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KEYSTONES TO OPPORTUNITY: A STUDY OF LITERACY SKILL IMPLEMENTATION AND ITS IMPACTS ON SCIENCE LEARNING

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Abstract

This study provides an argument for increased literacy teaching implementation in the science classroom. The population studied consists of students in Pennsylvania who took the Keystone Biology assessment at least one time during the 2012-2016 school years. These students were also members of school districts that were recipients of the Keystones to Opportunity grant. In this study, a higher funding percentage from the Keystones to Opportunity grant is indicative of increased literacy teaching implementation, and growth on the Keystone Biology Exam is indicative of science learning improvement. The Keystones to Opportunity grant is Pennsylvania's piece of the Striving Readers Comprehensive Literacy grant, which is a national initiative to promote comprehensive literacy gains in local educational agencies across the United States.

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Keystones to Opportunity grant

KTO

Striving Readers Comprehensive Literacy grant

SRCL

Introduction

The Keystones to Opportunity (KTO) grants program in Pennsylvania was initially funded by a national Striving Readers Comprehensive Literacy (SRCL) grant awarded to Pennsylvania by the U.S. Department of Education. The goal of KTO is to advance literacy skills through professional development, screening and assessment, targeted interventions for students reading below grade level, and research-based methods of improving classroom instruction and practice ("Keystones to Opportunity Background," n.d.). Each grant recipient school district was required to create and implement a comprehensive literacy plan, and the grade-level allocation of grant program funds from KTO was the choice of each district. Because the allocation of funds (and funded programming) varied among school districts, the project offered a potentially interesting way to evaluate the effects of literacy-focused programming on science learning.

This study offers an argument for increased literacy teaching implementation in science classrooms, with the overall goal of improving student learning regardless of the subject material. Casner-Lotto and Barrington (2006) point out that reading comprehension, English language, and writing in English are the three most important basic skills for job success for new workforce entrants according to employers. Guiliano and Sullivan (2007) add that "without adequate reading comprehension, writing proficiency…. Students pursuing higher education are vulnerable to failure" (p. 7). Both publications highlight the importance of literacy skills as part of a student's preparation to leave high school and enter the workforce or higher education. Both also suggest that literacy skills are important predictors of success in fields other than English/Language Arts. The use of literacy skills and their implementation as a predictor for Biology Keystone Test scores is the focus of this study.

Eligibility restrictions such as demographic need, academic need, and the implementation of a comprehensive literacy program, were major selection criteria used during the KTO grant application processes. These eligibility restrictions made comparing KTO to non-KTO districts difficult, due to selection bias, so only successful KTO applicants were compared in this study. How grant funds were distributed throughout grant-awarded districts was the choice of each district, which provided an opportunity to compare fund allocation and assessment scores. More specifically, the author hypothesized that a significant positive correlation would be observed between school districts' relative allocation of Keystones to Opportunity Grant funds to middle school and high school-aged students and Biology Keystone Test scores.

To test this hypothesis, Biology Keystone Test data were obtained for the 2012-2013, 2013-2014, 2014-2015, and 2015-2016 school years, with the 2012-2013 year acting as the baseline year (prior to the implementation of district literacy activities) and all other years included to measure growth. Each district's money allotment was distributed in its grant proposal into four categories: birth-5, elementary, middle school, and high school. The percentage of total grant money allotted to middle and high school was compared to improvement in test scores for each district.

Literacy is a complex topic centered around an individual's ability to read and write, and is influenced by a person's mediation and participation with literacy in a specific context (Kalman, 2008). Scientific literacy involves an understanding of scientific topics and their relationships to real-world applications. These applications can include economic productivity, cultural and civic affairs, and personal decision making (*National Science Education Standards*, 1996). Many past studies have focused on scientific literacy (Ayala, 2004; Dragoş & Mih, 2015; Loughran, Smith, & Berry, 2011). Far fewer studies have focused on the impact that general

literacy, the ability to read and write, has on students' abilities to learn and apply scientific knowledge.

A comprehensive literacy program is a group of methods employed by a school district with the intended purpose of capturing the multifaceted nature of literacy and improving the collective literacy of that district's students. These programs are approved by the school board of the participating district and are made available to the public. A comprehensive literacy program is usually unique to the district that it serves, reflecting the specific contexts of the students learning in that district. A few examples of methods used inside of the school building to improve literacy include professional development, instructional coaching, and data-based goals. These types of methods can have a direct impact on curriculum and instruction and affect the people who work and learn within the school. Other methods used outside of the school include efforts to increase community members' participation in literacy initiatives. These methods focus on involving those indirectly tied to a school district and who have vested interest in the outcomes of students. These indirect participants should not be taken lightly, as they can have as large of an impact on student outcomes and curriculum as in-school participants.

In 2011, the U.S. Department of Education awarded grants to six state education agencies (SEAs) through the national Striving Readers Comprehensive Literacy (SRCL) discretionary grant competition. The purposes of this grant included the establishment and support of a state literacy team, as well as providing help to each state to develop a comprehensive literacy plan (Applied Engineering Management Corporation, 2016). Pennsylvania was one of the awarded states.

In 2012, Pennsylvania in turn awarded 36.7 million SRCL grant dollars to 53 school districts and two charter schools. Pennsylvania named its particular SRCL grant program

"Keystones to Opportunity" (KTO): Pennsylvania's Vision for Sustainable Growth in Reading Achievement. KTO's main purposes were to improve literacy achievement for students with greatest needs and to place literacy at the center of learning across the curriculum (Pennsylvania's Keystones to Opportunity, n.d.).

To accomplish the main purposes of the grant, Pennsylvania decided to support the advancement of literacy skills through four major methods, including professional development, screening and assessment, targeted interventions for students reading below grade level, and the use of research-based methods of improving classroom instruction and practice. Another major part of the Keystones to Opportunity grant required each school grant recipient to implement a comprehensive literacy plan, as described previously in the paper "Keystones to Opportunity Background" (n.d.).

