Summer 2020

21st Century Physics Homework: A Mixed-Methods Approach Evaluating How an Individualized Online Homework Platform Can Provide Quality Feedback and Help Physics Students Engage in Self-Regulated Learning

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21ST CENTURY PHYSICS HOMEWORK: A MIXED-METHODS APPROACH EVALUATING HOW AN INDIVIDUALIZED ONLINE HOMEWORK PLATFORM CAN PROVIDE QUALITY FEEDBACK AND HELP PHYSICS STUDENTS ENGAGE IN SELF-REGULATED LEARNING

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Submitted in Partial Fulfillment of the Requirements

For the Degree of Doctor of Education in

Curriculum and Instruction

College of Education

University of South Carolina

2020

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DEDICATION

To Kate, who has persevered and struggled every bit as much as I have though this program. If I were to thank you for all the times you have been there for me, it would be longer than this dissertation and likely more fun to read. I love you!

To Elliot, who has been a never-ending source of joy during the entirety of this journey. Just this week you asked me if you could sit on my lap and "watch me work". You are a gift that I thank God for every day. I love you!

Of course, without my parents, none of this would be possible. I thank them for showing me how to love Jesus Christ and for instilling in me a love for science (thanks, Dad) and teaching (thanks, Mom). My entire family has been so supportive of me, and the monumental task of preparing a dissertation is dedicated to them for their inexhaustible kindness. I love you guys!

ACKNOWLEDGEMENTS

My USC doctoral professors have been gracious, kind, and patient throughout this process. I cannot think of people that I would rather learn from. Special thanks goes to Dr. Ismahan Arslan-Ari and her outstanding feedback and Dr. Michael Grant for his strong leadership. I also must thank my college professors. There are too many to list, but I am particularly grateful for Dr. Nick Uwarow, Dr. Brian Carruthers, and Dr. Don Jacobs who all encouraged me to pursue a doctorate. All the teachers at Harvest Baptist Academy played a role in causing me to love school enough to pursue a career in education. I am so thankful for their investment in my life. Finally, Mrs. Kiffany Bond will always deserve my respect and admiration for teaching me to read and write—an incredible gift.

ABSTRACT

American secondary students spend many hours each week working on homework. To get the most out of this homework, students need to receive quality feedback and engage in self-regulated learning when completing homework tasks. For teachers, traditional paper-and-pencil homework means extra time spent grading rather than giving good feedback. This study aims to answer the following questions: 1) How and to what extent does the implementation of individualized online homework and feedback impact self-regulated learning among Honors Physics high school students? and 2) How does the implementation of individualized online homework impact students' perception of the feedback quality provided by an individualized online homework platform?

To answer these questions, a convergent parallel mixed-methods study involving 14 secondary honors physics high school students in South Carolina was conducted. An individualized homework platform called Mastering Physics was introduced to the class in the fall of 2019. This platform individualizes student assignments with free-response questions that have randomized variables. Quantitative data about this intervention's effectiveness in impacting the areas of student self-regulated learning skills and perception of feedback quality were collected with the following instruments: 1) Online Self-Regulated Learning Questionnaire (Barnard, Lan, To, Paton, & Lai, 2009) and 2) an adapted version of the Feedback Environment Survey (Steelman, Levy, & Snell, 2004). Qualitative data was collected in the form of two focus group interviews.

Quantitative data were anlyzed using both descriptive and inferential statistics. Qualitative data, in the form of focus group transcriptions, were analyzed through memo writing, peer debriefing, first cycle coding and second cycle coding. The quantitative data did not reveal any significant differences which aligned with the qualitative data. Key findings are that participants' SRL skills did not significantly improve and that students did not perceive the feedback they received as being high quality.

