with their students (e.g., a task), come back into the professional development venue and reflect with others in forums about this experience may set the stage for this integration of participants’ engagement in the professional development and their experiences in teaching statistics. Prompts that invite participants to react to materials created by other participants which could include students’ work also seem to be promising in integrating participants’ engagement in this professional development with their experiences in teaching statistics. This type of activity would also benefit other audiences of the MOOC, such as pre-service teachers (college students) and teacher educators (college professors). It can be an opportunity for pre-service teachers to get in touch with the reality of teaching statistics lived by their MOOC colleagues and shared in forums. For teacher educators, it can be an opportunity to observe how teachers design and teach statistics in their classes.
From the participants’ side, they should be open to freely share their statistics teaching experiences with others, their (unidentified) students’ work, and be open to receive peer feedback with respect to the statistics content and the pedagogical approach implemented by them in their teaching. For that participants will need to be self-directed learners as they interact with materials and with others in the MOOC environment. Self-directed learning states that individuals have the responsibility for planning, implementing, and evaluating their own learning in tandem with their personal learning goals (Loizzo et al., 2017; Hiemstra, 1994).

From the results presented in previous chapters, materials will be vehicles for their interactivity in this MOOC, and the decision of interacting or not with a selected resource, and joining or leaving forum spaces will be up each participant’s autonomy. Participants’ autonomy will guide their interactivity in this MOOC. However, participants still will have to be aware of what they do not know, and aware of where to find resources and people (inside or outside the MOOC) related to their needs, which is called actionable knowledge in connectivism. In this sense, participants self-directing learning is essential for a positive experience in a MOOC for teacher professional development, and for MOOCs in general.

**Taking the Risk of Developing Identity as Statistics Teachers**

This MOOC has the potential to be a space for teachers to develop identity as statistics teachers. To convey this idea, I draw upon the work of Wenger (1998) who discusses the process of identity formation through participation in communities. For Wenger (1998) identity formation is defined as a dual process that involves identification and negotiation within a community of practice. In our case, the MOOC environment would behave as a community of practice.

By membership in this community, participants identify themselves as members as they see similarities and differences among themselves and others. This process may result in
participants bonding with others or separating from them. In this sense, a participant identifies
him/herself with others while he/she is also being identified by others (Trent & Gao, 2009). For
Wenger (1998) this identification happens through the three modes of belonging: engagement,
imagination and alignment.

In this MOOC, engagement occurred as participants invested themselves in this
environment by interacting with materials and with others in forums, as presented by the content
of their interactions in forums about the LOCUS test, Gapminder, and Statistical Tasks shown in
Chapter 6. Their engagement with activities and materials related to statistics teaching may have
given and/or reinforced their experiences with the subject. Imagination occurred as participants
shared in forums their envisioned actions as statistics teachers through their engagement with
materials and with others in forums, for example when dealing with the statistical task or
Gapminder as shown in Chapter 6. Alignment occurred as they shared their image of what it
means to be a statistics teacher and to teach statistics through data investigation, for example
when participants reinforced the importance of knowing the content statistics in order to be able
to teach their students as shown in Chapter 6.

Participants in this MOOC used the process of identification towards building their
identity as a statistics teacher when they shared their insecurities about statistical content
knowledge and statistical teaching. By doing so, they found echos from others who were feeling
in the same situation. Likewise, participants who were feeling confident in teaching statistics also
found their peers in this matter. Identification also happened from the point of view of expert
participants who engaged with those participants in moments of struggle and shared with them
that they also felt insecure about their statistics teaching in the past. In this sense participants’
development of identity in this MOOC could be described as a “relational phenomenon that is
both individually and socially constructed” (Davey, 2013, p. 27) as they engage this MOOC. The
two aspects of this phenomenon seem parallel to what Wenger (1998) described as macro (individual) aspects and micro (group) aspects of identity formation.

For Wenger (1998), negotiation means participants’ “ability, facility and legitimacy to contribute to, take responsibility for, and shape the meanings that matter within a social configuration” (p. 197). Through participants’ interactions in forums we could observe legitimacy in their contributions as they related most of their posts to their experience as teachers. We could also see them taking responsibility for their statistics teaching as well as envisioning potential changes in their practice in order to make their lessons more investigative.

Wenger (1998) says that in this negotiation process, members will produce meaning and judgment about what is under negotiation. If what is being negotiated doesn’t produce meaning by a participant, this participant may establish an identity of non-participation (Wenger, 1998; Trent & Gao, 2009). Based on Wenger’s (1998) claim, it is possible to hypothesize that participants who did not engage in forums (lurkers) may not have produced meaning through this MOOC. However, results of this study fall short in providing evidence to identify the reasons for their disengagement from this MOOC (non-participation identity).

Although I stated that this MOOC could be considered a space for teachers to develop their identity as statistics teachers, this statement needs to be taken with parsimony, because identity formation also happens by participants’ engagement in action, in this case engagement in real classes. This is to say that identity also happens as MOOC participants establish and nurture connections with their students, their schools, and take ownership of their statistics lessons. These connections transcend the MOOC space, which allows us to see a MOOC as one more available space for participants’ identity as a statistics teacher to be expressed and reshaped. In this sense, this study agrees with Wenger (1998) that identity construction is an ongoing process that is continuously constructed and reconstructed through the interactions participants initiate in social contexts, which means inside and outside of the MOOC environment.
Roles of Others in MOOCs

Results presented in Chapter 6 highlighted the presence of two type of participants: super-posters and the main instructor. In this section, I elaborate on the role of these two types of participants as well as their importance for this professional development ecology.

The Role of Super-Posters

Super-posters were presented in the results as participants who had the highest quantity of posts in forums. Then, a question that emerges from the results is one of whether super-posters could be considered model participants in this MOOC. The work of Huang et al. (2014) suggests that “superposters can, ideally, be model participants” (p. 2) in MOOCs. These authors highlight the benefits of super-posters’ actions in MOOCs as participants who support MOOC staff in answering questions of other participants, participants who start new conversations contributing to increase of participation in forums, and participants who inspire others by example of their interactions.

Although this study has presented evidence about the benefits of super-posters in forums such as starting new conversations and contributing to an increase in participation in forums, in this MOOC super-posters should not be considered model participants. Although their participation comprised the top 10% of forum posts, only one of four super-posters in this study (participant 4409) was a K-12 teacher, the supposed target audience of this MOOC. If super-posters were positions taken by K-12 teachers, then yes, super-posters could be considered as model participants in this MOOC that was designed for K-12 teachers professional development in statistics teaching. Although diversity was valued in this environment in which participants of
diverse backgrounds interacted with others, K-12 teachers acting as super-posters would imply that these K-12 teachers were leading the interactions in forums.

On the other hand, super-posters could be considered models of participation in this MOOC. They opened new discussion threads that expanded the network and increase the interactivity in this MOOC. By replying to posts of others, they were committed in contributing back to the network, and the content of their contributions were aligned with the goal of the MOOC (teaching through statistical investigations) and with the resources embedded in it. Through their contributions by creating discussions or posting in discussions created by others, they repurposed the content learned in this MOOC by sharing their experiences with others in forums.

Although this study does not present evidence with respect to super-posters supporting MOOC staff in answering questions and inspiring others in forums, it is possible to say that super-posters in this MOOC were models of participation in forums but they were not model participants since they were not the primary audience of this online professional development.

The Role of the Main Instructor

Results from the structure of the network presented in the last chapter showed that the main instructor had an essential role in the interactions established in forums. However, the role of the main instructor in this MOOC embraced more than only interactions with participants in discussion forums. According to Siemens (2003), in a connectivist perspective, the instructor’s task is "to create the ecology, shape the communities, and release learners into this environment" (p. 5).