The KTO grant also specified three goals for districts to strive for throughout the duration of the grant ("Keystones to Opportunity Background," n.d.). The first goal was to simply improve literacy learning outcomes, specifically for students at risk for academic failure. Second, the grant strove to create a culture of data-driven decision making, driving home the implementation of Bernhardt's Multiple Measures Data logic model at the state, regional and local levels. The final goal was to infuse digital technology and Universal Design for Learning, which the grant hoped would provide examples of technology tools and multiple pathways in which those tools can express and represent information. The grant also helped teachers to create new options for developing literacy persistence, stamina and motivation ("Keystones to Opportunity Background," n.d.).

Schools in Pennsylvania competed for awards through both a pre-application process and a final application process. The pre- and final application processes are relevant to this study

because they help to outline the characteristics of schools that were included in the study. The pre-application process was designed to identify LEAs/ECEs (Local Educational Agency/Early Childhood Education entity) with the greatest academic need and the greatest capacity for improving student literacy scores. Early Childhood Education applications were given priority points if they had a Keystone Star rating from the Pennsylvania Department of Education (which identifies its ECE as high quality), and the amount of money available to a Local Educational Agencies depended on the number of students targeted for the intervention. Schools also earned priority points if they planned to distribute funds to areas of literacy need, for example giving funds to a school in the district with lower than average PSSA reading proficiency scores (Pennsylvania Department of Education, 2012a).

Once completed, the pre-applications were scored by the granters using three major criteria: demographic need, academic need, and the capacity of the applicant to address these needs based on the quality of the comprehensive Local Needs Assessment. Demographic need was defined by the grant as those LEAs with a higher proportion of disadvantaged students (living in poverty; limited English-proficient; far below grade level or who are not on track to becoming college or career-ready by graduation; left school before receiving a regular high school diploma; at risk of not graduating with a diploma on time; homeless; foster care; pregnant or parenting teenagers; incarcerated; new immigrants; migrant; disabilities). Applicants who obtained an adequate score on the Pre-application were invited to submit a Full Application on February 1, 2012 (Pennsylvania Department of Education, 2012a).

The final, or full, application process was essentially a more in-depth version of the pre-application process (Pennsylvania Department of Education, 2012b). Applicants were scored based upon seven major criteria, and the highest scored applicants from this final round became

eligible for grant funding. First, applicants needed to identify the appropriate target group within their district that would be the focus of the grant money. This group included a listing of schools, classrooms, teachers, instructional leaders, and district administrators included in target group. The target group had to be large enough to still benefit the entire LEA and had to be the most likely group in the LEA to yield the largest improvements. Literacy outcomes were to improve through professional development, targeted changes in classroom literacy environments, the use of student assessment data to guide daily instruction, and the implementation of research-based literacy practices. All members of the target group were to commit to these literacy outcomes (Pennsylvania Department of Education, 2012b).

The second major component of the final application process was the development of a local comprehensive literacy plan, which had to be signed by a diverse group of stakeholders committed to improving literacy outcomes in the LEA from kindergarten to twelfth grade. The comprehensive literacy plan was to be rigorous and used to guide LEA literacy activities as described earlier in this section. Third, applicants needed to outline their plans to help teachers acquire the baseline knowledge and skills necessary to perform the duties outlined in the comprehensive literacy program. A majority of teachers would need to acquire the baseline knowledge and skills covered in nine literacy content areas during year one. Year one professional development for teachers or other LEA staff members had to be research-based, high-quality and consistent with the goals of the Keystones to Opportunity initiative (Pennsylvania Department of Education, 2012b).

Fourth, applicants needed to include a description of the ideal literacy environment with an analysis of LEA/ECE need for each possible target area: birth-3, preschool, elementary, middle, and high school. Fifth, each LEA had to outline how it planned to use data to inform

instructional decision making, including administering the required assessments, collecting and compiling the assessment data, analyzing and sharing literacy assessment results with the school community, engaging stakeholder groups in the community, and achieving adequate progress in literacy skills for targeted students by the end of year one. Sixth, a local literacy improvement plan needed to be included, which was a more specific version of comprehensive literacy plan down to each individual professional's responsibilities. Finally, each applicant needed to include a budget and budget narrative specific to their own LEA (Pennsylvania Department of Education, 2012b).

Rationale for Study

From a personal perspective, the researcher has experienced the impact that literacy has had on science learning for five years, and those experiences motivated him to undertake this study.

For the first two years of his teaching career, the researcher taught Anatomy and Physiology only. Students in this setting had few issues learning complex material and complex language, and much of the classroom material was backed up using a college level textbook.

In the third year of teaching, the researcher started to teach Biology, which was a very different experience than Anatomy and Physiology. Many of the students were taking the course for the second time, in an effort to meet graduation requirements, and the majority of the students were reading below grade level. Almost immediately upon beginning the school year, literacy was identified as the largest barrier to learning. These literacy issues included difficulties with major portions of learning, like listening and reading comprehension, as well as expressing ideas through writing and speaking.

By this third year, the school district happened to be in the third year of its comprehensive literacy program. Positive experiences related to the researcher from other teachers inspired the introduction of practices outlined in the district's comprehensive literacy program. These practices included teacher training and coaching, professional development, and many other examples of literacy initiatives. This experience had very positives outcomes on the researcher's classroom and provided interest in studying the true effectiveness of literacy teaching in the science classroom.

In the two most recent (fourth and fifth) years of teaching, the researcher has continued to implement literacy teachings into the classroom and has noticed that these skills also translate

well into the Anatomy and Physiology classroom. Even students reading at or above their grade's reading level have benefitted from the aspects described in the comprehensive literacy program.

From a much broader perspective, literacy skills and their impacts on students after they leave K-12 education are vitally important both to the individuals who are learning these skills and the communities that those individuals influence. According to Casner-Lotto and Barrington, reading comprehension, English language, and writing in English are the three most important basic skills for job success for new workforce entrants according to employers (2006). The basic skills included students with high school, two year college, and four year college graduates, which shows the importance of these skills across professions. These same employers rated the level of deficiencies of writing in English, reading, written communications, and critical thinking at 72%, 38% 81%, and 70%, respectively, in new job candidates (Casner-Lotto & Barrington, 2006). The first three percentages are directly addressed by a typical comprehensive literacy plan, and critical thinking skills can be improved through writing (Quitadamo & Kurtz, 2007). Concern for these numbers is forcing businesses to spend large sums of money on remedial training, which currently totals more than 60 billion dollars each year, most of which is focused on reading and writing (Corporate Voices for Working Families, n.d.).

