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ANALYSIS OF STUDENTS' MOTIVATIONAL AND AFFECTIVE BELIEFS IN GENERAL CHEMISTRY

A Thesis in

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by

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ABSTRACT

The research reported in this thesis explores students' motivations in a post-secondary general chemistry course utilizing a peer facilitated active learning environment. Particularly, this study seeks to address how students' personal characteristics and the social learning environment influences science self-efficacy, attitude, and overall satisfaction in general chemistry. A survey methodology was used to assess students' motivation to learn science, perception of formative feedback, course recommendation, and satisfaction. Analysis of questionnaire data (n = 160) revealed that students were more extrinsically motivated towards learning chemistry on average. Intrinsic motivation and other motivational components, such as self-determination and self-efficacy, were found to be lower on average. Regression analyses were used to find relationships among these constructs. In general, we find that student satisfaction and course recommendation are less dependent on students' personal characteristics (i.e., motivational orientation), but more dependent on what happens in the course (i.e., quality of instruction, and feedback provided by the instructor and assistants in instruction). Theoretical and practical implications of these findings are outlined and suggestions for further research are included.

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Chapter 1

Introduction

This thesis focuses on understanding college students' motivation to learn science. Specifically, the research examines how students' personal characteristics and feedback received influence a number of items, including, science self-efficacy, attitude (i.e., course recommendation), and satisfaction in general chemistry. Chapter 1 aims to contextualize the body of work this thesis represents. The chapter begins by discussing the significance of conducting research in the area of student motivation and formative feedback. Towards the end of the chapter, the research goals and questions are provided, and finally, an overview of the thesis is presented.

1.1 Overarching Problem

Introductory general chemistry is a required course for numerous majors. At most institutions, enrollment largely consists of students outside of the college of science (ACS Committee on Professional Training, 2005). A significant number of students who attempt introductory general chemistry have to drop the course. These students must either retake the course or change their major. It is reported that the rate of failures, dropouts, and repeats exceeds 30% for non-chemistry majors at most universities (Rowe, 1982). In some cases, attrition rates are as high as 50% in chemistry courses (Grove, Hershberger, & Bretz, 2008).

The concerning statistics do not end there. Further, the Committee on Science and Technology (2010) reports that half of all students who begin college majoring in the physical or biological sciences will drop out before their senior year, compared to the 30% drop out rate in the humanities or social sciences. According to the *Rising Above the Gathering Storm* report, the United States is ranked 27 out of 29 countries for producing science bachelor's degrees (2011).

Research suggests that students leave the science for a combination of reasons including: loss of interest in subject matter, feeling overwhelmed with difficult course content, and the potential for better educational opportunities in other disciplines (Committee on Science and Technology, 2010). Seymour and Hewitt (1997) propose that students leave science, technology, engineering, and math (STEM) disciplines for other disciplines perceived to be more supportive, less competitive, and have increased opportunities for collaboration.

In addition, numerous reports indicate the introductory science courses themselves are a major barrier to student success and matriculation in STEM disciplines. Introductory science courses are traditionally organized in the lecture format, and often have hundreds of students enrolled in each section. According to Black and Deci (2000), the traditional model for undergraduate science courses operates as follows:

> The unspoken assumption in the model seems to be that students will "sink or swim," according to their innate ability and motivation. Although not well researched, the consequence of this approach often seems to be a Darwinian "weeding out" of those who appear unqualified for careers in medicine or science.

As Bradforth, Miller and colleagues (2015) explain, these "weed out" courses and traditional teaching practices contribute greatly to attrition in STEM fields. Similarly, the President's Council of Advisors on Science and Technology (2012) argues that undergraduate STEM courses are neither providing students with high quality learning experiences, nor retaining students in these disciplines.

Student academic success in chemistry is most often related to cognitive factors such as prior experience (Tai, Sadler & Loehr, 2005; Lewis & Lewis, 2008), problem-solving ability (Bhattacharyya & Bodner, 2005), and conceptual understanding (Grove, Hershberger & Bretz, 2008). While cognitive variables can be predictive of student success in chemistry, alone they are not sufficient. A considerable amount of research has shown that cognitive factors must be supplemented by motivational or affective factors. In the 2012 Discipline-Based Education Research (DBER) report, the National Research Council outlines the importance of studying factors that affect student motivation to initially engage in, and then, to persist in the learning in science in order to improve undergraduate science education

Students' personal characteristics (e.g., intrinsic motivation) and the learning environment (e.g., quality of instruction, and/or feedback and other assistance provided by the instructor and assistants in instruction in a large science classroom) influence a variety of student outcomes. The study reported in this thesis explores the relationship among motivation and classroom factors, and science self-efficacy, course recommendation and student satisfaction.

1.2 Research Goals and Questions

There is a need in the chemical education community to understand students' motivation toward learning chemistry in order to build stronger undergraduate science courses and raise student achievement. The main focus of this investigation is to examine the influence of motivation and the learning environment on science self-efficacy, attitude, and satisfaction in college chemistry.

Regression analyses were used to examine the predictors of science self-efficacy, recommendation, and satisfaction. The present study answers the following research questions.

What is the relationship among students' personal characteristics and the learning environment, and:

(1) Science self-efficacy
(2) Course recommendation
(3) Satisfaction

1.3 Organization of Thesis

This thesis is organized into five chapters. This chapter (Chapter 1) introduces the research described herein. The significance of the research is discussed, and the research goal and questions are presented.

Chapter 2 reviews the literature relevant to this research. In this chapter, a brief overview of social cognitive theory is presented, and several factors influencing student motivation are considered. A range of research findings related to formative feedback are discussed. This is followed by a discussion of previous students conducted involving learning assistants. Finally, a conceptual model of formative feedback and self-regulation using learning assistants is provided.

In Chapter 3, my research methodology is outlined. Chapter 4 presents the results. A discussion of my findings in made in reference to literature.