With respect to creating the MOOC ecology, the main instructor had a fundamental role in many elements of this professional development. The main instructor opened all units of the
MOOC with a video informing participants what was going to be discussed in that unit. The main instructor, embraced the SASI framework (Students’ Approaches to Statistical Investigations) (Lee & Tran, 2015) that guided the design of this professional development and all resources and activities embedded in it. The main instructor defined which materials were offered in each unit of this MOOC, as well which material shared by participants should be included in the next version of this MOOC. The main instructor defined the prompts that anchored the discussion forums and conducted all video interviews with expert researchers in the field of statistics education, making them available for the MOOC’s participants.

Siemens (2003) does not provide a description about how the instructor shapes the community that might emerge during a MOOC, which opens opportunities to combine connectivism with other constructs such as Community of Practice (CoP). According to Wenger et al. (2002), “the heart of a community is the web of relationships among community members” (p. 58). This means to say that interpersonal relationships created by participants as they interacted with each other in this MOOC (when considering it as a CoP) were the foundation from which the community was shaped. In this sense, the community in this MOOC was shaped not only by the main instructor but also by other main participants (e.g., super-posters) who established and maintained interactions in this emergent community. Considering this MOOC as a potential instance of CoP helps us in gain perspective about the contribution of the main instructor in shaping an emergent community among participants in this professional development.

Results showed that the main instructor contributed to the community creation by being the steward of interactivity in this MOOC. By doing so, the main instructor provided resources for participants’ interactions, fostered their interactions with others in forums, and assured that participants were interacting with each other in the discussion threads. The instructor also acted as a broker in forums by creating a bridge between participants from one discussion thread to
participants from another discussion thread, which can be seen as an incipient community creation. As an important node in the networks created in this MOOC, the main instructor was a node near to other individuals in those networks which allowed her to assure that participants would not be without answers or guidance as they engaged in forums. By her position in the network and the level of interactivity she presented, the main instructor had influence on the three social networks presented in this study. Using CoP as an additional construct to understand the role of the main instructor in this MOOC allows us to see the instructor as the community leader who fostered participation in this community. The instructor’s leadership was also evidenced through the structure of her interactions in forums, in which the instructor was the most prestigious and the most influential node in the networks.

With respect to instructor releasing participants into the environment, Siemens (2007) suggests the instructor (educator) should act as a curator in the networked online environment. Instructor as a curator creates “learning resources that expose learners to the critical ideas, concepts, and papers within a field” (Siemens, 2008, p. 17). Bonk (2007) also proposed the notion of instructor acting as concierge in online environments. Instructor as concierge directs participants to resources they were not aware of. As concierges, instructors have access to resources that are shared with participants as they go through their journey of learning within online environments. They also encourage participants to explore resources shared by checking for suitability of the resource with participants’ interests (Bonk, 2007; Siemens, 2008).

In this MOOC, the main instructor role in forums was as a community leader who imprinted patterns of engagement mixing between the roles of curator and concierge. Acting as curator, the main instructor put together multiple materials presented by this MOOC and introduced new resources in forums as this professional development unfolded. Acting as concierge, the main instructor engaged with others in this MOOC and assumed the role of expert presenting advanced knowledge of the SASI framework as well its use with students. As
concierge, the main instructor assumed the role of a guide encouraging participants into their learning path as they interacted in this MOOC. Still on her role of concierge, the main instructor: greeted participants in the beginning of their journey in this MOOC, assessed participants’ needs, provided to them links to resources that were embedded in this MOOC or links to external resources that were previously curated by her, and asked questions of participants to invite them to think about how their students would deal with those resources.

In the next chapter I state the contribution of this study, followed by implications for research, theory, and methods when studying MOOCs for teachers’ professional development. I also present the limitations of the study and suggestions of future research in the realm of MOOCs for teachers’ professional development.
Chapter 8
Contributions, Implications for Research, Limitations, and Future Directions

In this chapter I present concluding thoughts about this study. I begin it by presenting a summary of the contribution of this study, followed by implications for research, theory, and methods when studying MOOCs for teachers’ professional development. I conclude the chapter by presenting the limitations of this investigation and delineating future research in the realm of MOOCs for teachers’ professional development.

Contributions

The contributions of this study to the literature of teacher professional development are organized in two sections. The first section focuses on the contributions of this study regarding the characteristics of teachers’ professional development described as best practices for effective teachers’ professional development. The second section focuses on the contributions of this study regarding participants’ interactions in MOOCs.

Contributions towards Characterizing MOOCs as Venues for Teachers’ Professional Development

A challenge that researchers and professional development providers share is designing professional development that is consistent with research already produced in the field. The literature on teachers’ professional development has been strongly based on face-to-face professional development experiences. The field has extracted some pivotal features that should lead professional development to be an effective experience for teachers. Therefore, it is expected that a new professional development should carry in its tenets these elements of effective
professional development that have already been learned and synthetized by the field (Garet et al., 2001; Desimone et al., 2002; Yoon et al., 2007; Blank & de las Alas, 2009; Desimone, 2009).

MOOCs are relatively new in the context of professional development, and research using this venue for teachers’ professional development is scant in the literature. This study contributes to the field of teachers’ professional development by describing how this MOOC embodied all characteristics of effective professional development, and how these characteristics cannot be transferred in a straightforward fashion from face-to-face professional development literature into this online environment. This study extends the literature of teachers’ professional development by showing how differently these characteristics are enacted when a MOOC is used as venue for statistics development of secondary teachers. It highlights participants’ autonomy as a common element that modified all characteristics proposed in the literature.

Aligning theoretical perspectives from the social theory of learning with connectivism, this study helps to create awareness in the field of teacher professional development regarding new characteristics that emerge when professional development is delivered in large-scale, via the Internet, and free of charge. In this sense, this study suggests a set of characteristics that MOOCs should comprise to be an environment for effective professional development for teachers.

Contributions towards Participants’ Interactions in MOOCs for Professional Development

In the last eighteen years, the field of professional development has reinforced the benefits of professional development initiatives in schools as a way to develop teachers’ professional knowledge in a situated perspective (e.g., Putnam & Borko, 2000). Although the literature has recognized the advantages of teacher’s professional development in the context of local schools (Putnam & Borko, 2000; Stein, Smith, & Silver, 1999; Carpenter, & Fennema, 1992), literature has also highlighted the importance and benefits of teachers interacting with
others in groups in arrangements existing outside the school as well (e.g., teacher and librarian
collaboration, teacher online professional development, professional development schools). These
arrangements are depicted as teachers engaging in collaborative groups, personal partnerships,
study groups, and so on, in which teachers look for opportunities to meet professional needs that
sometimes are not fulfilled by interaction with others in their schools, or by their participation in
traditional professional development programs.