These findings speak to both the importance of strong literacy skills for students, as well as how deficient students often are in these skills when entering the workforce and higher education. The implementation of a comprehensive literacy plan could certainly help to relieve some of these literacy concerns as well as better prepare students for their future endeavors. This study could help to shed light on the common misconception that literacy is only important for subjects and careers that are considered to be reading and writing heavy. Literacy skills should

not be viewed as an afterthought in science subjects, but as a group of abilities necessary to gain the well-rounded science knowledge that our educational system strives to provide. In the same vein, this study could provide positive persuasion for the implementation of a comprehensive literacy program across subjects other than English and Language Arts and make the case for more literacy proficient college and workforce bound students.

Not only do poor literacy skills hinder a new candidate entering the workforce, but these deficiencies could also cause problems for students pursuing higher education. Giuliano and Sullivan created a program for students entering secondary education that focused on improving vital academic survival techniques, two of which were reading comprehension and writing proficiency. Examples of how the program would improve these techniques include reading and understanding a college textbook, composing written lab reports, and defending a position on an environmental issue (Giuliano & Sullivan, 2007). The program was based upon the idea proposed by Moore (2004) that when entering college "many underprepared students need to play 'catch up' with their classmates, indicating that something in their prior educational experience… may account for their academic difficulties" (p. 32). The program also focuses on reflection through writing and communicating, another common tenant of a comprehensive literacy program, by having the students compose an environmental issue paper and give an oral presentation of the paper to the class. This project touches upon a point made by Merritt, Shajira, and Daisey (2003), who suggested that the combination of completing a task and then writing about the task is more effective for learning than only completing the task or writing alone. This stresses the idea that simply learning science is not enough and adding literacy strategies to science learning could prove beneficial. Concluding their study, Giuliano and Sullivan (2007) argue that "without adequate reading comprehension [and] writing

proficiency….students pursuing higher education are vulnerable to failure" (p. 7), again showing the importance of implementing a comprehensive literacy program and the literacy skills that those programs promote.

The studies outlined above point to multiple justifications for moving forward with this study. Literacy plays an important role in all fields, and studying literacy implementation on a larger scale could provide greater persuasion to implement literacy strategies in classrooms other than English and Language Arts, and produce College and career bound students that are more literacy proficient. Preparation for students' futures, both academic and professional, is the first goal of an educational program, and literacy skills taught across subjects could certainly help more students to realize this goal. Furthermore, science can no longer be looked at as a series of facts to memorize, but a multifaceted subject that requires proper communication skills.

Literature Review

A significant amount of literature has been previously published regarding literacy skills and science learning. This literature has covered such topics as scientific literacy, textbook reading ability and science learning, a current curriculum company and its use of literacy to improve learning, literacy education in the later grades, literacy instruction in the science classroom, and literacy skills' effects on science learning. With the purpose of this study being to identify a relationship between literacy skill implementation and Biology Keystone test scores, the author hopes that the research included in this section allows the reader to situate the research for this study into the overall literature regarding literacy skills and biology learning.

Scientific Literacy

There have been a number of studies relating to scientific literacy, which is important to differentiate from literacy's relationship to science learning. Scientific literacy is the understanding of scientific concepts related to real-world problems, including economic productivity, cultural and civic affairs, and personal decision making (*National Science Education Standards*, 1996). Loughran, Smith, and Berry (2011) edited a complete conglomeration of texts regarding scientific literacy's role in schools, as well as challenges, myths, and perceptions to scientific literacy. The National Research Council suggests three dimensions of science covered in a student's education, should that student expect to be scientifically literate by the end of twelfth grade: scientific and engineering practices, crosscutting concepts, and core ideas (National Research Council, 2012). The NRC framework also suggests multiple educational principles, such as "children are born investigators" (p. 24) and "connecting to students' interests and experiences" (p. 28), to guide and inform teaching (National Research Council, 2012). Studies looking at teachers' opinions of scientific literacy

include Dragoș and Mih's (2015), which suggested that teachers must develop a positive attitude towards science in order to improve scientific literacy in their own classrooms. The researchers found that, generally, teachers do share this positive attitude.

Scientific literacy was rarely linked to the ability to read and write; however, Ayala (2004) did make this connection by giving an alternate definition of scientific literacy in society: "Scientific literacy does not imply that a person must be learned in matters of science, but rather means functional literacy, the ability to comprehend what is read or written to an extent sufficient to perform adequately in society" (p. 394).

Scientific literacy alone does not provide the connection between science learning and literacy as sought in this paper and it is important to note the differences between scientific literacy and the effect that literacy skills can have on science learning.

Textbook Reading Ability and Science Learning

Many of the literacy skills covered in the Keystones to Opportunity grant can help students to better navigate and understand the material that is covered in a typical high school biology textbook. A number of studies focused on the relationship between textbooks and student comprehension. In a study to better understand textbook design's influence on science learning in students, Hall and colleagues (2015) sampled over one hundred students aged twelve to thirteen for their ability to understand science material learned from low and high cohesion textbooks. High cohesion texts function as a single unit, whereas low cohesion texts function more as a random sequence of individual thoughts (Shoebottom, 2016). High cohesion texts were found to improve student understanding more than low cohesion texts; however, reading ability was the largest predictor of student comprehension regardless of text design (Hall et al., 2015). With science textbooks being a major informational provider of science knowledge to

students, students' abilities to comprehend these textbooks is crucial for their science learning. The researchers then go on to suggest that basic reading skills and teaching reading skills in the classroom are crucial to learning (Hall et al., 2015). Ozuru, Dempsey, and McNamara (2009) performed a similar study on biology text comprehension in college students. The researchers found that a student's degree of benefit from reading a high-cohesion science text was dependent on student's reading abilities, with high ability students benefitting more than low ability students, once again hinting at the academic advantages that literacy skills can provide. Both of these studies highlight the importance of reading skill and comprehension, and their ties to increasing science knowledge gains (Hall et al., 2015; Ozuru et al., 2009).

Snow (2010) provides a perspective covering the complex academic language that science is typically written in and how it can negatively affect science learning. The author mentions that students need well-developed literacy skills to successfully navigate through the "sophisticated words and complex grammatical constitutions that can disrupt reading comprehension and block learning" (p. 450). These studies suggest the importance of building these literacy skills throughout a student's education, because the ability to read subject-specific science material is critical to science learning.