Finally, in Chapter 5, conclusions are drawn with regards to my research questions. The implications of my research are discussed. Critical points for future research are described. The chapter ends with a justification of my research's contributions in the areas of student motivation and formative feedback.

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Chapter 2

Theoretical Framework and Literature Review

In this chapter, relevant literature and the theoretical framework that situates this study will be presented. The review of literature is divided into five sections. The first section provides an overview of social cognitive theory, the theoretical underpinning for this study. The second section describes student motivation toward learning science. Particular attention is paid to the psychological constructs that have an affect on motivation. In the third section, formative feedback and the learning environment are highlighted. The chapter concludes with a brief review of previous studies involving learning assistants, followed by a proposed conceptual model of formative feedback and self-regulation using learning assistants.

2.1 Theoretical Framework

This study is theoretically aligned with social cognitive theory. Social cognitive theory, developed by Albert Bandura (1977, 1986, 2011), “construes human functioning as a series of reciprocal interactions among personal characteristics, environmental contexts, and behaviors” (Glynn et al., 2011). As conceptualized by social cognitive theory, students’ beliefs are inherently intertwined with the learning environment. The social environment can either support or limit student engagement (Vansteenskiste, Lens & Deci., 2006).

An underlying principal of social cognitive theory is that learning is most effective when it is self-regulated. We specifically adopt the model of self-regulation proposed by Pintrich et al. (2003). According to Pintrich, self-regulation is defined as:

> An active constructive process whereby learners set goals for their learning and monitor, regulate and control their cognition, motivation, and behavior, guided and constrained by the goals and contextual features of the environment (p. 64).

By this definition, self-regulation applies not only to cognition, but also, behavior and motivation during the learning process. The definition further extends to recognize that the contextual features of the learning environment can influence or limit students' self-regulation.

Students who are self-regulated set personal learning goals, select effective learning strategies, monitor performance, and adopt adaptive motivational beliefs. Whereas, poor self-regulators fail to set appropriate goals and select learning strategies, and display maladaptive motivational beliefs (Pintrich & Zusho, 2002). Self-regulation is manifested through awareness of: what are the goals of the task, what skills and knowledge the student possesses, how and when to apply those skills, and whether or not the student was successful towards some learning task.

Self-regulating beliefs are influenced by as well as influence motivation; therefore, students learn when they have a source of motivation to self-regulate their cognition (Austin, Hammond, Barrows, Gould & Gould, 2017). Several different motivational factors will be discussed in the following section (Section 2.2).

2.2 Student Motivation Towards Learning Science

The importance of motivation cannot be overstated (Dweck, 1986, 1988; Ames, 1992). Motivation directs and sustains goal-oriented behavior, and is among the most important factors influencing students' persistence in STEM disciplines (Liu, Raker & Lewis, 2018).

Motivation is a multi-component construct. In chemistry education, previous research has focused on motivational processes including: self-efficacy (Zusho, Pintrich & Coppola, 2003; Ferrell & Barbera, 2015; Lynch & Trujillo, 2010; Villafañe, Garcia & Lewis, 2014), self-regulation

(Black & Deci, 2000), interest and effort beliefs (Ferrell, Phillips & Barbera, 2016), self-concept (Lewis, Shaw, Heitz & Webster, 2009), and self-determination (Black & Deci, 2000; Ferrell, Phillips & Barbera, 2016).

Quantifying student motivation is difficult because it is not directly observable (i.e., it is a latent variable), and is therefore often oversimplified or overlooked (Ferrell & Barbara, 2015). Motivation is complex, and highly situational. For this reason it is necessary to study motivation in specific contexts (Pintrich, 2003).

The research detailed here in this thesis extents upon the current body of work regarding the motivational processes of students in college chemistry. We choose to examine five constructs associated with academic science motivation: intrinsic motivation, extrinsic motivation, self-determination, and self-efficacy.

Intrinsic motivation involves inherent satisfaction in learning. Students who are intrinsically motivated engage in behavior because they find it personally rewarding. High academic achievement is associated with intrinsic motivation (Liu, Ferrell, Barbera, & Lewis, 2017). Intrinsic motivation differs from extrinsic motivation, which involves learning or performing activity in order to earn external rewards, such as advancing toward a career or earning a good grade, or to avoid an undesired punishment.

Self-determination refers to students' belief about the control they have over their learning, also known as, autonomy (Black & Deci, 2000). In Self-Determination Theory (SDT), behaviors vary based on the degree to which they are controlled or autonomous. According to Black and Deci (2000), controlled behaviors have an external locus of causality, and are experienced as being influenced by external pressures such as grades. Whereas, autonomous behaviors have an internal locus of causality and are performed out of personal interest. Autonomy-supportive educational settings (i.e., student centered learning environments) have been found to increase autonomous self-regulation, and therefore, increases academic achievement. Autonomy support results when an individual in authority, “takes the other’s (e.g., a student’s) perspective, acknowledges the other’s feelings, and provides the other with pertinent information and opportunities for choice, while minimizing the use of pressures and demands” (Black & Deci, 2000).

Self-efficacy refers to students’ belief that they can achieve well or perform a specific task proficiently. Self-efficacy emerged from Bandura’s social cognitive theory (Bandura, 1977; 1986; 2001), and is one of the most studied factors influencing motivation, particularly in the science education community. According to social cognitive theory, if a student does not feel able to accomplish a task he/she will tend to avoid the task and/or give up readily. Whereas, students exhibiting high self-efficacy tend to choose more challenging learning tasks, and persist at them thereby leading to high achievement.

Self-efficacy is cyclical rather than fixed indicating self-efficacy is highly influenced students experiences in a course (i.e., the social learning environment) (Villafañe, Garcia & Lewis, 2014). Self-efficacy generally increases with positive experiences and decreases with negative ones. In addition, self-efficacy is task- and content-specific and therefore needs to be assessed as such (Villafañe et al., 2014).