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CHAPTER 1

INTRODUCTION

National Context

Educators have long used homework as a tool to enhance instruction and help students to solidify and practice academic skills outside of the classroom. American secondary students spend, on average, 6.8 hours each week working on that homework (National Center for Education Statistics, 2011, Table 35). While this statistic does not indicate whether the homework is of high or low quality, it does inform the educational community that research into this area is important due to the thousands of hours spent on homework by students each year across the county. If students spend an average of 6.8 hours each week on homework, then each student would be spending over 244 hours each year on homework in a typical 36-week school schedule! Although homework is a nearly ubiquitous experience for American high school students, its effect size in educational studies ranks consistently low on Hattie's three separate rankings of effect sizes across educational research (Hattie, 2008, 2012; Hattie, Masters, & Birch, 2015). However, homework can act as a tool for a teacher to receive and to give high-quality feedback. In contrast to homework all on its own, feedback from teacher to student and vice versa ranks high in its effect size on student achievement (Hattie, 1999; Hattie & Timperley, 2007).

Technology has been aiding teachers in the effort to use homework effectively over the last several years with numerous companies offering online web-assignments through venues like: Mastering Physics, WeBWork, Khan Academy, MasteringPhysics, and MathXL. Yuen, Edgcomb, and Vahid (2016) demonstrated the usefulness of such tools with 553 students from three different universities. They found that students using online platforms for homework made better attempts at the problems even when the answers were readily viewable. Teachers across the country can use the technology of online homework platforms to enhance the homework assignments they give through its increased ability to give timely and elaborate feedback.

Self-regulated learning theory underlies this study and has been the subject of numerous educational studies, impacting educators across the country (DiBenedetto & Bembenutty, 2013; Nichols, Tippins, & Wieseman, 1997; Schunk & Zimmerman, 2012; Seraphin, Philippoff, Kaupp, & Vallin, 2012; Zimmerman, 2008). It is an appropriate foundation from which to launch an exploration of how individualized online homework assignments and feedback can impact students' ability to engage their self-regulated learning (SRL) skills.

The success of any online educational tool surely depends on a variety of incredibly complex, and often unforeseen, factors. Besides being an obvious time-saving tool, the potential benefits that individualized online homework platforms might have in promoting self-regulated learning and enhancing feedback quality make further study on the topic very promising.

Local Context

When I started teaching physics, I recognized several challenges I was facing that needed to be addressed. First, I realized that the feedback I was giving to my students regarding their homework was surface level at best. Since the grading process for paper-based homework took me so long, I was only able to tell students what answers they got right and wrong. Occasionally, during especially busy times of the year, I was only able to count the homework for completion and did not even have time to check each answer for accuracy. This shortcoming did not affect just me. Conversations with other teachers in my department revealed that they too felt like they were providing students with inadequate feedback. In addition, I noticed that students often struggled to engage in SRL behaviors to what I perceived to be their fullest potential. I wanted to make my homework more beneficial to my students, so I began to look for a way that I could implement a technological solution that would improve the feedback that my students could receive and promote their use of SRL behaviors.

I have been using a homework assignment platform called WebAssign with my Advanced Placement (AP) Physics 1 course for over two years. I was even featured on the WebAssign blog for using this technology in my secondary classroom (Creative Lab Experiences in the Physics Classroom, 2016) and am interested in helping other teachers use this type of technology successfully in their classrooms. My students have told me that even though physics problems are difficult, using an online homework platform has helped them sharpen their understanding of the topics we have covered. My AP Physics classes are small and full of highly motivated students. These students seem to have a great ability to engage in SRL, and I wanted to see if using an online homework platform with my other classes could help students in those classes to also engage in SRL by providing them better feedback.

Statement of the Problem

Science teachers at my high school feel unable to adequately provide students with quality feedback through homework that promotes students' SRL behaviors. Science teachers at my high school had over a 37:1 student-teacher ratio in 2016 (Greenville County Schools, 2016). This high number of students has prompted my colleagues to lament about the difficulty in assigning relevant, meaningful homework that does not take an incredibly long amount of time to grade.

Technology, specifically online assessment tools, have been aiding instructors in their efforts over the last several years with several companies offering online web-assignments through platforms like: Mastering Physics, WeBWork, Khan Academy, WebAssign, and MathXL. These tools have been found to be beneficial to students in terms of achievement (Hernandez-Julian & Peters, 2012; Yuen et al., 2016). My own experience with WebAssign in college was one of frustration. I did not find it to be helpful but largely suspected that this was because of the way in which it was implemented. I wanted to find a platform and a way to implement that platform to prevent my students from experiencing the same kinds of frustration that I had felt.