A Current Curriculum Company and its Use of Literacy to Improve Learning

An organization that aims to include literacy learning in the science classroom, Seeds of Science Roots of Reading, provides research-based curriculum that claims to teach essential science understandings while building literacy skills. The curriculum provided by this organization focuses on 2nd through 5th grades and implements literacy into the science classroom using their "do-it, talk-it, read-it, write-it" method. This method not only causes the students to do hands-on science work in the classroom, but also encourages them to then

communicate their work with their peers through multiple mediums (oral, written), which helps the students to practice literacy skills ("Seeds of Science Roots of Reading," n.d.). Using the Seeds of Science Roots of Reading program has been shown to improve vocabulary, writing, and science content (Goldschmidt & Hyekyung, 2011). Seeds of Science Roots of Reading also conducts its own research regarding the implementation of literacy into the science classroom for ELL students, including how to make science instruction more accessible for ELLs (Cervetti, Bravo, Duong, Hernandez, & Tilson, 2008) and how cognates can be used to improve science learning for ELLs (Bravo, Heibert, & Pearson, n.d.). These methodologies touch upon multiple tenets of the KTO grant and give possible representations of what a district curriculum coupled with a comprehensive literacy program could look like.

Literacy Education in the Later Grades

Many studies have focused on how literacy instruction has had an impact on students' learning in the earlier grades, and there has been less attention to the topic for the later grades. This should not discount the importance of literacy for older students, who have many different literacy issues in contrast to their younger counterparts. The following two studies published by the Carnegie Corporation of New York made an effort to look at students' literacy skills throughout their schooling, which provides a relatively rare research perspective on the literacy skills of students in the later grades. The first report, *Time to Act: An Agenda for Advancing Adolescent Literacy for College and Career Success* (Carnegie Council on Advancing Adolescent Literacy, 2010) focused on kindergarten through fourth grade with continuance into the later grades, while the second report, *Reading in the Disciplines: The Challenges of Adolescent Literacy* (Lee & Spratley, 2010) focused on the transition from kindergarten through fifth grade reading to sixth through twelfth grade reading.

The first of these reports, *Time to Act*, focused on how literacy improvement has begun to lag behind the demands of the global economy. The report argues that to reverse this negative trend in literacy skills, literacy instruction must be systematically implemented into classroom practice, accompanied by support for teachers with professional development that reflects the current research on literacy. This implementation and support needs to continue into the later grades, as most students are only receiving the requisite literacy instruction that they need until the third grade, which hinders their ability to continue improving literacy skills until they enter the workforce. The report then provides five principles to abide by as action is taken towards improving literacy, including literacy for all, making adolescents college and career ready, what makes successful reform, including these changes at all levels, and a call to action (Carnegie Council on Advancing Adolescent Literacy, 2010). Many of the tenets of this report match those included in the Keystones to Opportunity grant, with both stressing literacy instruction throughout a student's education experience. This link indicates the importance of literacy skills in the learning process.

The second report published by the Carnegie Corporation of New York, entitled *Reading in the Disciplines: The Challenges of Adolescent Literacy*, looked into various problems circulating throughout adolescent literacy and provides possible solutions to them. The report mentions problems in the following areas: vocabulary knowledge, topic and text structure knowledge, knowledge of how to work with broken down text comprehension, and knowledge of how to model one's own reading comprehension. To correct these issues, the report provides a "reading to learn" approach to literacy as opposed to the "learning to read" method that is most commonly used when teaching adolescents literacy skills. This "reading to learn" approach requires students to read within the context of whatever subject they are currently learning, and

causes students to incorporate many different academic concepts, skills, and modes of reasoning into their literacy learning. This transition from one approach to the other happens near the fifth and sixth grades, with the "reading to learn" approach begins to dominate students' literacy skills (Lee & Spratley, 2010). This report once again stresses the importance of continued literacy instruction throughout a student's education, which is mirrored by the KTO grant.

Literacy Instruction in the Science Classroom

Many of the important aspects of the Keystones to Opportunity grant include methods to improve teacher instruction in literacy. As mentioned before, these methods include the use of data-based goals, professional development, instructional coaching, and other strategies to improve teachers' abilities to instruct literacy skills in their classrooms. These methods are crucial to the success of a comprehensive literacy program, with the teachers being the primary instructor in the students' literacy education. Without a strong foundation in literacy instruction, teachers may struggle to teach literacy, making the levels of student literacy understanding outlined in the comprehensive literacy program difficult to reach.

Instructional coaching and the use of data-based goals are common methods mentioned by comprehensive literacy programs to improve student literacy. Instructional literacy coaching has been shown to improve teachers' literacy instruction skills (Matsumura, Garnier, Correnti, Junker, & DiPrima Bickel, 2010), and data-based goals have been tied to improvements in the instructional practices of teachers (Ittner, Helman, Burns, & McComas, 2015). In the latter study, teachers were provided with instructional coaches who used data to develop professional development sessions throughout the school year which were aimed at improving teacher literacy instruction and student outcomes. The goals of the study were to improve student learning through teacher learning as well as to improve district wide literacy practices (Ittner et al., 2015).

The use of both instructional coaching and data-based goals in this study outline a useful combination of two important tenets of a comprehensive literacy plan, both of which are aimed at improving teacher literacy instruction.

A common method mentioned by comprehensive literacy programs to improve literacy instruction is professional development, which was found to improve teachers' literacy instruction skills as well as student literacy skills (Correnti, 2007). A different study looked at professional development's effect on 9th and 10th grade teachers' integration of literacy instruction into their biology teaching, and found that professional development had a positive affect not only on teachers' ability to teach literacy but also on how often they implement literacy into their daily lessons (Greenleaf et al., 2011). Neuman and Cunningham (2009) investigated early language and literacy teaching practices by placing teachers into three groups: a three credit course in early language and literacy, the same three credit course with ongoing instructional coaching, and a control group without the course or coaching. The authors were interested if the addition of literacy coaching to professional development would improve literacy instructional skills. Teacher knowledge did not improve; however, the authors found significant improvements in language and literacy practices when combining instructional literacy coaching along with professional development rather than only professional development. These studies point out a number of different benefits to literacy instruction and learning from proper professional development; this further advocates for the implementation of a comprehensive literacy program, because many of these programs include professional development as a method to improving student literacy.