2.3 Formative Feedback and The Learning Environment

Formative feedback is information used to reduce the discrepancy between students’ current understandings and desired performance (Hattie & Timperley, 2007). Ideally, feedback enables students to self-reflect, self-assess, and self-regulate (Nicol & Macfarlane-Dick, 2006; Sadler, 1989). If delivered correctly, formative feedback can inform student learning and raise student achievement.

According to Hattie and Timperley (2007), effective feedback answers three major questions: ‘where am I going?’, ‘how am I going?’, and ‘where to next?’ The first question is directed at the goal or level of performance a student is expected to achieve. The second question provides students with information regarding their performance towards the goal. The third question provides information that will lead to greater possibilities for learning. Feedback is most effective when faulty interpretations are addressed. Feedback that attends to processing has the capacity to help students develop strategies to detect errors as to provide oneself with feedback. Feedback at the self-regulation level helps students engage with the task.

Nicol and Macfarlane-Dick (2006) argue that formative feedback needs to clarify what good performance is in order to facilitate the development of self-assessment; students can only achieve learning goals if they understand those goals.

In order to be formative, feedback needs to be understood. A considerable amount of research shows that students do not understand the feedback given by tutors and are therefore unable to reduce the discrepancy between current and expected performance (Higgins, Hartley & Skelton, 2002; Orsmond & Merry, 2011; Carless, 2006).

Research in social cognitive theory suggests that classroom learning environment influences students' motivational goal orientation (Ames & Archer, 1988). Furthermore, Janssen and Prins (2007) showed that goal orientation influences the types of feedback individuals seek.

2.4 Learning Assistants

The Colorado Learning Assistant Model was established in 2003 at the University of Colorado at Boulder and has since been adopted in over 55 institutions around the country (Learning Assistant Alliance, n.d.). The purpose of the LA program at CU-Boulder is to integrate efforts to transform large-enrollment STEM courses to be more interactive and student-centered with efforts to recruit and prepare undergraduate science and math students to be K-12 teachers.

Although the program goals are different from those at Penn State, their research findings show that the LA program is successful in transforming lecture style courses, and results in learning gains for both LAs and enrolled students. Table 2-1 summarizes previous research conducted involving LAs.

Table 2-1. Summary of Studies Involving Learning Assistants

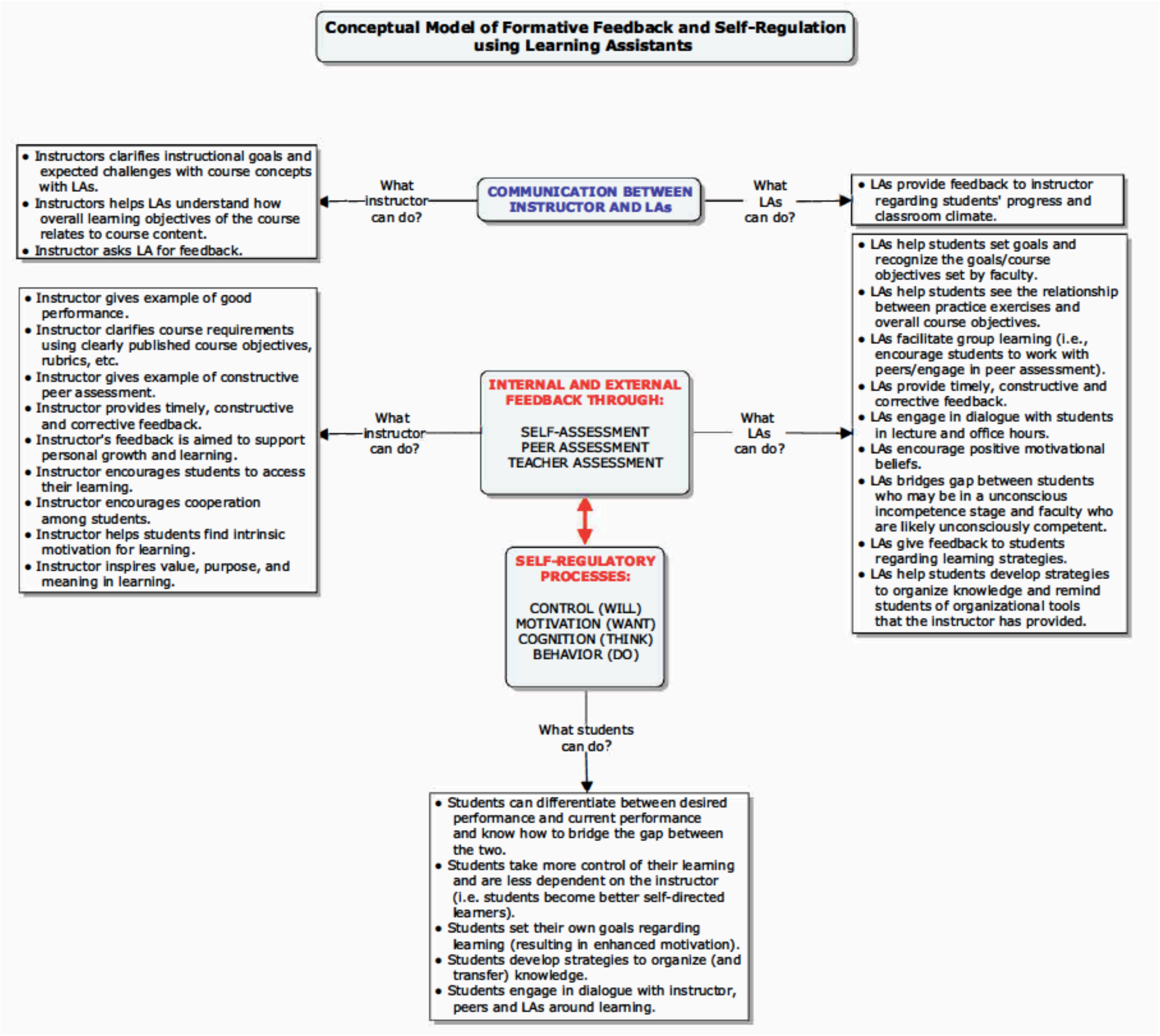
Study	Summary of Methods	Findings	Conclusions
Gray, Webb, & Otero (2016)	Compared the teaching practices of secondary science and math teachers who served as LAs as undergraduates (n=15) to colleagues that were certified through the same program but did not serve as a LA (n=14).	Former LAs used significantly more reformed teaching practices (especially in their first year of teaching).	A possible explanation for this is that the experiential nature of the LA program allows for integration of pedagogy and practice.
Gray, Webb, & Otero (2011)	Studied how in-service teachers who are former LAs (n=12) and teachers who did not participate as an LA (n=12), but who were certified to teach through the same program, value formative assessment.	Former LAs tend to focus on assessment to inform students or to inform instruction. Whereas, some non-LAs only focus on assessment for evaluation (i.e., summative assessment).	The LA program creates situated learning environment wherein LAs have the opportunity to integrate teaching experience and formal information on teaching and learning, which gives LAs a good understanding. LAs are practiced in tailoring explanations to students' current understandings during interactions with students. Thus, allowing LAs to assimilate the concept of formative assessment into their view of effective teaching.
Talbot, Hartley, Marzetta, & Wee (2015)	Studied satisfaction in LA supported courses using an end-of-semester survey (n=534, 63% response rate).	The majority of students reported that having LAs associated with the course "helped them learn, increased their satisfaction with the course, and increased their satisfaction with the teaching of the course.	LAs support transformative efforts and have a positive impact on students' attitudes.
Otero, Pollock, & Finkelstein (2010)	Overview of program evaluation efforts at CU Boulder.	(1) LA program has successfully increased the number of undergraduate students going onto complete math and science certification programs; (2) Students in LA supported courses	LA program is successful.