Self-regulated learning is a set of procedural skills that students demonstrate by planning for a cognitive performance activity of some kind, performing that cognitive task, and then being able to reflect upon their planning and performance once the activity is complete (Zimmerman, 1986, 2008). The homework that I am typically able to assign gives student few tools to aid them in SRL behaviors. For example, a student beginning one of my homework assignments may not know how long to expect to work on an assignment and would be better able to plan with that information. They may also get stuck on a problem and not want to move on in case they are doing something wrong. Students may also have a hard time in the reflection phase of SRL if they do not have easy access to their prior homework assignments and scores. Traditional pen-and-paper homework does not seem to aid a student very well in their ability to engage in SRL.

Feedback is an essential part of the learning process (Stenger, 2014). Hattie and Timperley (2007) claim that feedback can help students answer questions such as "Where am I going? How am I going? [and] Where to next?" (pp. 88-90). In a meta-analysis, Hattie (1999) showed that feedback maintains a large effect size in promoting student learning. It is difficult to provide quality feedback on paper-based physics assignments at LSCH because of the large student-teacher ratio. In addition, when meaningful feedback is provided, its potency is often diminished by the length of time required to return feedback to students. This delay in providing feedback can diminish its effectiveness (Opitz, Ferdinand, & Mecklinger, 2011).

Purpose statement

The purpose of this action research was to evaluate the impact of Mastering Physics (MP), an individualized online homework platform, on students' self-regulated learning skills and perceptions of feedback quality in a South Carolina high school.

Research questions

1. How and to what extent does the implementation of individualized online homework and feedback impact self-regulated learning among Honors Physics high school students?

2. How does the implementation of individualized online homework impact students' perception of the feedback quality provided by an individualized online homework platform?

Statement of Research Subjectivities and Positionality

I am a lower-middle-class, white male in his early 30's. I work as a professional physics educator in a large South Carolina high school. My wife is also a teacher and we have one son. We are actively involved in our community through our schools and our ministries in our local church.

I decided to pursue a graduate degree in educational technology for a variety of reasons. First, I have a great desire for learning and have never really stopped being a student since I started attending school. After receiving my master's degree, pursuing a doctorate seemed a natural progression to continue my love of learning. In addition to this, I have always enjoyed using technology in my classroom as a teacher far more than most of my colleagues and very much enjoy helping them with technology issues that they face. Getting a graduate degree in educational technology would enable me to better serve my fellow faculty members. Rendering this degree even more relevant, my school transitioned to implementing a personalized learning device format during the 2017-18 school year, in which every student receives a Chromebook. Finally, public education offers little advancement for teachers in terms of positions apart from receiving further education. Wanting to grow my career in public education and best support my family, I decided to pursue a higher degree.

Personally, my strong Christian faith leads me to care deeply about my community including my students and colleagues. Since I believe that each stakeholder was created in the image of God, I strive to serve them with the utmost respect and dignity, doing my best to provide an excellent education for my students. These beliefs push me toward becoming the best education technology professional that I can be. This means that I will be focused on solving problems at my school to help enhance the education that students receive and that I and my colleagues provide. My personal beliefs strongly inform my chosen research paradigm.

An educational researcher's paradigm is vitally important to their work. It is the set of assumptions upon which they design their research methodology and conduct their experimentation. I have chosen pragmatism as my educational research paradigm because of its compatibility with action research as well as its alignment with my Christian faith. While not all of Creswell's (2014) tenets of pragmatism align with my personal faith, the idea that there is one true reality with multiple personal interpretations of that reality in the human experience fits within my personal worldview. Action research fits within the pragmatic paradigm. Szyjka (2012) informs us that "pragmatism epitomizes John Dewey's idea of finding what works in building knowledge among those who seek to advance scientific truth" (p. 111).

Professionally, I have shown a pattern of pursuing excellence in education. My colleagues have recognized my passion for education by nominating me to receive an "Outstanding Science Teacher" award from our district science teachers association. In 2018, I led the students of my AP physics class to set a new world record for the highest launch from a Galilean Cannon (Guinness World Records, 2018). I have been recognized by my administration as a leader in educational technology by being placed on a Digital Leadership Corps at my school and have also been recognized by my district for my dedication to the field of education by being awarded a spot as a finalist in the Teacher of the Year program in Greenville County for the 2017-18 school year (Greenville County Schools, 2017). These professional accomplishments make me an ideal candidate to pursue an advanced degree in the field of educational technology. With this degree, I will be able to increase the impact that I can have on future students.