Finally, it is important to note that many of the methods suggested by the KTO grant and an accompanying comprehensive literacy program would not require drastic changes in teacher

instruction. Goldstein and Flynn (2011) studied introductory biology curriculum at the college level. The authors noticed that many students were having trouble with analytical and quantitative thinking skills. These skills are indirectly important to biology learning, similar to literacy's indirect impact on learning. The authors focused on making alterations to already existing exercises rather than making drastic changes in the curriculum and were interested in how these smaller alterations can lead to positive changes in student learning and attitudes. The authors found that these small alterations did create the desired positive changes in student learning and attitudes (Goldstein & Flynn, 2011). This is relevant to KTO grant implementation, because the vast majority of changes in teacher practice suggested in the program would require alterations to existing methods of teaching, rather than a complete overhaul of curriculum. Making less drastic changes to teachers' work lives could improve program fidelity of implementation.

Literacy Skills' Effects on Science Learning

Multiple studies have touched upon the methods mentioned in the Keystones to Opportunity grant and their impact on various aspects of learning and teaching, many of which have been mentioned above. Interestingly, very few studies have focused on a more direct link between literacy skill acquisition and science learning. A study considering English language learners (ELLs) found that most science materials do not consider literacy, even though literacy and language development is possible through science. This same study also found that ELLs learn science best when combined with literacy instruction (Fradd, Lee, Sutman, & Saxton, 2001). In a Pelger and Nilsson study (2015), students were questioned on their own experiences with writing and scientific learning. A common theme amongst the students was that their ability to communicate scientific findings through writing was tied to better science knowledge

gains. These are the types of skills that a comprehensive literacy program could build in students throughout a school district, and this study speaks to the usefulness of such a program for English language learners.

Many of the benefits that students could reap from a comprehensive literacy program transfer into higher academics after high school. Jerde and Taper (2004) studied the difficulties that many college students have with writing scientific papers. They did this by comparing previous college composition courses taken, scientific writing experience, and tutorial services available across a group of college students in relation to their performance when completing two writing projects. The authors hoped to better understand not only how prepared students are for scientific writing when entering college, but also if the efforts provided (tutorial services) at the university were generating significant student writing ability gains. The authors found that previous scientific writing experience was the only factor that had lasting impacts on scientific writing performance. This study speaks to the importance of introducing literacy skills into science curriculum throughout students' schooling to promote better literacy skills by the time they reach literacy-heavy classes and jobs. Many students entering higher academia are ill prepared for the rigors of scientific writing in college and attempting to rectify the lacking writing ability of students while in these literacy-heavy positions usually produces no writing gains. These ideas further promote the implementation of the KTO program's ideas, in an effort to avoid shipping prospective college students away from our high schools lacking the requisite skills to succeed at the next level.

The current literature regarding literacy and science learning allows connections to be made between the methods mentioned in the Keystones to Opportunity grant and biology learning. Indirect connections, including scientific literacy, textbook reading ability, curriculum

companies' use of literacy, and literacy education in the later grades, identify different topics not historically associated with science learning. When these topics are examined more closely, strong connections begin to form between literacy and science learning, advocating for the inclusion of literacy skills in science learning. Literacy instruction in the science classroom and how literacy skills affect science learning constitute two direct connections between literacy skills and science education. These connections serve as evidence for why these skills should be included in science curriculum and makes the argument for literacy inclusion in the science classroom more difficult to refute.

Methodology

The following hypotheses were generated in response to the above research question:

H_O: No significant correlation will be observed between school districts' relative allocation of Keystones to Opportunity grant funds to middle and high school aged students and Biology Keystone Test scores

H_A: A significant positive correlation will be observed between school districts' relative allocation of Keystones to Opportunity grant funds to middle school and high school aged students and Biology Keystone Test scores

The author expects to reject the null hypothesis for a number of reasons. Allen (2014) found that any attempt to increase reading levels would improve standardized biology assessment scores, which points to a link between the types of literacy goals in the KTO grant and improved Biology Keystone test scores. Allen's study focused upon ninth and tenth grade students, who make up a key demographic of this experiment. Also speaking to literacy skills and biology learning, Lakrim (2007) noted that "writing helps to improve learning, memorizing, and more importantly, understanding, complex biological concepts, and students' performances increase over time as seen in the different situations" (p.23). Lakrim's study is relevant to the above hypotheses because it not only hints at a relationship between a major literacy skill and biology learning, but also suggests that this learning increases over time.

Greenleaf et al. (2011) performed a study that attempted to link the effects of professional development integrating literacy with biology teaching and that development's effects on teachers' instruction and students' academic literacy and science achievement. The researchers

found that students in ninth and tenth grades receiving the treatment scored better on state standardized tests than those in the control classrooms across the multiple subjects, including reading comprehension, English language arts, and biology. This study speaks for the importance of solid professional development when integrating literacy into the science classroom, as well as its possible benefits to the students in those classrooms. Greenleaf et al.'s study also suggests that strong literacy skills can benefit students across subjects and covers the aforementioned key demographic (ninth and tenth grade students). Overall, Greenleaf et al.'s study provides strong persuasion against the null hypothesis (Greenleaf et al., 2011).

For each year in the study, Biology Keystone Exam data were retrieved from databases online. The 2012 -2013 school year data ("Pennsylvania Dept of Education - State Federal Reporting Measures," n.d.) and the 2013-2014, 2014-2015, and 2015-2016 data ("Keystone Exams Results," n.d.) were consolidated from multiple locations within the Pennsylvania Department of Education website. 2012-2013 acted as the baseline year for the study, prior to the implementation of grant-funded activities. Notably, it also was the first year that the Keystone Biology Test was required for graduation from Pennsylvania high schools. The subsequent years provided Keystone Exam scores for the same schools, over the first three years of KTO intervention.

All districts included within the study were recipients of KTO grant awards, which allowed for the use of an internal comparison group using nearly identical criteria between districts. These criteria included demographic and academic need, as well as implementing the many facets of a comprehensive literacy plan, both of which were part of the KTO grant application process. Money allotment for the grant was included in four categories: birth through five years old, followed by elementary, middle, and high school aged students. The

percentage of total money from the four categories that was allotted to middle and high school acted as the primary predictor of the study.