		have greater learning gains than students in traditional lecture courses (using a conceptual content survey at the beginning and end of the semester). Learning gains were even greater for LAs themselves; (3) After serving as a LA, LAs exhibit attitudinal gains as measured by CLASS (see Adams et al., 2006); students leave LA experience with more favorable beliefs about science, learning in general, and with greater mastery of content than peers.	

2.5 Conceptual Model

Self-regulation refers to the degree to which students can regulate their cognition, motivation, and behavior. Formative feedback can empower students to engage in self-regulated learners (Nicol & Macfarlane-Dick, 2006). Many argue “that one of the most important goals of an instructor of an introductory college science courses is to help student become more motivated self-regulated learners” (Druger, 2006; Glynn et al., 2011). In Figure 2-1, a proposed conceptual model of formative feedback and self-regulated utilizing learning assistants is presented, and is adapted from the principles of good feedback practice by Nicol and Macfarlane-Dick (2006).

There are two modes of feedback that can promote the development of self-regulation. The first mode of feedback is external feedback. Students engage in self-regulation as they interpret external feedback from instructors and others, including peers and learning assistants, while monitoring their progress towards a goal. The second mode of feedback is internal feedback; students self-regulate as they monitor their completion of a task and assess progress towards a goal. The proposed model shows the connection between feedback and self-regulatory processes, and describes the role of the instructor, learning assistants, and students in the learning process.



- Instructors clarifies instructional goals and expected challenges with course concepts with LAs.
- Instructors helps LAs understand how overall learning objectives of the course relates to course content.
- Instructor asks LA for feedback.

- LAs provide feedback to instructor regarding students' progress and classroom climate.

- Instructor gives example of good performance.
- Instructor clarifies course requirements using clearly published course objectives, rubrics, etc.
- Instructor gives example of constructive peer assessment.
- Instructor provides timely, constructive and corrective feedback.
- Instructor's feedback is aimed to support personal growth and learning.
- Instructor encourages students to access their learning.
- Instructor encourages cooperation among students.
- Instructor helps students find intrinsic motivation for learning.
- Instructor inspires value, purpose, and meaning in learning.

- LAs help students set goals and recognize the goals/course objectives set by faculty.
- LAs help students see the relationship between practice exercises and overall course objectives.
- LAs facilitate group learning (i.e., encourage students to work with peers/engage in peer assessment).
- LAs provide timely, constructive and corrective feedback.
- LAs engage in dialogue with students in lecture and office hours.
- LAs encourage positive motivational beliefs.
- LAs bridges gap between students who may be in a unconscious incompetence stage and faculty who are likely unconsciously competent.
- LAs give feedback to students regarding learning strategies.
- LAs help students develop strategies to organize knowledge and remind students of organizational tools that the instructor has provided.

- Students can differentiate between desired performance and current performance and know how to bridge the gap between the two.
- Students take more control of their learning and are less dependent on the instructor (i.e. students become better self-directed learners).
- Students set their own goals regarding learning (resulting in enhanced motivation).
- Students develop strategies to organize (and transfer) knowledge.
- Students engage in dialogue with instructor, peers and LAs around learning.

Figure 2-1. Conceptual model of formative feedback and self-regulation using learning assistants, adapted from Nicol et al., 2006

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Chapter 3

Methods

In this chapter, methods of data collection and analysis are described. Data collection took place during November 2017. Approval from the Institutional Review Board (IRB) at Penn State University was obtained prior to the collection of all data within this study.

3.1 Research Context

3.1.1 Participants

Participants (n = 160) were recruited from one section of a first-semester general chemistry course at Penn State University during the fall of 2017. This is a course required by several science and non-science majors. The respondent population consisted of science (25.0%), engineering (38.1%), and other (36.9%) majors. The majority of students were in their freshman year (71.7%), followed by sophomore (25.8%), and junior (2.5%) years. For detailed demographic information, see Appendix B.

In accordance with IRB policy, students were informed that they would be participating in a research study, and that their participation would have no impact on their grade. Data was not sensitive in nature and no identifiers linked individuals to their responses.