Although the study of teachers engaging with others is present in the literature of teacher
professional development (e.g., mentoring, coaching, professional development schools) research
has not yet characterized discussions that emerge from teachers interacting in MOOCs. This study
contributes to the literature of professional development regarding the nature of discussions based
upon material and produced by interactions of participants in this MOOC. Based on participants’
posts, it provides evidence to the field of teacher professional development that their interactivity
in this environment is based on materials that this professional development made available to
them. It contributes by providing empirical evidence that materials are very important for the
creation of organic networks among participants, and raises awareness about the role of
discussion prompts in forums, showing that participants’ interactivity happened regardless the
presence of prompts. In terms of participation, it exposes that some participants will emerge as
leaders of engagement in this professional development, and professional development providers
should be aware of their potential benefits. This investigation also adds to the literature on the
role of facilitators in teachers’ professional development by showing that the facilitator in this
MOOC (i.e., main instructor) acted as a concierge in this online environment, directing
participants to resources they were not yet aware of. The concierge role taken by the MOOC
facilitator seems to differ from the typical role taken by professional development facilitators in
face-to-face professional development initiatives, in which the facilitator helps the group of
teachers to engage with each other about the topic that is being learned.
For the fields of mathematics education and statistics education, this study contributes by presenting empirical research about a MOOC as a new form of teacher professional development, in which mathematics teachers are getting acquainted with the pedagogical approach of teaching statistics through data investigations, exposing their perceptions of this approach and their intentions of further implementation in their classrooms. The use of a MOOC as described in this study for professional development in the teaching of statistics can further contribute by reducing the scarcity of research on the training of mathematics teachers in statistics teaching identified (Barnett, 1982; North, Scheiber & Ottaviani, 2010; Wessels, 2011).

This study also contributes to the fields of mathematics education and statistics education by exposing the preferences of these teachers in terms of developing their professional knowledge about statistics teaching. Teachers in this MOOC displayed an individual mode of interaction with materials available in this professional development. They aggregated resources and shared back to the network their perceptions about the materials and their perceptions about potential connections of these materials with their practice. Results from this study contribute to the mathematics education and statistics education literature to orient further professional development practices according to what mathematics teachers are already voluntarily looking for with respect to a professional development focused on teaching statistics through investigations. It shows that mathematics teachers in this MOOC are interested in improving their statistical content knowledge as they display their insecurities with regarding their knowledge of statistics and their skills of teaching statistics to their students. It also shows that mathematics teachers in this MOOC are interested in knowing new pedagogical approaches to teach statistics to their students and equally interested in learning more about technological tools that could be implemented in their teaching.

This study contributes to the literature of teacher professional learning by portraying teachers’ ownership of their learning, represented by their interactions with materials and other
practitioners in this online professional development. Thus, results from this study may also assist school teachers in understanding what engagement in a MOOC for professional learning can be. For the ones who are already engaged in MOOCs, this study provides evidence of the types of engagement a teacher can experience in a MOOC focused on teachers’ professional development on statistics teaching. Evidence of it can be found in posts shared by teachers about the benefits perceived by them as they engaged in this MOOC. For example, it illustrates participants’ aggregation of resources and their learning from experiences of teachers geographically dispersed. For those who have not yet tried MOOCs for professional development, the spread of results of studies like these may help skeptical teachers to be more comfortable trying this new mode of professional development, and having ownership over their own learning experiences. Results from this study may also contribute to the decision making of teacher educators, supervisors, and policy makers helping them understanding the possibilities and limitations for teachers’ development hosted in MOOCs, which may allow them to be better informed as they make decisions about the use of free professional development initiatives such as this one.

Contributions from this study should be seen as a starting point for expanding the literature of teachers’ professional development using MOOCs. More studies validating the conceptualized new set of characteristics for MOOCs as spaces for effective professional development as well as new studies focusing on teachers’ interactions in MOOCs for professional development are needed to help the field of teacher education to theorize and to understand the full potential of MOOCs for preparation of in-service teachers.

**Implications for Research**

In this section I state implications of this study for other researchers who are interested in studying participants engagement in MOOCs for teachers’ professional development, and in
MOOCs for statistics professional development of teachers. I write about the quality of participants’ posts in MOOC forums, their individualist modes of interaction, the importance of MOOCs addressing statistics content and pedagogical knowledge, and the role that MOOC resources play in teachers’ practice.

**Quality of Participants’ Posts in MOOC Forums**

This study depicted the content of participants’ interactions in forums and showed that their interactions were based upon resources provided by the MOOC. In terms of results, it presented a broad picture about what participants collectively were talking about in forums with respect to each resource. In the process of coding the content of participants’ interactions and writing the results, I noticed that participants’ posts were different from one another with some presenting sophisticated contributions to forums while others were meaningless posts or redundant questions that generated noise in forums increasing the number of posts without increasing the quality of the discussion taking place in those forums. This reality evidenced in this study suggests to researchers investigating the quality of participants posts in MOOC forums for professional development purposes. Considering reflection as an essential component in teachers’ learning (Shulman, 1987; Schon, 1987), when these teachers engage in a MOOC for professional development purposes, one may assume that they will use forums to reflect upon their practice. However, reality has shown that their posts are an unbalanced conglomerate of meaningful posts and meaningless posts. Thus, it seems important for future research to investigate the quality of individual contributions (participants’ posts) comprising the broad picture of the content of posts generated collectively by them as they engage in forums for professional development purposes.

To situate my point, it is important to recall that the need to understand the quality of participants’ contributions in forums is not new and research in distance education has used
different approaches to evaluate the quality of forums embedded in Learning Management Systems (LMS) used in higher education online courses. According to Spatariu, Hartley & Bendixen (2004), these approaches are based on: levels of disagreement, argument structure analysis, interaction-based, and content analysis. In levels of disagreement, participants’ posts are coded by “the level of disagreement that is exhibited in relation to previous posting” (Spatariu et al., 2004, p. 2). In argument structure analysis, participants’ posts are coded according to the quality of the argument demonstrated by them on the topic being discussed. In interaction-based, participants’ posts are coded “as a part of a larger discussion” (Spatariu et al., 2004, p. 6). Finally, in content analysis participants’ posts are coded “according to the message type” (Kinshuk & Hunt, 2004, p. 3). The common point among the approaches above synthesized by Spatariu et al. (2004) is that participants’ contribution in forums should be seen in tandem with previous interactions already taken by participants who previously engaged in those forums.

Some of these approaches have been used to assess quality of participants’ contributions in regular MOOC forums (e.g., Bonafini, Chae, Park, & Jablokow, 2017; Wang, Yang, Wen, Koedinger, & Rosé, 2015; Gillani, Eynon, Osborne, Hjorth, & Roberts, 2014). Finding from these authors align with the scenario described at the beginning of this section, in which some posts are aligned with the content of the course and with the purpose of the discussion while others are unrelated posts such as operational questions (e.g., ‘When can I receive my certificate?’) or posts demonstrating high levels of agreement among participants without presenting an argument or debate about the topic being discussed (e.g., ‘I agree with participant [name of participant]’, ‘You’re right [name of participant]’, and ‘Good point [name of participant]!’). Still in regular MOOCs (i.e., MOOCs not specifically designed for teacher professional development), Suen (2014) suggests other approaches to assess quality of participants contributions in forums such as participants’ peer feedback and participants’ auto-scoring (self-checking).
Although research has started to investigate the quality of forums posts in regular MOOCs, studies analyzing the quality of participants’ contributions in MOOCs for teachers’ professional development (e.g., Kellogg, Booth, & Oliver, 2014) and how teachers learn from their reflections shared with others in forums are scant in the literature.

When studying the quality of participants’ posts in forums, researchers and MOOC instructors should also inform participants about the importance of their comments with respect to comments generated by the ones who previously engaged in those forums. Raising participants’ awareness about the purposes of forums in an online professional development hosted by a MOOC has the potential to inhibit participants’ meaningless posts, and thus reduce the noise in forums which may in turn allow participants better use of their time as they engage in MOOCs. As a consequence, it is possible that participants would perceive a higher value of the discussions they engage with, which may influence the level of their contributions to these forums.