For the study's principal outcome variable, each district's Keystone Biology scores were provided from the Pennsylvania Department of Education in four aggregated data categories: Below Basic, Basic, Proficient, and Advanced. The numbers of students in each category were reported as percentages. A subscore was found for each year by subtracting the total number of students who scored in the Below Basic and Basic categories from the total students who scored in the Advanced and Proficient categories in each district. Improvement for each year was then calculated by taking the baseline year's (2012-2013) subscore and subtracting it from the subscore of each subsequent year individually (e.g. (subscore 2015-2016) – (subscore 2012-2013)). This calculation provided an improvement value for each district individually in which each treatment year was compared to the baseline year. This measure was created by the author and provides a method of measuring the percentage of students crossing over from a failing grade (basic or below basic) to a passing grade (proficient or advanced) per year.

For each year after the baseline, the relationship between the predictor (relative allocation of grant funds) and the outcome (improvement) was evaluated, initially with a simple correlation. These same correlations were then analyzed for "room to grow" schools as well, which included schools with over 50 percent of Biology Keystone test takers scoring at the basic or below basic level in the baseline year 2012-2013. The "room to grow" parameter was used to remove ceiling effects.

Multiple analyses were completed by the researcher in an attempt to gain a better understanding of the data. For example, the equivalency of the initial populations in regards to fund allocation was analyzed with all districts involved followed by those with "room to grow".

With the allocation of funds being the choice of each district, it was important for the researcher to understand if a school's initial test scores affected how they allocated grand funds in the first place. In other words, the researcher was curious if schools were starting with varying baseline test scores. This measure was found by comparing the percentage of students that scored in the Below Basic level in the baseline year against grant award allocation.

Another analysis to better understand the data was to correlate percentages of English language learners with improvement, which the author thought could have had an impact on the data, considering that the treatment is focused on bettering the English language abilities of students. Teachers' average years of experience were also correlated with improvement, because teacher skill gained over time could impact the effectiveness of the treatment.

Summary of Findings

The alternative hypothesis, that a significant positive correlation will be observed between school districts' relative allocation of Keystones to Opportunity grant funds to middle school and high school aged students and Biology Keystone Test scores, was not supported. The null hypothesis, that no significant correlation will be observed between the above variables, cannot be rejected.

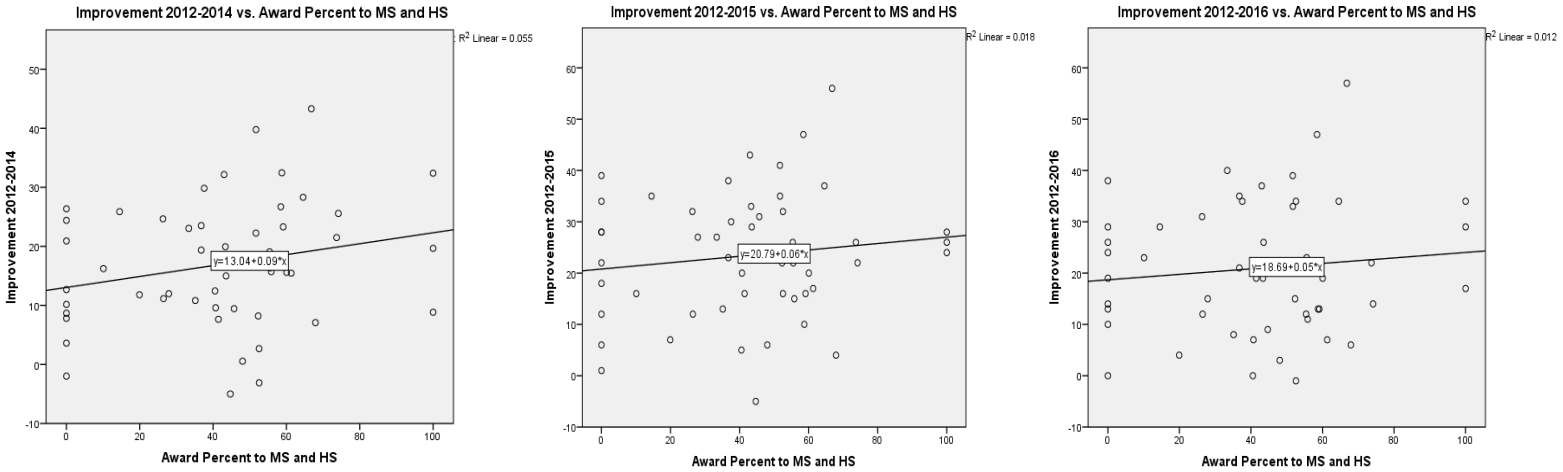
Using data from all fifty schools, a weak correlation was found between the award percentage to middle school and high school and improvement in Biology Keystone Test scores from the Baseline (2012-2013) to Year 1 (2013-2014) school years. Although not significant, the correlation (0.234) in year one seemed promising; continued intervention for the next few years was expected to show stronger correlations as literacy teaching proficiency improved with time using the training outlined in the comprehensive literacy plans. Unexpectedly, the subsequent 2014-2015 and 2015-2016 school years provided <u>decreasing</u> strengths of correlation. This information is included in Table 1 below.

		Improvement 2012-2014	Improvement 2012-2015	Improvement 2012-2016
Award Percent to MS and HS	Pearson Correlation	.234	.134	.111
	R^2	.055	.018	.012
	Sig. (2-tailed)	.102	.353	.444

Table 1. Correlation, R^2, and significance values between the KTO grant award percentage and improvement each year.

Graphs 1.1, 1.2, and 1.3 all show the positive relationship between award percent to middle and high school and assessment scores that the alternative hypothesis suggested;

however, none of the relationships provided significant values. Award percent to MS and HS also appeared to have less success in improving assessment scores as the years progressed.