3.1.2 Course Overview

First-semester general chemistry is the first of two courses in the general chemistry sequence. Students in this course are introduced to atomic and molecular structure as well as molecular properties. Students also learn about general principles of reactions including stoichiometry and thermodynamics.

The course consists of three 50-minute lectures and one 50-minute recitation weekly for 15 weeks. Lectures are held in a large classroom (>300 seats) and recitations are held in a smaller classroom. The course is taught in a lecture format using a peer facilitated active learning environment. Instructor used a clicker response system to facilitate discussion among students and learning assistants. Refer to Section 3.1.3 for further information regarding learning assistants.

3.1.3 LA Program at Penn State

The Eberly College of Science (ECoS) Learning Assistant Program was initiated in the fall of 2011 by the Center for Excellence in Science Education (CESE) in order to incorporate active learning and research-based teaching practices into undergraduate science and math courses (Penn State Center for Excellence in Science Education, 2018).

A Learning Assistant (LA) is an undergraduate peer leader who facilitates active collaborative learning in and out of the formal classroom setting. The role of the LA varies depending on the course and instructor. However the majority of LAs support large-enrollment lecture-based courses. During lecture, LAs encourage peer-interaction and discussion during break out problem solving sessions or clicker questions, and provide formative feedback to students regarding their learning. Additionally, LAs facilitate learning outside of class during office hours or problem solving sessions.

The LA program prepares its LAs to facilitate student learning. First, LAs meet weekly with the lead faculty to plan for the upcoming week and reflect on the previous week. Second, all first semester LAs are required to enroll in a science pedagogy course. In this course, LAs across departments reflect on their teaching experiences and discuss relevant literature. The pedagogy course focuses on content crucial to learning and teaching including prior knowledge, organization of knowledge, metacognition, self-regulated learning, and motivation. LAs use this information immediately in their role in the classroom to facilitate group work and content discourse. For more information about the Learning Assistant Program at Penn State, see: www.cese.science.psu.edu/learning-assistant-program/.

3.2 Data Collection

Data was collected during recitation sections as a paper and pencil questionnaire. The administration took place during the second-to-last week of the semester. Thus, data collected at this point reflects students' opinions when they have been exposed to most of the course material, and have an understanding about where they stand in the course.

3.3 Measures

Demographic Information. The first section of the survey asked for general information about the participant including college, year, and gender. See Appendix A for full instrument.

Science Motivation. Student motivation toward learning science was assessed using the Science Motivation Questionnaire-II (SMQ-II), a validated instrument developed by Glynn et al. (2009, 2011). The SMQ-II is a 25-item instrument that measures five motivational factors: intrinsic motivation, career motivation, grade motivation, self-determination, and self-efficacy (Table 3-1). This survey used a 5-point Likert scale with a score 1 indicating “never” and 5 “always.”

Table 3-1. Questions included in the SMQ-II (Glynn et al., 2011)[a]

Subscale	Items
Intrinsic Motivation	1. Learning science is interesting.
	2. I am curious about discoveries in science.
	3. The science I learn is relevant to my life.
	4. Learning science makes my life more meaningful.
	5. I enjoy learning science.
Career Motivation	6. Learning science will help me get a good job.
	7. Understanding science will benefit me in my career.
	8. Knowing science will give me a career advantage.
	9. I will use science problem-solving skills in my career.
	10. My career will involve science.
Self-Determination	11. I study hard to learn science.
	12. I prepare well for science tests and labs.
	13. I put enough effort into learning science.
	14. I spend a lot of time learning science.
	15. I use strategies to learn science well.
Self-Efficacy	16. I believe I can earn a grade of “A” in science.
	17. I am confident I will do well on science tests.
	18. I believe I can master science knowledge and skills.
	19. I am sure I can understand science.
	20. I am confident I will do well on science labs and projects.
Grade Motivation	21. Scoring high on science tests and labs matters to me.
	22. It is important that I get an “A” in science.
	23. I think about the grade I will get in science.
	24. Getting a good science grade is important to me.
	25. I like to do better than other students on science tests.

[a] Questions were randomly ordered in the survey students’ received.

Perceptions of Feedback. The items used to measure course feedback was adopted from the Assessment Experience Questionnaire (AEQ) developed by Gibbs and Simpson (2003). The original AEQ is a 36-item instrument that contains six subscales: time demands and student effort, assignments and learning, quantity and timing of feedback, quality of feedback, use of feedback, and examination and learning. The three subscales concerning feedback (i.e., quantity and timing of feedback, quality of feedback, and use of feedback) inspired the items used in this study. Additionally, the AEQ is used to assess written feedback. Since we wanted to evaluate students perceptions of verbal feedback, items were rewritten to fit our research needs. Our instrument contained 18-items regarding feedback, and was scored using a 5-point Likert scale, with 1 indicating "strongly disagree" and 5 "strongly agree."

Outcome Variables. Students intention to recommend the course was measured by asking "I would recommend this course to another student," with response in the affirmative being coded as 1 and those in the negative or unsure as 0. Student satisfaction with the course was measured by asking "How satisfied are you with the feedback in the course?" with participants rating their satisfaction on a 5-point scale ranging from "not at all satisfied" (1) to "very satisfied" (5).

3.4 Data Analysis

Quantitative data were analyzed via statistical procedures using Statistical Package for the Social Sciences (SPSS) 25.0 software.

3.4.1 Descriptive Statistics

Descriptive statistics, including mean, standard deviation, and skewness and kurtosis values, were analyzed for all data.

3.4.2 Exploratory Factor Analysis

In order to determine the interrelationship among items pertaining to feedback, principle component analysis with varimax rotation was performed. In extracting factors, we selected all factors with eigenvalues greater than 1.

Three feedback factors emerged in the initial solution. The items "In this course I get plenty of feedback about how I am doing" and "I would learn more if I received more feedback" were not included in the initial solution because they did not satisfy the minimum factor loading criterion. In addition, the item "LAs mainly tell me how well I am doing in relation to others" was eliminated because it lowered the Cronbach's alpha value for the subscale. In the second solution, the items "I do not use feedback for revising" and "I tend to not talk to LAs" were removed for the same reason.