My personal and professional attributes also present challenges to my journey of becoming a professional in the field of educational technology. The message of my personal faith might offend a student or colleague with whom I work. While I plan to do my best to mitigate such conflict with kindness and grace, the possibility of conflict remains and presents a challenge to be overcome daily. In addition to this, my socioeconomic status and position could prevent me from accurately assessing the perceptions of my students who may come from a completely different background than me. To help adjust my perspective to better serve students of all types, I often get involved with student activities such as the Solid Rock Club, spirit week, and by hosting a fundraising video game tournament. While these actions cannot completely mitigate all risks, I trust that they will help me to understand my students on a deeper level.

Definition of Terms

In this study the following terms and variables will be considered:

Self-Regulated Learning

Self-regulated learning "refers to self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals" (Zimmerman, 2000, p. 14) and is "the degree to which students are metacognitively, motivationally, and behaviorally active participants in their own learning process"(Zimmerman, 2008, p.

167). This study will focus on the self-evaluation, goal-setting and planning, reviewing records, and environmental structuring that students engage in.

Feedback

This study will use Shute's (2008) definition of feedback as "information communicated to the learner that is intended to modify his or her thinking or behavior for the purpose of improving learning" (p. 154) and Hattie and Timperly's (2007) definition of feedback as "information provided by an agent (e.g., teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding" (p. 81). This combination highlights that feedback is provided about performance with the intent of the modification of thinking.

Homework

Homework will be defined in this study as "tasks assigned to students by school teachers that are meant to be carried out during non-school hours" (Cooper, 1989, p. 7). In an interview with Bembenuty (2011), Cooper changed the wording of "non-school hours" to "noninstructional time" (2011, p. 340). This change fits here since homework may actually be done in class during noninstructional time in my classroom.

Individualized, online homework platform

An individualized, online homework platform can be described as a web-based software that delivers non-identical assignments to students. Software platforms such as MP, WeBWork, WebAssign, MathXL and others function in this way. In this study, MP is the specific individualized, online homework platform used in the intervention.

Mastering physics

MP describes itself as "the world's leading online homework, tutorial, and assessment system for science and engineering, designed to improve results and increase student engagement before, during, and after class" ("Information for educators and administrators: Mastering physics," n.d.). Pearson, the company that hosts the MP platform, has granted me permission to use their software in this study (Pearson support team, personal communication, March 25, 2019).

CHAPTER 2

LITERATURE REVIEW

Introduction

The purpose of this action research was to evaluate the impact of MP, an individualized online homework platform, on students' self-regulated learning skills and perceptions of feedback quality at a large South Carolina high school (LSCH) in Simpsonville, South Carolina. The study focused on answering two main questions 1) How and to what extent does the implementation of individualized online homework and feedback impact self-regulated learning among Honors Physics high school students? and 2) How does the implementation of individualized online homework impact students' perception of the feedback quality provided by an individualized online homework platform?