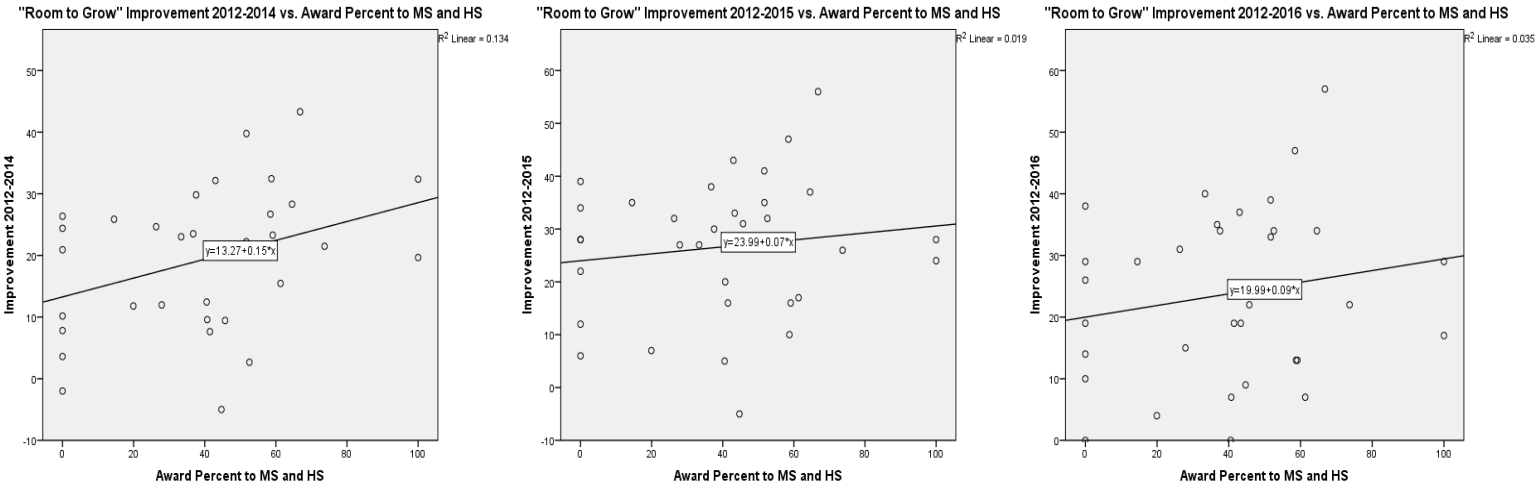
Graphs 1.1, 1.2, and 1.3. Award percent to middle school and high school plotted against improvement by year from 2012 to 2016.

One concern was that a ceiling effect might be a factor: Relatively high-performing schools have less "room to grow" in that, for example, there is no category higher than Proficient. Narrowing the school sample using a "room to grow" condition (schools in which greater than fifty percent of all Biology Keystone Test takers scored Basic or Below Basic in baseline year 2012) yielded slightly improved however still largely insignificant results. Growth from school years 2012-2013 to 2013-2014 yielded a significant correlation (0.366, $p<0.036$); however, the following two school years once again provided decreasing, non-significant correlations. This information is included in Table 2 below.

		Improvement 2012-2014	Improvement 2012-2015	Improvement 2012-2016
Award Percent to MS and HS	Pearson Correlation	.366*	.137	.187
	R^2	.133	.019	.035
	Sig. (2-tailed)	.036	.448	.297

Table 2. Correlation, R^2, and significance values between the KTO grant award percentage and improvement each year following the "room to grow" parameter.

Graphs 2.1, 2.2, and 2.3 incorporated the "Room to Grow" parameter, and still all show the positive relationship between award percent to middle and high school and assessment scores that the alternative hypothesis suggested. Unlike the above graphs, the 2012-2016 year did show an increase in improvement with higher award percent than the 2012-2015 year; however, it still fell short of the initial 2012-2014 year.



Graphs 2.1, 2.2, and 2.3. Award percent to middle school and high school plotted against improvement by year from 2012 to 2016 with the "Room to Grow" parameter applied.

When comparing English language learners and improvement, a negative correlation did exist, suggesting a barrier between these students and the purposes of the KTO grant. Also, a positive correlation linked teachers' years of experience and improvement in test scores. Both

tests were ultimately statistically insignificant; however, they do help to suggest other factors that may have affected student improvement.

Interestingly, correlating the percentage of students in the Below Basic level in the baseline year with grant fund allocation to middle and high school provided a statistically significant negative value. This correlation suggests that districts that focused their funding on middle and high school started their grant initiatives with significantly fewer low performing students. This also suggests that the study's pre-intervention scoring measure (baseline year test scores) is not independent of the treatment (grant fund allocation). As such, improvement against the baseline year is less likely for schools with more grant fund allocation to middle and high school, because those schools have less students that are eligible to shift from the below basic and basic (failing) values to the proficient and advanced values (passing) that this study used to measure improvement. This suggests the necessity of a more sensitive performance measure.

Implications

Despite the rejection of the alternative hypothesis, there are a number of possible implications from this study. These implications include issues with aggregate data, validity concerns regarding differences between test groups, and finally a look at how states design intervention programs and the impacts of those designs.

Natural issues arise when working with aggregate data. Relationships at one level of analysis cannot be assumed to be equal at another level, and relationships from aggregate levels are only valid to make predictions for those aggregate levels (Clark & Avery, 1976). Alker expands upon this issue when noting that the inherent difficulty of making multilevel inferences based on a single analysis level is likely the strongest disadvantage of using aggregate data (1969). Similar difficulties arose when trying to estimate learning gains on the Biology Keystone exam from the aggregate data presented by the Pennsylvania Department of Education. The aggregate data included percentage values for students scoring in each of the four major categorical values (Basic, Below Basic, Proficient, and Advanced).