From Individualist Interaction Towards Cooperation and Collaboration Among Participants in MOOCs

Although research points out that participants are interested in collaborating and cooperating with their peers in online environments (e.g., Anderson, 2005; Caspi & Gorki, 2006), results from this study suggest that participants interacted in forums on an individual basis. This mode of interaction aligns with Poellhuber, Anderson, and Roy (2011) who state that participants in online environments are looking for the individual freedom and flexibility afforded by self-paced participation. Based on the mode of participation in this MOOC, a suggestion for future research is to investigate how participation in MOOCs for teacher professional development could go beyond individualist interaction towards cooperation and collaboration among participants.
According to Johnson and Johnson (2008), in individualist interaction participants work by “themselves to accomplish learning goals unrelated to those of the other students” (p. 404). Although 54% of participants in this MOOC reported having the same goal as they joined this professional development (i.e., strengthen their understanding of how to engage students in statistical investigations), participants’ engagement in forums was based on their individual contributions that were disjointed in time and space from one another. They commented on posts of each other but they did not create anything together (any artifact) despite the fact that 54% of participants had reported to have the same goal in this professional development. In addition to interacting in forums in an individual mode, participants of this study also used the MOOC and its forums as a source of resource aggregation and resource sharing. The phenomenon of resource aggregation and resource sharing in this MOOC is an example of participants’ actionable knowledge described in Connectivism, meaning “an understanding of where to find knowledge may be more important than answering how or what that knowledge encompasses” (Duke, Harper & Johnston, 2013). Although individualist interaction was allowed in this MOOC, the individualist approach does not contribute to enhancing the sense of community among participants. In fact, this approach resembles the acquisition metaphor proposed by Sfard (1998), depicting participants’ learning individually as an acquisition and accumulation of knowledge.

As a participatory course in which participants are responsible for setting their own learning goals without having any mandatory activity, MOOCs for teachers’ professional development are flexible in design, allowing individualist, cooperative or collaborative forms of participation. Thus, if we wish participants to cooperate and/or collaborate with each other in MOOCs for professional development, we will have to design and document through research experiences that prompt this kind of behavior.
MOOCs Addressing Statistics Content and Pedagogical Knowledge

Results from this study show participants sharing their insecurities with respect to their knowledge of statistics content as well its teaching. This evidence suggests that researchers might investigate the potential of MOOCs to offer a professional development experience that focuses on teachers’ growth in both statistics content knowledge and its pedagogical knowledge.

Literature of effective professional development states that professional development that focuses on teachers’ content knowledge and ways students learn that content has a better chance to improve students’ conceptual understanding of the subject (Covay Minor, Desimone, Caines Lee, & Hochberg, 2016; Borko, 2004; Garet et al., 2001; Desimone et al., 2002; Ingvarson et al., 2005; Cohen & Hill, 1998). The focus of professional development on teachers’ content knowledge has to do with the goal that “teachers must have rich and flexible knowledge of the subjects they teach” (Borko, 2004, p. 5).

The rationale of this study shows that teachers from different countries face the same challenge: teaching statistics to their students without having had a good preparation or formal training. Findings from this study add evidence to the global picture of teachers not feeling prepared or confident to teach statistics (Chadjipadelis, Meletiou-Mavrotheris & Paparistodemou, 2010; Franklin, 2013; CBMS, 2012; Meletiou-Mavrotheris & Mavrotheris, 2007; Begg & Pfannkuch, 2004). The results from this study indicate that although participants in this professional development showed disposition to incorporate the pedagogical approach to teaching statistics through data investigation in their classes, they also made public their insecurities with the responsibility of teaching statistical content that they don’t feel prepared for. A MOOC solely focused on developing pedagogical approaches in teachers such as this one did not seem enough in helping teachers to overcome their insecurities with respect to statistics content. I hope this study can be used as a rationale to justify future offerings and research investigation of MOOCs
focusing on development of teachers’ statistics content knowledge as well their pedagogical knowledge.

**The Role MOOC Resources Play in Teachers’ Practice**

This study shows that resources were fundamental for participants interactions in this MOOC, and consequently their learning from this professional development. By joining this MOOC, participants had a chance to aggregate resources about statistics teaching, and feed-forward the network by sharing their practice and their envisions of potential implementation of those resources in their classroom. Results from this study showed that this MOOC was a great source of statistics teaching resources for all teachers. However, due its design, this MOOC did not present participants’ implementing these resources in their practice, as discussed in Chapter 5. Thus, a suggestion for researchers is to investigate the role that resources aggregated by participants in a professional development MOOC plays in their practice of teaching statistics.

Teachers base their teaching on official curriculum materials such as textbooks and complement these materials with the creation and/or adaptation of additional resources (Gueudet, & Trouche, 2012). When thinking about teachers who engage in a MOOC designed for statistics professional development and their demand of teaching statistics to their students, is is important to investigate questions such as:

- To what extent does a MOOC for statistics teachers place teachers’ use of resources in the center of curriculum construction?
- How do teachers select resources from their experience with a professional development MOOC?
- How do they plan the implementation of these resources in their practice?
- How do their choices of using certain resources from a MOOC professional development influence their classroom practices and their students learning? and
- What is produced as a result with this resource implementation?
A framework focused on resources such as the documentational approach of didactics from Gueudet and Trouche (2012) could be used by researchers to gain knowledge about how teachers interact with resources acquired from their professional development as they implement these resources in their teaching. According to Gueudet and Trouche (2012) the documentational approach is based on instrumental geneses proposed by Guin, Ruthven, and Trouche (2005). Gueudet and Trouche (2012, p. 25) distinguish “between an artefact, available for a given user, and an instrument, which is developed by the user, starting from this artefact, in the course of his/her situated action”. These two intertwined processes are highlighted by the Gueudet and Trouche (2012, p. 25) as “instrumentation (constitution of the schemes of utilisation of the artefacts) and instrumentalisation (by which the subject shapes the artefacts)”. While instrumental geneses were focused on teachers incorporating technology tools in their practice, a documentational approach extends this framework to any material (i.e., any resource). As a teacher incorporates in his/her lesson a resource or a set of resources of any nature, Gueudet and Trouche (2012) suggest that this incorporation can be described by “Document = Resources + Scheme of utilization” (p.25), in which ‘Resources’ are materials created, modified, and/or recombined by the teacher, ‘Scheme of utilization’ is an organization of the target activity, and ‘Document’ is the outcome of teachers’ activity.

Since participants in this MOOC displayed the behavior of resource aggregators and did not display implementation in their practice (due to time and design constraints), to investigate the role resources play in their practice seems to be a natural follow-up on this study and also valid for other MOOCs that are used for professional development purposes. The work of Gueudet and Trouche (2012) on documentational approach may be a tool in depicting the role of the resources acquired through a MOOC in teachers’ practice. I see the study of the role of resources acquired in MOOCs in teachers’ practice as a promising research strand that has the potential to expand the scope of research on MOOCs for teachers’ professional development. In
the next section, I approach the implications for theory mainly focusing on the role of connectivism as a theoretical lens for this study.

**Implications for Theory**

This dissertation made use of the social theory of learning (Wenger, 1998) to describe participants’ engagement, and connectivism (Siemens, 2005; Siemens & Downes, 2011) to frame teachers’ learning through participation as they establish and experience connections. The decision to use social theory of learning (Wenger, 1998) combined with connectivism (Siemens, 2005; Siemens & Downes, 2011) reflects the position taken in this study that learning is fundamentally a social experience (Wenger, 1998; 2006), and happens through participation in social practices such as this MOOC.