The final factor analysis solution contained 12 of the 18 items and were loaded into two factors (Table 3-2). The factors were labeled as Helpful Feedback and Lack of Feedback. The Kaiser-Meyer-Olkin measure of sampling adequacy for the final solution was 0.840, which is higher than the 0.7 (Kaiser, 1974). Furthermore, the Bartlett's Test of Sphericity was found to be significant: $\chi^2(66) = 670.45$, $p < 0.001$.

Table 3-2. Exploratory factor analysis for feedback items

	F1	**F2**
Factor 1: Helpful Feedback		
LAs help me better understand things.	0.860	
LAs help me go back over how I approached a problem.	0.829	
I listen to LAs carefully and try to understand what they are saying.	0.721	
LAs show me how to do better next time.	0.676	
Feedback from LAs prompts me to go back over material covered.	0.584	
When I talk to LAs I understand why I got the grade I did.	0.548	
Factor 2: Lack of Feedback		
Whatever feedback I get comes too late to be useful.		0.801
I rarely understand how to improve by talking to a LA.		0.740
I receive hardly any feedback in this course.		0.718
When I get things wrong or misunderstand them I don't receive much guidance in what to do about it.		0.708
I do not understand some feedback from LAs.		0.691
Feedback from LAs do not help with subsequent assignments.		0.553

3.4.3 Internal Consistency Reliability

Internal consistency was determined for the motivation and feedback factors. The grade motivation item “Scoring high on science tests and labs matters to me” was removed from further analysis because it significantly lowered the Cronbach’s alpha value for the construct.

The Cronbach’s alpha for each of the five motivation factors and two feedback factors are presented in Table 3-3. Each alpha coefficients was above the recommended value of 0.7 (Tavakol & Dennick, 2011) indicating satisfactory internal consistency for each construct.

Table 3-3. Cronbach’s alpha coefficients for all subscales

Subscale	Cronbach’s α
Motivation	
Intrinsic	0.832
Grade	0.711
Self-determination	0.792
Career	0.880
Self-efficacy	0.841
Feedback	
Factor 1	0.819
Factor 2	0.835

3.4.4 Regression Analyses

Hierarchical regression analysis was used to examine the effects of motivation measures and feedback measures on science self-efficacy and overall course satisfaction. Logistic regression analysis was conducted to examine the influence of motivation and feedback on intention to recommend the course.

3.5 References

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Chapter 4

Results and Discussion

4.1 Descriptive Statistics

To describe the academic motivation of general chemistry students, descriptive statistics were calculated. Means and standard deviations for student motivation and feedback subscales are summarized in Table 4-1.

Table 4-1. Mean and standard deviations for motivation and feedback factors

Subscale	Mean (SD)
Motivation	
Intrinsic	3.88 (0.71)
Grade	4.40 (0.55)
Self-determination	4.00 (0.61)
Career	4.29 (0.86)
Self-efficacy	3.89 (0.67)
Feedback	
Factor 1	3.49 (0.72)
Factor 2	3.53 (0.68)

The mean values suggest that students are more extrinsically motivated on average. Grade motivation (4.40) was the highest scoring factor, followed by career motivation (4.29). This result is comparable to the study by conducted Glynn et al. (2011) who found that extrinsic grade motivation was the highest scoring construct among both science majors (n = 367) and non-science majors (n = 313). Intrinsic motivation (3.88) and self-efficacy (3.89) were the lowest scoring motivation subscales on average. The self-determination mean score was 4.00.

It is also interesting to explore motivational differences between science and non-science majors (Table 4-2). Science majors scored higher than non-science majors on all motivation subscales. Students who are science majors were still highly extrinsically motivated; career motivation (4.68) was the highest scoring factor, and grade motivation (4.59) was the second highest scoring factor. The intrinsic motivation mean score was also higher for science majors than non-science majors.

We conclude that students in general chemistry are extrinsically motivated toward learning. This result is not all too surprising as earning a high grade in classes is important to many students. Although students were motivated toward earing a high grade and recognized the relevance to their future careers, they did not seem to find course content relevant to their interests.

Table 4-2. Comparison of means by major

	Science	Engineering	Other	Total
Intrinsic	4.24 (0.68)	3.71 (0.72)	3.80 (0.66)	3.88 (0.71)
Grade	4.59 (0.38)	4.33 (0.63)	4.33 (0.53)	4.40 (0.55)
Self-determination	4.21 (0.66)	3.81 (0.63)	4.05 (0.50)	4.00 (0.61)
Career	4.68 (0.47)	4.02 (0.75)	4.31 (0.70)	4.29 (0.71)
Self-efficacy	4.08 (0.63)	3.91 (0.72)	3.73 (0.63)	3.89 (0.67)
Feedback F1	3.66 (0.67)	3.44 (0.78)	3.43 (0.66)	3.49 (0.72)
Feedback F2	3.84 (0.84)	3.61 (0.62)	3.39 (0.60)	3.53 (0.68)
Recommendation	0.89 (0.38)	0.83 (0.38)	0.69 (0.47)	0.80 (0.40)
Satisfaction	4.08 (0.68)	3.92 (0.86)	3.84 (0.83)	3.93 (0.80)

Among both science and non-science majors self-efficacy was the lowest scoring construct. Previous research has demonstrated that although it is often a low-scoring construct, self-efficacy is found to have the strongest correlation with course performance (Ferrell, Phillip & Barbera, 2016; Austin, Hammond, Barrows, Gould & Gould, 2017; Lynch & Trujillo, 2011; Villafañe, Garcia & Lewis, 2014; Zusho, Pintrich, & Coppola, 2003).

In addition, based on mean scores, science majors are more satisfied with the course and are more likely to recommend the course to another student compared to non-science majors.