In reviewing the literature for this study, I searched a variety of databases for scholarly articles, books, dissertations, and research reports related to my study. I used the EBSCO Information Services reference database to access the following collections in my search: Academic Search Complete, Applied Science & Technology Source, Associates Programs Source, Computer Source, eBook Academic Collection, Education Full Text, Education Index Retrospective, Education Source, ERIC, General Science Full Text, Health and Psychosocial Instruments, Middle and Junior High Core Collection, PsychArticles, Psychology and Behavioral Sciences Collection, PsychInfo, Science Reference Center, Senior High Core Collection, and Teacher Reference Center. In addition to EBSCO Information Services, I searched the Google Scholar database for related literature. The Google Scholar database is estimated to be the largest in the world with over 389 million documents (Gusenbauer, 2019). In addition to these database aggregates, I also frequently inspected the American Association of Physics Teachers website along with The Physics Teacher website for related studies. Finally, I used frequent Google searches to mine education and blog websites for research and to find data published through my state and district. In seeking to answer the research questions for this study, I used the following key search terms alone and in conjunction with one another when searching EBSCO and Google Scholar: online homework platform, online homework, individualized homework, Mastering Physics, MasteringPhysics, self-regulated learning, self-regulation, SRL, self-regulated learning theory, physics education, physics, secondary physics education, feedback, formative feedback, mastery learning, student performance, and homework. While searching for these terms, advanced search features were used to find exact matches and combinations of words. When evaluating articles to use as sources in my study, my primary consideration was relevance to my topic and research questions. With relevance determined, I used the following criteria to evaluate the quality and appropriateness of referencing a particular study: peer-review status, age of material, design of study (experimental, quasi-experimental, meta-analysis, etc...), and geographic location of study. These criteria were evaluated all together with none having explicit "veto" power, but rather each article being weighed on its own merit in supporting the literature foundation of my study. When I found literature that I believed could be relevant to my study, I would add it to my reference manager, Mendeley. Mendeley's ability to import citations was helpful in establishing a quick reference of material that I had looked at all in one place. Entering literature into Mendeley served as a first round of selection. Subsequent selections took place when I used Mendeley's folder function to categorize literature into useful topics. Articles that I did not use ended up being left uncategorized. In addition to creating folders within Mendeley, I also used the star feature within Mendeley to keep track of articles that I had found especially salient. To date, I have imported 516 articles into Mendeley and have referenced 64 of them in my literature review. In addition to Mendeley, I used Microsoft Word to organize 85 articles into an annotated bibliography compendium containing summaries, description of method, general topic, and descriptions of relevance to my study.

A review of related literature follows this paragraph. In short, the major topics covered in this review are 1) Self-Regulated Learning 2) Individualized Homework and Student Achievement 3) Feedback and 4) Online platforms and self-regulated learning.

Self-Regulated Learning

Self-regulated learning has been defined in similar ways by multiple authors, but each definition and model has subtle nuances that make each one unique despite their similarities. Below, a definition of self-regulated learning is identified and described followed by a more detailed description of SRL, an explanation of how it is measured, references to the kinds of evidentiary support that individual SRL models have, and the kind of metanalytic support that the construct enjoys as a whole. Self-regulated learning theory applied in the secondary physics classroom is then explored followed by a description of the connection between self-regulated learning and online homework platforms.

Definition of SRL

Self-regulated learning theory describes how students engage with their own thinking before, during, and after completing cognitive tasks. So broad is this topic that it prompted Greene and Azevedo (2007) to remark that:

> SRL models, including Winne and Hadwin's, generally cover a broad array of phenomena, including many well-researched areas, such as goal setting, motivation, personal epistemology, and emotions. It would be a formidable and lengthy task indeed to review the empirical work in each. (p. 338)

Though they are not exactly discrete parts of self-regulated learning theory, self-control and self-discipline are familiar terms that help one begin to think about the process of self-regulated learning (Schunk & Zimmerman, 2012). SRL theorists further examine how students are "motivationally, and behaviorally active participants in their own learning process" (Zimmerman, 2008, p. 167).

Zimmerman (2000) defines self-regulation in SRL as "self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal goals" (p. 14). Others view this same concept more generally "as a generic umbrella term for the set of processes and behaviors that support the pursuit of personal goals within a changing external environment" (Matthews, Schwean, Campbell, Saklofske, & Mohamed, 2000, p. 172). In contrast, other conceptualizations stress the metacognitive (Winne, 2011) and communal nature (Jackson, MacKenzie, & Hobfoll, 2000) of SRL. Self-regulated learning theory provides educators with a framework for analyzing student behavior and achievement in light of a student's ability to control his or her own cognitive behaviors when completing academic tasks such as homework.