Due to the novelty of connectivism as a proposed learning theory for a digital age (Siemens, 2004) aligned with scant studies using connectivism as framing tool to understand participants’ engagement in online environments such as MOOCs for teachers’ professional development, it is important to discuss the potentials and caveats of connectivism as theoretical grounding. For that, I start by briefly recapping the connectivist perspective presented in Chapter 3 and talking about the existing criticisms of connectivism. Later, I state the contributions of this study that were directly related to the choice of theoretical framework and discuss its limitations as theory to frame learning in online environments. The purpose of this section is not to advocate in favor of or against connectivism as a theoretical framework or learning theory. On the contrary, the goal is to provide inputs based on empirical results generated by this investigation that may contribute to the debate and future use of connectivism as a theoretical perspective.

Connectivism is about forming connections among people and with technology. Learning in this perspective occurs in communities within networks, in which networks support the
establishment of connections and information sharing among learners, thus encouraging lifelong learning (Siemens, 2003). Connectivism subscribes to a "distributed knowledge" epistemological framework (Downes, 2007) in which learning is a network formation process of connecting specialized nodes or information sources (Siemens, 2004), and instruction, when it exists, fosters learners in their process of becoming self-initiated and lifelong learners.

According to its proponents, connectivism has emerged as an alternative learning theory that recognizes how technology has impacted society and consequently has produced changes in teaching and learning processes. Thus, connectivism acknowledges that with the increasing use of technology in our daily life, learning also relies on informal learning that occurs all the time--when one engages with the network, participates in a community of learning, does some work-related tasks, or interacts with others via social tools. Consequently, connectivism is about forming connections among people and with technology.

Critiques of connectivism state that it is not a learning theory and it should be considered as a phenomenon that emerged from the broad use of the Internet (Bell, 2011). Authors such as Kop & Hill (2008), prefer to define connectivism as a theoretical framework for understanding learning in online environments while others adopt connectivism as a pedagogical theory, restraining its contribution to the delivery of instruction (Anderson & Dron, 2011). In this study, connectivism was taken as a pedagogical theory used to frame learning through interactions in the MOOC environment.

**Contributions of Connectivism**

The connectivism part of the theoretical lens of this study allowed me as researcher to interpret learning as a process in which participants established and nurtured connections with others and with materials in this online professional development. The four principles of
connectivism to achieve network learning (autonomy, diversity, openness, and interactivity) helped the researcher in analyzing and interpreting these features in the MOOC that was object of this study. Through the data, the researcher could identify participants’ autonomy as they established connections through the network. The theoretical framework allowed the researcher to see diversity as a trait of the data in terms of participants’ characteristics (e.g., worldwide participation, participants with diverse professional role, and diverse experience), and in terms of variety of available materials (pdfs, videos, software, etc.). Connectivism was a lens for the researcher to identify openness of resources in this MOOC as a valuable element for participants’ interactions in forums. From this point of view, the researcher could observe that openness of connections among participants seemed to have created a friendly environment in which participants could share with others their personal facts and their insecurities. Through the lens of the theoretical framework, interactivity was observed as a participant’s activity that was primarily related to the resources made available by the MOOC provider. These four principles of connectivism also emerged when analyzing the characteristics of effective professional development in this MOOC. Without using connectivism as a theoretical lens, this study could not provide this kind of empirical contribution to the literature.

The Need for Further Theoretical Development of Connectivism

Using connectivism, it was possible to frame participants’ learning through their connections within the network. Interactions were the construct used in this study to depict these connections. Although interactions emerge as an essential construct for connectivist learning, the theory does not state a definition of interaction per se, nor refer to a known one. In this sense the researcher felt some form of incompleteness of connectivism to be considered a theory of
learning. To fulfil this gap, the researcher combined connectivism with a definition of interaction (Wagner, 1994) that was compatible with the theoretical lens of this study.

Another caveat noticed through this empirical study was that connectivism did not provide guidance for one to understand the process of learning that happened through the network. As in constructivism, for instance, we have the process of perturbation and equilibration as one learns (Fosnot, 1996). Here we have only participants making connections through the network but it is not clear how learning is internalized by the individual and what the processes are that the individual goes through to keep expanding, contriving, or stabilizing his or her network. The process of acquisition of knowledge can be described by the network formation and/or its expansion. However, it not clear in connectivism what happens when participants find contradictory information in their network. Is it just a shutdown of a network branch? Is there any process of reconciliation among the nodes and edges? The theory does not mention anything with respect to these situations. Less is known about contriving process in the network. Does it happen? If yes, in which situations? In terms of stabilizing the network does it mean that the participant is assimilating the schemes formed by his or her network or it may indicate stagnation of the network? Again, the theory does not mention anything with respect to these situations.

Connectivism helps researchers in conceiving learning as a process of network formation that happens through participants’ interactions but it does not say anything with respect to the content of these interactions produced by participants. This means that connectivism does not help researchers and users in decomposing interactions or even to evaluate them as productive interactions or not. If researchers would be interested in this kind of knowledge a different framework should be combined with connectivism.

If one decides to compare learning among different participants, connectivism also does not provide any guidance for it. Could one say that participant A learned more because her network is more dense (more nodes and edges) than participant B? In cases like this one,
researchers could choose to compare participants’ learning by their interactions with materials and with others, which already happen in connectivism, and maybe add to it the contributions that come from participants’ creations of new resources or their remixing and repurposing of resources existing within the network. Although this seems an interesting idea, empirical results from this study did not present robust evidence of participants voluntarily creating new resources or remixing and repurposing existing ones. This fact indicates that it may be hard for researchers to compare participants’ learning under the lens of connectivism. Prompts may be used as tools to address the intention of participants creating new resources or remixing and repurposing existing ones. Thus, definitely more studies are necessary with respect to comparison of participants’ learning through the lens of connectivism.

In conclusion, connectivism as a theoretical lens had a strong synergy with the reality of this MOOC, since the theory "rely[ies] on the ubiquity of networked connections between people, digital artifacts, and content, which would have been inconceivable as forms of distance learning were the World Wide Web not available to mediate the process" (Anderson & Dron, 2011, p. 87). On the other hand, the networked context of MOOCs flourishes connectivist learning, once through the network participants can define their learning goals, obtain knowledge from it, participate in an open and accessible way, and also contribute to knowledge creation to the network (Anderson & Dron, 2011). Thus, one cannot deny the value of connectivism highlighting learners connecting to each other via social networking and collaboration tools. This synergy made natural the adoption of connectivism as a theoretical framework to guide this research. By pointing out what was achieved in this study through using connectivism as well as what wasn’t possible to capture due connectivism’s limitations, I expect this research will contribute to advancing knowledge and debate about the use of connectivism as theoretical lens for online learning.
Implications for Methodology

Findings from this study shown that MOOC for teachers is a reality and it can be a promising venue for teachers’ professional development due to its free cost for schools and the high quality of materials provided by this initiative. Participants’ forum posts are still the main source of data used to depict participants’ engagement in this environment. Thus, to discuss the methods used to analyze participants’ engagement in these venues seems to be important for the field of online education, and this dissertation can contribute to the literature of methods used to analyze participants’ interactions in MOOCs.

Since this study was focused on understanding the nature of participants’ interactions with materials and with others in a MOOC for teachers’ professional development purposes, the decision to qualitatively analyze participants’ posts and understand the structure of their interactions with the use of Social Network Analysis (SNA) seemed the most appropriate at the conception of this investigation. In fact, the addition of SNA techniques strengthened the qualitative content analysis by reviewing roles of participants within the network that were not possible to capture by solely analyzing the content of their posts. The results from this study are an outcome of a positive synergy between SNA techniques with qualitative content analysis, strengthening its methodology and contributing to research methods in MOOCs attending the call for the use of diverse methods in MOOC research posed by Veletsianos, Collier, and Schneider (2015). However, it is important to highlight that the use of qualitative content analysis with inductive coding proved to be an exhaustive approach to analyze content of forums posts.