4.2 Regression Analyses

Motivational data is of interest, however, the main goal of the investigation was to elucidate the relationships among variables. See Appendix C for correlation studies.

Here, we use a hierarchical regression model to examine the extent to which gender, motivation, and feedback predict science self-efficacy. Table 4-3 presents the results of hierarchical regression analysis. Gender and both intrinsic and extrinsic (grade and career) motivation had positive associations with science self-efficacy. Feedback received in the course did not significantly impact science self-efficacy in general chemistry.

Table 4-3. Results of hierarchical regression analysis: predictors of science self-efficacy

	Outcome: Self-Efficacy in Science		
Predictor	Model 1	Model 2	Model 3
Constant	3.82 (0.08)***	-0.13 (0.37)	-0.05 (0.38)
Background			
Gender	0.13 (0.10)	0.24 (0.07)***	0.23 (0.08)**
Motivation Measures			
Intrinsic		0.25 (0.09)**	0.24 (0.09)**
Grade		0.33 (0.09)***	0.33 (0.09)***
Self-determination		0.13 (0.08)	0.11 (0.08)
Career		0.22 (0.09)**	0.23 (0.09)*
Feedback Measures			
Factor 1			0.06 (0.04)
Factor 2			0.01 (0.04)
ΔR^2	0.012	0.520	0.008

Unstandardized estimates with standard errors are reported in parentheses.
*p < .05, **p < .01, ***p < .001.

Another hierarchical regression model examined the degree to which gender, motivation, and feedback predict course satisfaction in general chemistry. Table 4-4 displays the results of the hierarchical regression analysis. Course feedback had a significant and positive association with course satisfaction in general chemistry. Interestingly, students' personal characteristics (i.e., motivational sources) did not significantly influence their overall satisfaction with the course, rather, the feedback was a predictor students' satisfaction.

Table 4-4. Results of hierarchical regression analysis: predictors of course satisfaction

	Outcome: Satisfaction		
Predictor	Model 1	Model 2	Model 3
Constant	3.90 (0.10)***	1.99 (0.63)**	2.56 (0.56)***
Background			
Gender	0.07 (0.13)	0.14 (0.13)	0.07 (0.11)
Motivation Measures			
Intrinsic		0.05 (0.14)	-0.01 (0.13)
Grade		0.04 (0.15)	0.07 (0.13)
Self-determination		0.12 (0.14)	0.04 (0.12)
Career		0.24 (0.14)	0.21 (0.14)
Feedback Measures			
Factor 1			0.25 (0.06)***
Factor 2			0.31 (0.06)***
ΔR^2	0.003	0.099	0.222

Unstandardized estimates with standard errors are reported in parentheses.
*p < .05, **p < .01, ***p < .001

A logistic regression model (Table 4-5) examined the extent to gender, motivation, and feedback predict intention to recommend the course (1 = Yes; 0 = No or unsure). The three steps had the same outcome variable (course recommendation). In Step 1, gender was included. In Step 2, motivational constructs including intrinsic motivation, grade motivation, self-determination, and career motivation were added. In Step 3, feedback measures, Factor 1 (i.e., helpful feedback) and Factor 2 (i.e., lack of feedback) were added.

Table 4-5. Results of logistical regression analysis: predictors of science course recommendation

	Regression Coefficient (β)			
Predictor	Step 1	Step 2	Step 3	Odds ratio
Constant	1.17 (0.39)***	-3.56 (0.42)	-3.00	3.69
Background				
Gender	0.28 (0.39)	0.39 (0.42)	0.36 (0.44)	1.32
Motivation Measures				
Intrinsic		0.48 (0.46)	0.57 (0.51)	1.57
Grade		0.45 (0.48)	0.65 (0.49)	0.82
Self-determination		-0.20 (0.47)	-0.45 (0.52)	1.50
Career		0.41 (0.47)	0.28 (0.53)	1.61
Feedback Measures				
Factor 1			1.11 (0.42)**	3.05
Factor 2			0.22 (0.40)	1.24

For the intention to recommend the course model, the Nagelkerke R^2 value equaled 0.16 and the Cox-Snell R^2 value equaled 0.25 ($\chi^2(8) = 15.85, p = 0.04$). The classification results revealed that 75.7% of the cases were correctly classified. The factor predicting student intention to recommend the course was helpful feedback (odds ratio: 3.05, CI (95%): 1.33-7.05). Students who perceived that they received valuable feedback reported stronger intention to recommend the course to another student.

4.3 References

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Chapter 5

Conclusions

This study examined student motivations in an introductory general chemistry course utilizing learning assistants. Findings indicate that classroom factors (i.e., the feedback and assistance provided by the instructor and learning assistants) was a predictor of satisfaction and feedback in general chemistry. In addition, science self-efficacy was significantly related to intrinsic and extrinsic motivation.

This study has several limitations. First, participants were taken from a single section of general chemistry at a particular institution; therefore, the results may represent the students in this context, but not be applicable to other situations. Second, the sample size (n = 160) is small, which could limit generalizability. Third, the survey design relies on self-reported data, therefore, the findings are only associational. Fourth, the findings are based on only quantitative data. In the future, qualitative interview studies could triangulate quantitative results. Additionally, since self-efficacy and other motivational factors are domain-specific the instrument should be revised as to replace the word “science” with a more accurate descriptor (e.g., “chemistry,” “organic chemistry,” “biology) with future uses.

Future studies should consider how motivational and affective processes are connected to achievement (e.g., course grade). There is also a need to examine further the nature of feedback provided by learning assistants via qualitative studies.