Description of SRL

Self-regulated learning theory does not describe an abstract, highly conceptual idea regarding student behavior, but rather provides a concrete framework for analyzing student activities before, during, and after cognitive or performance-based tasks. Self-regulated learning can be observed through a variety of student-employed learning strategies including self-evaluation, goal-setting and planning, reviewing records, and environmental structuring among others (Zimmerman & Pons, 1986). The SRL process is typically described as the internal, cyclical use of planning, performance, and reflection to facilitate learning (Black & Deci, 2000; Winne & Hadwin, 1998). Many models of SRL exists and each describes their own nuanced approach to explaining learners' ability to manage, or not, their learning (Boekaerts, 1996; Efklides, 2011; Pintrich, 2000; Winne & Hadwin, 1998; Zimmerman, 2000). Boekaert's (1996) model, for instance, is structured around two main concepts of student self-regulation, motivation and cognition, while Efklide, Winne, and Hadwin focus more on the metacognitive processes involved in learning (Efklides, 2011; Winne & Hadwin, 1998). For this study, Zimmerman's (2000) model served as the primary framework for the concept of SRL and warrants a detailed explanation. This framework divides SRL into the following phases: 1) forethought phase, 2) performance phase, and 3) self-reflection phase. Each of these phases is further subdivided into two classes each containing specific subprocesses. The forethought phase contains the subprocesses of goal setting and strategic planning in a class called task analysis. In this same phase, self-efficacy, outcome expectations, intrinsic interest/value, and learning goal orientations are classified as self-motivational beliefs. Self-control is a class within the performance phase and contains the subprocess of imagery, self-instruction, attention focusing and task strategies. Also in the performance phase, the self-observation class contains self-recording and self-experimentation as subprocesses. Self-reflection contains two classes—self-judgment and self-reaction. Self-judment includes the subprocesses self-evaluation and causal attribution while the self-reaction phase includes self-satisfaction/affect and adaptive/defensive. Each phase in this model is cyclically viewed with students returning to the forethought stage and continuing through the cycle**.** Figure 2.1 visualizes how this model functions in phases. Zimmerman's model is a social-cognitive one and was chosen, in part, due to its ability to more easily explain how environmental factors are paired with social and cognitive behaviors (Dignath, Buettner, & Langfeldt, 2008; Moos & Ringdal, 2012). This is to say that the specific behaviors in the model are impacted by environmental factor such as the implementation of MP. SRL theory serves to advance our understanding of how learners do or do not regulate their learning before, during, and after a cognitive or performance based task.

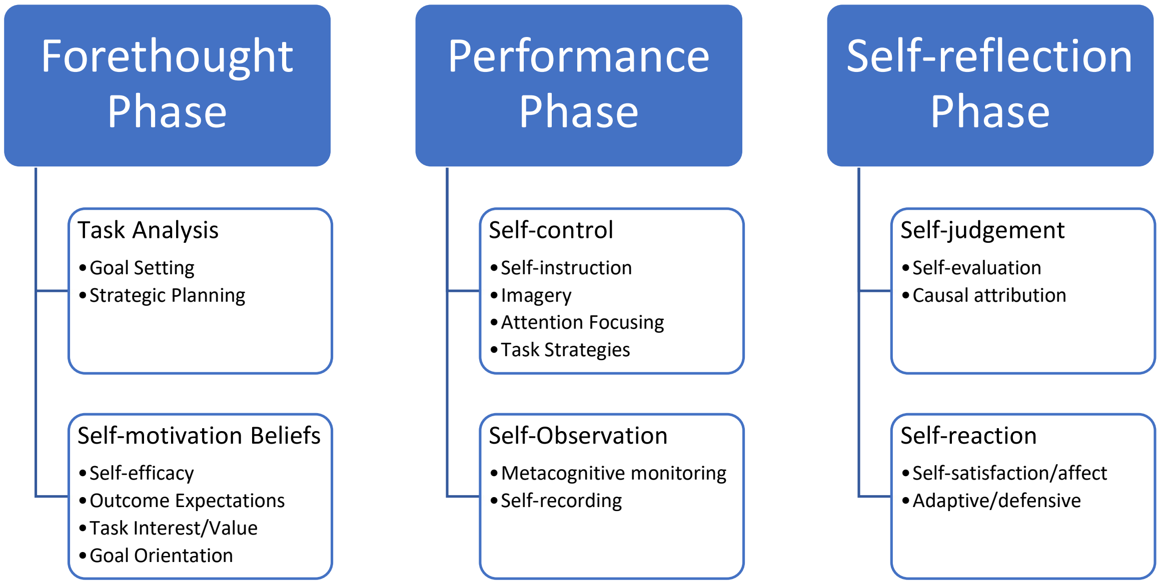


Figure 2.1. Zimmerman's model of SRL. Adapted from *Motivating Self-Regulated Problem Solvers* (p. 239), by B. Zimmerman and M. Campillo, 2003, Cambridge University Press. Copyright 2003 by Cambridge University Press. Adapted with permission.