Although this MOOC did not present a huge number of participants, with 817 registered participants and the ratio of enrolled participants to the number of instructor staff of 817:6 (i.e., 137 participants per instructor), while regular MOOCs (i.e., MOOCs not specifically designed for teachers’ professional development) receive much higher enrollment with a ratio of enrolled...
participants to the number of instructor staff exceeding 5000 per instructor (Huang et al., 2014), the manual qualitative coding and analysis using qualitative software as NVivo, and the need to do multiple passes on the data (2370 posts) seem to not be the most efficient approach for high volume of data as in MOOCs.

Advances in research methods brought from other fields such as the Language Technologies have shown more feasible approaches to understand the nuances of participants’ engagement in MOOC environments (Wen, Yang, & Rosé, 2014). The use of text-mining and sentiment analysis techniques are promising in providing an accurate view of what participants are discussing in forums as well their opinions about the course (Wen, Yang, & Rosé, 2014; Adamopoulos, 2013). These techniques combined with the SNA approach may expedite the process of analysis and provide a more systematic way of portraying participants’ interaction in MOOC environments.

The use of lurking as a methodological tool in designing the research questions and understanding how to approach this study are also contributions of this investigation to research methods and may help researchers in understanding the affordances and constraints of the environment being studied when framing the research questions. Lurking is defined as a silent and legitimate peripheral participation in which participants “were actively following the course but did not actively engage with other learners within it” (Milligan, Littlejohn, & Margaryan, 2013, p. 151). Lurking was essential in this study so the researcher could observe that participants’ engagement in this MOOC could be described by their interactions with course materials and with other participants. Lurking also helped the researcher in the process of comparing and contrasting the set of characteristics of effective professional development proposed in the face-to-face literature of professional development to the potential characteristics emerging for this new venue of teachers’ professional development.
Limitations

The findings of this study make contributions regarding the use of a MOOC as a real context for teachers’ professional development. However, these findings face some limitations. The first limitation is related to the fact that this study analyzed only one offering of this MOOC. Although this MOOC presented hundreds of active participants who actively contributed to the network formed through their engagement with this professional development, the findings may not be generalizable to other professional development MOOCs. Two suggestions are recommended in addressing this limitation. First, for robust understanding of the nature of participants’ interactions in a MOOC for statistics teachers, to investigate participants’ interactions in multiple cohorts of the same MOOC is recommended to validate if the findings presented in this study are also present in other instances of the same MOOC. Second, to extend the validity of findings from this study to teachers’ professional development in other areas of knowledge, it is recommended that the design of the study and its analyses should be replicated in different MOOCs for teachers’ professional development, for example MOOCs focused on pedagogical approaches for mathematics school teaching.

The second limitation is related to the process of getting data from teachers’ perceptions of learning (self-reported data) instead of relying on direct evidence of teacher practices. The justification for this decision had to do with the latitude and abundance of participants in the MOOC coming from different places and countries, and the physical limitation of the researcher in following these teachers at their practices. The official duration of the MOOC was six weeks, and in this short amount of time it was difficult for the researcher to establish a bond with some of these participants, and obtain permission from their districts and from their students in order to observe and capture teachers implementations of what they have learned from this professional development.
The third limitation is related to the method of data collection used to gather teachers’ perceptions of their engagement in this MOOC. Due to the fluid nature of participants’ interaction in this MOOC, the researcher made a decision to rely solely on an online survey inputs coming from volunteer participants. Conducting interviews with these participants, instead of running an online survey, could lead to deeper knowledge of their perceptions of their engagement in this MOOC. This approach was not taken due to the inherent difficulty in retaining teachers’ attention and participation in research once the MOOC is over.

**Future Directions**

This research raises several suggestions for future investigations in which I expect to further contribute to the literature of MOOCs used for teachers’ professional development purposes. In this section, I selected four main topics for future research that will help me in providing in-depth knowledge of MOOCs being used for teachers’ professional development.

First is to investigate the effect of varying forum prompts on the quantity of posts generated by MOOC participants. Understanding the effect of different types of prompts on the quantity of posts generated by participants may help to raise awareness about the importance (or non-importance) of prompts in a discussion, which may help MOOC designers to craft prompts that promote more interactions among participants.

The second suggestion for future research is to use the Interaction Analysis Model (IAM) by Gunawardena, Lowe and Anderson (1997) or a similar model to examine participants’ posts in terms of co-construction of knowledge through their interactions in forums. The IAM model comprises five phases of knowledge co-construction that occur during the online discussions (Gunawardena et al., 1997). They are: phase 1—sharing or comparing information, phase 2—discovery and exploration of dissonance or inconsistency among ideas, concepts or statements,
phase 3—negotiating of meaning or co-construction of knowledge, phase 4—testing and modification of proposed synthesis or co-construction, and phase 5—agreement statement(s) or application of newly constructed meaning. Results from qualitative analysis using inductive coding performed in this study showed that participants had a high level of agreement and a low level of disagreement among themselves in forums. These results may indicate that participants’ behavior in forums were associated with phase one and phase two of the Interaction Analysis Model (IAM). However, full analysis of the data corpus generated by participants’ interactions in forums may give a more complete understanding of the cognitive activities performed by these participants. This investigation could or not include an analysis of the discussion prompts vis-à-vis posts produced by participants.

The third suggestion for future studies is to analyze participants’ forum posts through sentiment analysis. Sentiment analysis (or opinion mining) “is the field of study that analyzes people’s opinions, sentiments, evaluations, appraisals, attitudes, and emotions towards entities such as products, services, organizations, individuals, issues, events, topics, and their attributes” (Liu, 2012, p. 7). Mining collective sentiment of participants in forums may shed light of how they relate to their peers in this online professional development. It may also contribute to understanding participants’ attitudes (latent affection) towards their students and the role of affection in participants’ statements when they share in forums their visions of implementation of some tool or approach learned from their experience in this MOOC. Collective sentiment analysis can also be used to better understand their insecurities with respect to statistics content and statistics teaching.

The last suggestion for future research is to investigate the role of the main instructor in this MOOC by analyzing her interactions with other participants in this professional development. The use of teaching presence construct from Community of Inquiry framework (Garrison, Anderson & Archer, 2000) may be helpful in depicting the role of the main instructor.
in this MOOC. Teaching presence is defined as “the design, facilitation and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile outcomes” (Anderson & Krathwohl, 2001, p.5). The construct of teaching presence is broken down into three critical roles of the instructor: designing and organizing the learning environment and activities, facilitating discourse, and providing direct instruction (Anderson, Rourke, Garrison, & Archer, 2001). Results from Chapter 5 provide inputs with respect to the design and organization of this MOOC environment with regard to best practices highlighted in the literature. Results from Chapter 6 provide inputs with respect to the main instructor facilitating discourse (when acting as a concierge) and designing and organizing the learning environment (when acting as a curator) besides highlighting the network role take by the main instructor in three networks through this MOOC. The use of qualitative content analysis of participants’ posts aligned with social network analysis, will provide a different perspective to the quantitative standard way of analyzing teaching presence. Analyzing the main instructor interactions with other participants in this professional development has the potential to inform and extend the literature about the nature of instructional effort in MOOCs for teachers’ professional development.