Despite the limitations described, the findings have important implications for chemistry educators. The finding that student satisfaction and course recommendation depends more on what students get from the course (e.g., feedback received) rather than what students bring with them to the classroom (e.g., motivational beliefs) suggests that instructors should consider increased opportunities for feedback within their classes. In addition, the evidence that motivation is a predictor of science self-efficacy indicates that motivation should be also considered in order to help facilitate the development of self-efficacy among students. This is important as previous research has demonstrated that self-efficacy has the strongest correlation with course performance. We found that students enrolled in first semester general chemistry and who participated in this study were more extrinsically motivated on average. If students are extrinsically motivated, contextualizing course content with regards to future careers could be considered. Conversely, if students are intrinsically motivated, providing more opportunities for problem-solving is a potential strategy. Additional research is needed to better understand the influence of motivation and the classroom environment on student outcomes in college chemistry.

Appendix A

Student Survey

Part 1. Please circle your response.

1. Year: Freshman Sophomore Junior Senior

2. College: a) Eberly College of Science
b) College of Engineering
c) College of Agricultural Sciences
d) College of Earth and Mineral Sciences
e) College of Health and Human Development

3. Gender: Female Male

Part 2. Please circle the response that reflects your opinion, using the following scale:

1	2	3	4	5
Never	**Rarely**	**Sometimes**	**Usually**	**Always**

1.	The science I learn is relevant to my life.	1	2	3	4	5
2.	I like to do better than other students on science tests.	1	2	3	4	5
3.	Learning science is interesting.	1	2	3	4	5
4.	Getting a good science grade is important to me.	1	2	3	4	5
5.	I put enough effort into learning science.	1	2	3	4	5
6.	I use strategies to learn science well.	1	2	3	4	5
7.	Learning science will help me get a good job.	1	2	3	4	5
8.	It is important that I get an “A” in science.	1	2	3	4	5
9.	I am confident that I will do well on science tests.	1	2	3	4	5
10.	Knowing science will give me a career advantage.	1	2	3	4	5
11.	I spend a lot of time learning science.	1	2	3	4	5
12.	Learning science makes my life more meaningful.	1	2	3	4	5
13.	Understanding science will benefit me in my career.	1	2	3	4	5
14.	I am confident I will do well on science labs and projects.	1	2	3	4	5
15.	I believe I can master science knowledge and skills.	1	2	3	4	5
16.	I prepared well for science tests and labs.	1	2	3	4	5
17.	I am curious about discoveries in science.	1	2	3	4	5
18.	I believe I can earn a grade of “A” in science.	1	2	3	4	5
19.	I enjoy learning science.	1	2	3	4	5
20.	I think about the grade I will get in science.	1	2	3	4	5
21.	I am sure I can understand science.	1	2	3	4	5
22.	I study hard to learn science.	1	2	3	4	5
23.	My career will involve science.	1	2	3	4	5
24.	Scoring high on science tests and labs matters to me.	1	2	3	4	5
25.	I will use science problem-solving skills in my career.	1	2	3	4	5

Part 3. Please circle the response that reflects your opinion, using the following scale:

1	2	3	4	5
Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

1.	In this course I get plenty of feedback about how I am doing.	1	2	3	4	5
2.	LAs mainly tell me how I am doing in relation to others.	1	2	3	4	5
3.	I listen to LAs carefully and try to understand what they are saying.	1	2	3	4	5
4.	Feedback in this course comes very quickly.	1	2	3	4	5
5.	LAs help me better understand things.	1	2	3	4	5
6.	LAs help me go back over how I approached a problem.	1	2	3	4	5
7.	When I get things wrong or misunderstand them I don't receive much guidance in what to do about it.	1	2	3	4	5
8.	LAs show me how to do better next time.	1	2	3	4	5
9.	Feedback from LAs do not help with subsequent assignments.	1	2	3	4	5
10.	I receive hardly any feedback in this course.	1	2	3	4	5
11.	When I talk to LAs I understand why I got the grade I did.	1	2	3	4	5
12.	Feedback from LAs prompts me to go back over material covered earlier in the course.	1	2	3	4	5
13.	I would learn more if I received more feedback.	1	2	3	4	5
14.	I do not understand some feedback from LAs.	1	2	3	4	5
15.	I do not use feedback for revising.	1	2	3	4	5
16.	Whatever feedback I get comes too late to be useful.	1	2	3	4	5
17.	I rarely understand how to improve by talking to a LA.	1	2	3	4	5
18.	I tend not to talk to LAs.	1	2	3	4	5

Part 4. Please circle your response.

1. I would recommend this course to another student.

   Yes No Unsure

2. How satisfied are you with the feedback in this course?

   1 2 3 4 5

Appendix B

Demographics of Participants

	N	%
Female	83	52.5
Male	71	44.9
Freshman	114	71.7
Sophomore	41	25.8
Junior	4	2.5
Senior	0	0
Science	40	25.0
Engineering	61	38.1
Other	59	36.9

Appendix C

Correlation Studies

Pearson correlations for all scales and science self-efficacy (n = 135)

	1	2	3	4	5	6	7	8
1. Self-efficacy	---							
2. Gender	0.110	---						
3. Intrinsic	0.601*	-0.031	---					
4. Grade	0.534*	-0.121	0.384*	---				
5. Self-determination	0.448*	-0.195*	0.511*	0.413*	---			
6. Career	0.624*	-0.111	0.721*	0.562*	0.497*	---		
7. Feedback F1	0.161*	0.112	0.111	0.029	0.146*	0.005	---	
8. Feedback F2	0.135	0.020	0.42*	0.054	0.092	0.119	0.041	---

Pearson correlations for all scales and satisfaction (n = 136)

	1	2	3	4	5	6	7	8
1. Satisfaction	---							
2. Gender	0.051	---						
3. Intrinsic	0.248*	-0.041	---					
4. Grade	0.189*	-0.125	0.388*	---				
5. Self-determination	0.208*	-0.198*	0.513*	0.415*	---			
6. Career	0.291*	-0.113	0.719*	0.563*	0.498*	---		
7. Feedback F1	0.333*	0.091	0.137	0.043	0.155*	0.013	---	
8. Feedback F2	0.415*	0.021	0.138	0.052	0.089	0.198*	0.035	---