In an attempt to alleviate some of these aggregation issues, individual test scores for each student were sought from the Pennsylvania Department of Education; unfortunately, a response was never received. Individual student test scores would have provided solid micro level data to analyze, rather than the four major categorical values. Without individual scores, a true growth value (e.g., "an 8 point increase in average student test scores from 2012-2015") couldn't be calculated; instead, the study was limited to using Boolean values of whether students did or did not grow from the below basic or basic (failing) groups to the proficient or advanced (passing) groups. One issue with using such metrics is lack of specificity; the data report at best the change in the passing rate of students for each year, but not by how much they were passing the

assessment. Also, a student that had shown no growth in the study due to not crossing the pass-fail threshold could have had major growth anywhere from zero percent to forty nine percent; however, our data was not fine-grained enough to detect this growth. Without the individual student scores, any confident idea of a treatment's true effects on the population studied becomes difficult to obtain. Clark and Avery (1976) speak directly about this issue, mentioning that researchers "Need to be careful of biased correlation and regression coefficient estimates instead of truer micro level estimates when trying to draw causal inferences from statistical analysis" (p. 429). The U.S. Department of Education should take more care when deciding how they will report student scores. Studies like this one, that aim to point out the benefits of a federally funded grant program, run into major obstacles when trying to prove the very point that would give legitimacy to the grant program that the government spent 200 million dollars on. Instead, researchers are left attempting to draw conclusions from heavily aggregated data amidst analytic limitations. Possibly worse is the Commonwealth of Pennsylvania, who make it very difficult for interested stakeholders to gain access to the kind of raw data that this study would have benefitted from. It's understandable for the commonwealth to want to provide privacy protections for its citizens; however, ignoring requests for raw data (none of which would have provided any sort of identifiable information) works against the efficacy of this grant, which could provide a wealth of positive benefits for students in classrooms across the state.

Validity concerns also arose when comparing the different schools in our studies. To compare the equivalency of our original 50 schools, a comparison was made between each school's percentage of students starting at Below Basic in 2012 vs. award percentage given to MS and HS. This was done to assess whether districts whose improvement plans focused on secondary school were starting from a different baseline than programs whose focus was at the

earlier grades. The correlation was negative, indicating that districts focusing large percentages of their funds on MS and HS started their grants (baseline scores 2012) with significantly fewer low performing students. This clearly hurts the equivalency of the populations, because schools with high award percentages for MS and HS had less room for possible growth on overall assessment scores.

In an effort to measure literacy implementation's impact on science learning, relative grant money allocation was used as a predictor for this study. This raises concerns because relative allocation acts as a surrogate variable for true literacy implementation and does not take each school district's efficacy when implementing the tenets of the KTO grant into account. The use of this surrogate variable introduced unmeasured variability into the experimental model.

Final implications involve state intervention program design and level of teacher autonomy. At one extreme, high levels of teacher autonomy foster improved teacher learning of literacy practices and how to teach them; teachers that are comfortable in and have a say in their own practices deliver those practices more effectively. Little (1995) explains that learner autonomy is dependent upon teacher autonomy, with teachers being better able to promote learner autonomy if they have been encouraged to be autonomous in their own education . High levels of teacher autonomy also contribute to increased teacher participation and motivation; two major contributing factors to teacher buy in. Little also adds that autonomous learning creates positivity in the classroom. A positive attitude, for both students and teachers alike, can be one of the most important factors of motivation, and these ideas are not confined to education. In the counseling and behavioral change fields, patient autonomy can be linked to increased motivation for treatment, and increased treatment effectiveness (Ryan, Lynch,

Vansteenkiste, & Deci, 2011). All of the above points underscore the value of autonomy in the workplace and educational environment.

Increased teacher autonomy is certainly not without drawbacks when designing state intervention programs, especially when trying to obtain reliable measurements from the study's treatment. Efficacy issues arise with more autonomy with the increased probability that teachers will not implement strategies as the study intended. A teacher who is allowed to teach in whatever way they are most comfortable may be more effective in that environment; however, as teachers stray further from the proposed methods of the experiment, efficacy suffers. Validity issues also become a major factor when promoting teacher autonomy. Decreased equivalency of populations as students in different classrooms receive increasingly different treatments with increased teacher autonomy leads to major concerns when trying to pull sound data from the study's results.

At the other extreme, decreased teacher autonomy may yield better measurable results for state intervention programs where fidelity to an established program with known success is required. Efficacy would improve, with stricter teacher guidelines leading to implementation of the core values of the intervention program much closer to their intended purposes. Validity would also see an improvement, with a much higher percentage of classrooms in the study implementing treatments more equally, increasing the equivalency of the study's populations.

Lowering teacher autonomy would almost certainly have drawbacks, mainly because of teacher discouragement. Teachers under the management of strict guidelines must leave their comfort zones in their own classrooms, which would almost certainly have a negative impact on their teaching capabilities. Also, as Little and Ryan et al. mentioned previously, autonomous

learning fosters positivity towards learning, this motivation is a key component of treatment effectiveness (Little, 1995; Ryan et al., 2011)

Certainly, a comfortable middle ground between teacher autonomy and measurable results would be the ideal place to launch a state intervention program. For the researcher, it is difficult to decide where that middle ground exists to produce the most ideal results to study. The positive outcomes of the KTO grant and its literacy objectives were much more obvious at the individual, ground level. Issues arose when taking test data at the aggregated level and using that data to infer correlations between treatment and result. If nothing else, the KTO grant attempted to improve the literacy skills of students and the literacy teaching skills of professionals. Simply being unable to measure the improvement of those skills and their effects on biology learning is not an indictment of the grant itself, but more so of the data made available to the researcher.

Keystones to Opportunity was a federally funded grant awarded to Pennsylvania to address the growing concern that United States students are falling behind in literacy-related skills. Pennsylvania was responsible for selecting schools based upon a rigorous application process, which happened to select the author's school district as a recipient of the KTO grant. The observed impacts of the grant were immediate, and prompted a study that would focus on literacy skills and science learning.

Teaching a trigger course during the No Child Left Behind-era grants a unique perspective when relating student gains in the classroom and her or his score on a standardized exam. The Keystone Biology exam is certainly no exception to this relationship, and serious improvements shown in the researcher's district during the first year of the grant prompted the search for a wider perspective on the parallels between the literacy goals outlined in the grant

and biology learning. Ironically, both the KTO grant and the very measure used to determine the effectiveness of the KTO initiative provided major obstacles when trying to uncover how useful the KTO grant was for science learning, due to validity concerns and issues analyzing aggregate data. Many other educational initiatives and assessments share similar struggles.

There are so many positive initiatives happening in schools across the country every day that are providing legitimate opportunities to improve student learning. Some of those same initiatives are falling short when proving their worth to the broader public, who ultimately control the direction of public education, both positively and negatively. As an educational community we can do better in the design and report of these initiatives, and in turn, improve our communication with the broader public. That way, initiatives like the KTO grant will continue to be employed in schools, and students will continue to reap the benefits of those initiatives. This study hopes to provide advice on how that can be achieved.

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