**MOOCs in Teachers’ Professional Learning Trajectory**

I will end this work by sharing with the reader my vision for MOOCs in teachers’ professional learning trajectory. As presented in the study, a MOOC is a free-of-charge space for professional learning in which participants aggregate and share resources, and experiences as they engage with materials and with others. In terms of MOOCs being used by teachers to improve their professional learning, I see MOOCs positioning themselves as flexible and open learning spaces where teachers can join in at any point during their professional career.
Results from this study showed that the same MOOC can be used as a source of professional learning for teachers throughout their career. Since these professionals are in different moments of their careers their goals when looking for MOOC for their professional development may differ from one another, although this fact does not preclude these professionals from sharing the same professional development environment. Since the MOOC audience is comprised of a varied assortment of participants with different professional backgrounds and different careers, the same reasoning can be extended to other participants who have different professions such as graduate students and college instructors.

As these different teachers engage in a MOOC, it is also possible that their modes of engagement may vary according to their goals and needs. Some teachers may make use of a MOOC as part of their formal training, while others may make use of a MOOC as part of their informal training. Some teachers may engage in a MOOC as a result of a lead-oriented activity (as in the case of pre-service teachers who participated in this MOOC as a course assignment), while others may engage in a MOOC as a product of self-directed activity. While some teachers may pursue a MOOC as independent learners, other teachers may join a MOOC as groups, making their engagement in a professional venue part of their collaborative learning.

In terms of teachers’ professional career trajectory and modes of engagement, MOOCs hold great potential to be democratic platforms for teachers’ professional development, acting as spaces for teachers’ lifelong learning in which they may continue to improve their professional knowledge.
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Appendix A

Online Survey with MOOC Participants

Instructions

Please complete the following questions to reflect your experiences and opinions as accurately as possible. If there is a question in the survey that you do not want to answer or you do not feel applies to you, you may leave it blank and move to the next question. If you don’t find an answer that fits exactly, choose the one that comes closest. The survey has four pages. You can go back to previous pages and edit your responses while completing the survey. At the top of each page you will see a progress bar showing how much of the survey you have already completed. You can only take the survey once and your information will be kept confidential. This study is giving away a $100 Amazon gift card to the winner of a random drawing of all participants who complete the survey. If you have any questions about the survey, please email me, Fernanda, at fcb5100@psu.edu. I really appreciate your input!
Q1 Who was your audience when you posted in the MOOC forums? Please select all that apply.

☐ Your local colleagues (1)
☐ Other statistics teachers (2)
☐ The MOOC’s instructors (3)
☐ Yourself (4)
☐ Other (5) ____________________________________________

Q2 When you responded to someone else in the MOOC forums, you usually wrote responses for ____________. Please select all that apply.

☐ The original message writer (1)
☐ The audience on that discussion thread (2)
☐ The entire audience in the MOOC (3)
☐ The MOOC’s instructors (4)
☐ Other (5) ____________________________________________
Q3 What percent of your posts were comments to others’ posts only to acknowledge that they have been heard?

- I didn’t comment into others’ post to acknowledge that they have been heard (1)
- 1% to 20% of my total posts (2)
- 21% to 40% of my total posts (3)
- 41% to 60% of my total posts (4)
- 61% to 80% of my total posts (5)
- Greater than 80% of my total posts (6)

Q4 In the discussion forums, did any participant(s) stand out as leader(s) of the discussion(s)?

- Yes (1)
- No (2)

Display This Question:
If In the discussion forums, did any participant(s) stand out as leader(s) of the discussion(s)?
= Yes

Q33 If so, what did you learn from their participation?


Q5 In what ways are you similar to or different from other participants you have encountered in this MOOC?
Q6 Which similarities or differences between you and others, if any, have influenced your participation in this MOOC?

__________________________________________________________________________

Q7 In the discussion forums, did you seek out posts of *particular people*? If so, why?

__________________________________________________________________________

Q23 What were the most valuable discussions in the forums? Why were they valuable?

__________________________________________________________________________

Q10 Was the process of writing a post and comments beneficial to you? In which sense?

__________________________________________________________________________

Q8 Were there times when you wrote a post and then deleted it before sending it?

  - Yes (1)
  - No (2)
Display This Question:
*If Were there times when you wrote a post and then deleted it before sending it? = Yes*

Q9 What was the reason for you to delete the post before sending it?

________________________________________________________________________

Q11 How did you perceive the overall amount of participation, including yourself and others, in the discussion forums?

- There were too many posts and comments (1)
- There were the right amount of posts and comments (2)
- There were too few posts and comments (3)
- I did not participate in the forums (4)

Q12 What percent of all posts did you read?

- I didn't read posts (1)
- 1% to 20% of all posts (2)
- 21% to 40% of all posts (3)
- 41% to 60% of all posts (4)
- 61% to 80% of all posts (5)
- >80% of all posts (6)

Q13 As a MOOC participant, to what extent did you feel you were part of a community?
Q14 Did any participant in this MOOC contribute to your learning?

☐ Yes (1)

☐ No (2)

Display This Question:

If Did any participant in this MOOC contribute to your learning? = Yes

Q38 If so, how did they help you?

Q15 Did you interact with others in venues other than forums? If yes, in which of these venues did you interact? Please select all that apply.

☐ Email (1)

☐ Facebook (2)

☐ Wikis (3)

☐ Chat (4)

☐ Skype (5)

☐ In person meetings (6)

☐ Other (7) ____________________________

☐ I didn't interact with others aside of the TSDI MOOC platform (8)
Q16 Would you participate in discussions if they continue in a different website, such as a Facebook group, after the MOOC ends?

☐ Yes (1)

☐ No (2)

☐ I don't know (3)

☐ Other (4) ________________________________________________

Q17 Did you write something in the discussion forums and nobody replied to your post (or to your comment) or it took a long time for someone to respond to your post (or comment)?

☐ Yes (1)

☐ No (2)

Display This Question:

If Did you write something in the discussion forums and nobody replied to your post (or to your comment) = Yes

Q35 What did you think when this happened?

________________________________________________________________
________________________________________________________________
________________________________________________________________
Q18 How important is it to you that others read your posts?

- Very Unimportant (1)
- Unimportant (2)
- Neither Important nor Unimportant (3)
- Important (4)
- Very Important (5)

Q19 How much of the materials (e.g., videos, tasks, simulations, articles) provided in this MOOC did you access?

- 20% or less (1)
- 21% to 40% (2)
- 41% to 60% (3)
- 61% to 80% (4)
- >80% (5)
- I didn't access any course materials (6)

Q20 How did you decide whether you would access the MOOC materials (e.g., videos, tasks, simulations, articles)?
Q22 I used (or intend to use) materials generated by other teachers in this MOOC

- Strongly Disagree (1)
- Disagree (2)
- Neither Agree nor Disagree (3)
- Agree (4)
- Strongly Agree (5)

Q21 In the discussion forums, did you seek out posts about specific materials?

- Yes (1)
- No (2)

Display This Question:
If In the discussion forums, did you seek out posts about specific materials? = Yes
Q36 What kind of posts mattered to you? Posts about ____________________. Please select all that apply.

☐ teaching statistics to elementary school students (1)
☐ teaching statistics to middle school students (2)
☐ teaching statistics to secondary school students (3)
☐ teaching statistics to college students (4)
☐ teaching AP statistics (5)
☐ teaching statistics investigation (6)
☐ use of technological tools (7)
☐ use of free resources (8)
☐ Other (9) ____________________________________________

Q24 Considering your interactions with materials and with other participants in this MOOC, which learning experiences were the most helpful to you? Why?

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
Q26 For each action named below indicate the level of its importance to your learning when participating in discussion forums.

<table>
<thead>
<tr>
<th>Action</th>
<th>Very Important</th>
<th>Unimportant</th>
<th>Neither</th>
<th>Important</th>
<th>Very Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posting (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commenting (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q31 Are you willing to contribute to this study by participating in a volunteer interview about participants’ interactions with materials and with others in MOOCs? If yes, please, give your information below and I will get in touch with you.