Measuring SRL

Taking measurements of learners' SRL skills involves uncovering the way in which learners make decisions that govern the outcomes of their learning. Successful measurement tools come in a variety of forms such as interview schedules, scales, and questionnaires. These tools are often chosen based upon which model of SRL is being used to interpret the results. (Boekaerts, 1999; Magno, 2010, 2011; Pintrich, Smith, Garcia, & McKeachie, 1993). In reviewing the assessment methods used to measure SRL, Boekaerts and Corno (2005) reason that when "researchers examine students' self-regulatory capability from different vantage points using different methods of assessment (triangulation), and the results appear similar, then they can be reasonably certain that major aspects of reliability and validity have been achieved" (p. 224). In alignment with this reasoning, this study utilizes an SRL measurement tool OSLQ (Barnard et al., 2009) for its focus on online or hybrid learning environments along with an interview protocol designed to uncover students' engagement of SRL skills. In their development of the OSLQ, Barnard et al. make note of its alignment with the Zimmerman model and its ability to reveal SRL abilities, particularly in an online environment.

SRL Evidence

SRL models are supported by numerous empirical and theoretical studies. Boekaert's dual-processing model (1996; Boekaerts & Corno, 2005) has had a multiplicity of support (Boekaerts, 1999; Boekaerts & Rozendaal, 2006; Rozendaal, Minnaert, & Boekaerts, 2003) while strong support has also been given to Winne and Hadwin (1998), Elfklide (2011), Pintrich (2000) and their respective models (Dermitzaki & Efklides, 2000; Greene & Azevedo, 2007; Schunk, 2005). The Zimmerman (2000) model used in this study is supported by empirical research focused both on athletic and academic learning (Cleary & Zimmerman, 2001; Cleary, Zimmerman, & Keating, 2006; Kitsantas & Zimmerman, 2002) including science education (DiBenedetto & Zimmerman, 2010).

SRL models are supported through a variety of individual studies about individual models, but the concept as a whole is also supported through various meta-analyses (Dignath et al., 2008; Dignath & Büttner, 2008; Sitzmann & Ely, 2011). The SRL model used in this study as well as the construct as a whole has strong support from extant literature and provides a strong foundation for the current study.

Secondary Physics Education and Self-Regulated Learning

Secondary physics students in particular have been shown to benefit from engaging in SRL behaviors. Cognition, metacognition, and motivation are key components of self-regulated learning that can lead to science students learning and achieving more (Schraw, Crippen, & Hartley, 2006). In fact, both science teachers and science students benefit from being explicitly taught the self-regulated learning skills involved with metacognition (Nichols et al., 1997; Seraphin et al., 2012). Particularly, the self-reflection phase of SRL seems to benefit physics students (Li, Ye, Tang, Zhou, & Hu, 2018; Nikou & Economides, 2016). The Seraphin et al. study was particularly large with 648 secondary students showing a statistically significant increase on a test measuring their knowledge of the nature of science after they had been taught metacognitive skills. DiBenedetto and Zimmerman (2010) employed a microanalytic method of analysis on data gathered from 51 high school seniors studying science regarding their use of SRL skills and found a significant difference in performance between students that corresponded with their employment of SRL skills. Negatively, secondary physics students who perceive a more rigid environment in which to explore science, which may contribute to diminished SRL abilities, saw a negative performance impact (Neber & Schommer-Aikins, 2002).