- Name (1) ________________________________
- Email (2) ________________________________
Appendix B

Semi-Structured Individual Interview with Members of the MOOC Instruction Team

Warm-up

1) How was the experience of conducting a MOOC for statistics teachers?

2) How would you describe the instructor’s role in a MOOC for teachers? In your perspective, what is expected from an instructor in this environment?

3) What was the purpose of the discussion forums in the TSDI MOOC?

4) What do you think about the amount of participation by people in the discussion forums?

Probes

• there were too many posts and comments.

• there were the right amount of posts and comments.

• there were a few posts and comments.

5) Does the majority of posts align with your expectations regarding the design and participation of an online professional development for statistics teachers?

Interactions with other participants

6) Considering your participation in the discussion forums, what influenced you to try to comment on others’ post to acknowledge that they have been heard?

Probe:

• Why?

7) What usually cause you to comment on forum posts (or to not comment on forum posts)? Was there any theme that made you to choose to comment on posts of others?
8) Do you recall if was there someone who wrote the most posts in the discussion forums you visited?

Probes:

a. Yes Who was? What were these posts about?

b. No

9) In your perspective, who were the ‘leading participants’ in the discussion forums?

10) Considering the TSDI MOOC’s discussion forums, what were the majority of posts about?

11) What were the most relevant discussions that you participate in the TSDI forums?

12) Was there any participant in the discussion forums that you consider an expert? Why?

13) Describe the way you typically read the posts in the discussion forums. For instance, did you start reading the posts by date or by post title? Did you look for particular people or specific topics?

14) Were situations that you wrote a post and then deleted it before sending it?

Probes:

• What was the reason for you to delete the post before sending it?

15) Did participants’ exchange extra materials through the discussion forums? How did this happen? How might practice benefit participant’s learning in the MOOC?

Learning

16) Would you say that you learned something by participating in the discussion forums?

a. Yes

• What did you learn?

b. No

17) Which is the most important to one’s learning when participating in discussion forums?
• Posting?
• Reading?
• Reading and commenting?
• Reading and posting?
• Reading, posting, and commenting?

Why?

18) How discussion forums can be used to enhance participant’s learning in MOOCs?

19) How forums can be used to promote discussions that fosters teacher’s statistical content knowledge?

Probes:

• Is it something that you would like the MOOC to develop on teachers?

20) What MOOCs can do to engage peripheral participants as lurkers?

Community

21) Would you say that the TSDI participants had a sense of community?

Probes:

a. Yes
   • What makes you say that?
   • Describe an event/experience that make you to think in this way?

b. No
   • What makes you say that?

22) Would you participate in the forum discussions if they continue in a different website such as a Facebook group?

a. Yes Why?

b. No Why not?
Identity

23) How important was participant’s identity identification (such as age, education level, country of origin, etc.) when engaging in forums?

24) How comfortable did you feel interacting with others in the TSDI discussion forums?

25) Do you think participants sharing aspects of their personal experience in discussion forums is important to participant’s learning in MOOCs

Wrap-up

26) Is there anything you would change regarding the discussion forums?
Appendix C

Invitation Letter for Participants’ Online Survey

Dear MOOC participant,

As part of my work toward a doctorate degree in Curriculum and Instruction with emphasis in Mathematics Education, I am conducting research related to participants’ interaction in online professional development. I am interested in participants’ interactions (with each other and with materials) as a way of learning in a MOOC for statistics teaching. As a participant in the TSDI MOOC, I am specifically interested in ascertaining your perceptions of your course experience in this online professional development.

If you decide to participate, next you will have 35 questions related to your interaction experience within the TSDI MOOC. I estimate it will take approximately 30 minutes to complete this questionnaire. Your participation is voluntary and you can abstain from answering any or all questions without any explanation. Your completion of this survey will serve as your consent. All of your responses will remain confidential as all identifying information including your name and email address will be deindentified, thus protecting your anonymity.

There are no anticipated risks to you as a participant. The benefits of your participation have the potential to significantly impact research in MOOCs as professional development venues as well as the characteristics of teachers’ interactions when teachers use these venues that may lead to an establishment of a global community of practice.

If you have questions or comments please contact me (fcb5100@psu.edu) or my advisor, Dr. Rose Mary Zbiek (rmz101@psu.edu). This research was approved by the Institutional Review
Board for the protection of human subjects at The Pennsylvania State University. Access the survey here: [survey link]

Thank you very much for your consideration of this invitation.

Sincerely,

Fernanda Bonafini fcb5100@psu.edu
Appendix D
Invitation Letter for Individual Interview with Members of the MOOC Instruction Team

Dear (insert name),

As part of my work toward a doctorate degree in Curriculum and Instruction with emphasis in Mathematics Education, I am conducting research related to MOOCs as online professional development. My investigation focuses on exploring the characteristics of MOOCs as effective professional development for teachers, teachers’ interactions that happen in MOOCs discussion forums, and the instructor’s role in fostering participants’ learning through their interactions. In this interview, I am specifically interested in ascertaining your perceptions regarding the interactions that occurred in the TSDI MOOC that you developed and implemented.

If you decide to participate, I would like to invite you to participate in a semi-structured interview that can happen in person or via Skype. If in person or by Skype, the interview will be audio recorded only. I estimate the interview will take two hours and, if necessary, any follow-up can be done by phone call or email.

Your participation is voluntary and you can abstain from answering any or all questions without any explanation. Your participation in this interview will serve as your consent. All of your responses will remain confidential as all identifying information including your name and email address will be deidentified, thus protecting your anonymity.

There are no anticipated risks to you as a participant. The benefits of your participation have the potential to significantly impact research in MOOCs as professional development venues as well as the characteristics of MOOCs instructor’s interactions that may lead to an establishment of a global community of practice.
If you have questions or comments please contact me (814-321-4561 or fcb5100@psu.edu) or my advisor, Dr. Rose Mary Zbiek (814- 863-1210 or rmz101@psu.edu).

This research was approved by the Institutional Review Board for the protection of human subjects at The Pennsylvania State University. Questions or comments can also be directed to the Institutional Review Board for the protection of human subjects at The Pennsylvania State University.

Thank you very much for your consideration of this invitation.

Sincerely,

Fernanda Bonafini

fcb5100@psu.edu
VITA

Fernanda Cesar Bonafini

Education
Ph.D., Curriculum and Instruction in Mathematics Education (Minor in Statistics), The Pennsylvania State University, 2018
M.Ed., Mathematics Education, São Paulo State University, Brazil, 2004
Mathematics Education Teaching Licensure in Secondary Education, Faculdades Oswaldo Cruz, Brazil, 2000
B.S., Electrical Engineering, Faculdade de Engenharia São Paulo, Brazil, 1998

Selected Academic and Professional Experience
Graduate Assistant, The Pennsylvania State University, College of Education, C&I (May 2013 – May 2018)
Graduate Research Assistant, The Pennsylvania State University, Mid-Atlantic Center for Mathematics Teaching and Learning [MAC-MTL] (Aug 2011 – May 2013)
Instructor, Faculdades Integradas Campos Salles (FICS) (Feb 2011 – Jul 2011)
Instructor, Universidade Paulista (UNIP) (Sep 2008 – Dec 2009)
Program Coordinator of Executive and Finance MBA Programs, Insper Institute (IBMEC) (Mar 2003 – Mar 2008)
Instructor, Faculdade de Engenharia São Paulo (FESP) (Feb 1999 – Dec 2004)

Scholarly Publications


Grants, Fellowships, & Awards
James and Esther Pollock St. Clair Award – 2015 and 2014.