Individualized Homework and Self-Regulated Learning

Technological advancements are enhancing students' ability to engage in SRL behaviors. This enhancement comes from the software facilitation of SRL behaviors, that is, it is much easier for students to engage with the instructional tools that allow them to track data, attempt multiple tries, and receive immediate feedback (DiBenedetto &

Bembenutty, 2013; Jacobson & Archodidou, 2000; Tabuenca, Kalz, Drachsler, & Specht, 2015) even if individualized homework platforms are not viewed as necessarily superior by students (Demirci, 2007). These advanced tools can enhance student performance and, at worst, compare similarly to more traditional forms of homework (Hauk, Powers, & Segalla, 2015; Hernandez-Julian & Peters, 2012). Bembenutty's (2009) study involving 58 college freshmen demonstrated that students who performed more SRL behaviors, as measured by questionnaires and homework logs, were far more likely to be successful on homework assignments. If more SRL behaviors correlate with higher homework achievement, then it seems likely that an individualized online homework platform will be able to make SRL behaviors even easier for students to engage in and allow them to reap the benefits of improved performance. The typically autonomous nature and design of online homework platforms require students to think metacognitively while completing cognitive tasks on the platform (Bembenutty, 2009; Schunk & Zimmerman, 2012; Zimmerman, 2000). Using an online homework platform in this study is likely to encourage learners to use SRL strategies that they already possess by making it easier for them to use those skills.

Individualized Homework and Student Achievement

In this section, definitions of online homework are defined and then described in general as well as in relation to particular studies. Next, the identification of the benefits and shortcomings of online homework is provided. The section is completed with the idea of student achievement being introduced and defined.

Definition of Homework

Homework is such a ubiquitous experience, that it may seem unnecessary to define it. It is, however, exactly the broadness of the term that makes it important to clearly define what homework means for the context of this study. Harris Cooper, one of the foremost experts on homework research gave a (1989) definition of homework that is as traditional as it is straightforward. He defined homework as “tasks assigned to students by school teachers that are meant to be carried out during non-school hours” (p. 7). Cooper later adjusted this definition slightly in an interview by changing the words “non-school hours” to “non-instructional time” (Bembenutty, 2011, p. 340), since homework may actually take place in a school setting. Corno’s (1996) version of “schoolwork brought home” (p. 27) doesn’t quite seem to fit the context of this study as a definition for homework since it seems to imply that the tasks are just leftover school work and not tasks that are specifically designed for non-instructional time. Viewing homework as a tool to develop future workplace ethic and skills (Corno & Xu, 2004) is also neglected. Rather, for this particular research setting, homework is viewed specifically in light of its ability to increase student understanding of the content area, physics, and takes the form of individualized questions on an online platform.

Description of Individualized Homework

Individualized homework often, and in this study, takes the form of online homework. Online homework platforms allow students to access and complete assignments via the internet. They are usually subscriptions that colleges, schools, or districts pay for. Often, they come as a resource with the adoption of a textbook or curriculum. Online homework platforms typically require students to log in with a unique username and password and allow them to track their progress throughout the duration of a course. It is not uncommon to see online homework platforms used in college, though their adoption in secondary, middle, and elementary schools has been less ubiquitous, which leaves a gap in the research where the current study fits nicely.

Online homework systems offer the potential to assess a large number of students quickly while producing positive learning outcomes. These advantages come from these platforms' ability to offer efficient solutions for automatic grading, question randomization, and cheating prevention. (Doorn, Janssen, & O'Brien, 2010). Math-based courses, such as physics, are particularly benefited by these advantages (Basitere & Ivala, 2017; Bonham, Beichner, & Deardorff, 2001; Bonham, Deardorff, & Beichner, 2003; Callahan, 2016; Yuen et al., 2016). Online homework seems to have established its place as a valuable tool in the physics teacher's toolbox. The individualization that an online homework platform provides is at the heart of this study. The individualized questions, answers, and feedback that such a system can provide should help students with the self-regulating behaviors described in the previous section. Specifically, individualized homework assignments with multiple tries should cause students to plan their answers more strategically and not guess too often (Kortemeyer, 2015). In addition, since the feedback they receive will be somewhat customized to their answers, it should drive them to pay careful attention to the feedback that they receive. The online nature of the homework may also promote the self-regulating behavior of reviewing records (Zimmerman & Pons, 1986). Self-regulated learning focuses on critically thinking about one's own thinking, otherwise known as metacognition. It seems that individualized, online homework has the potential to drive students to engage in cognition and metacognition more productively.

Definition of Student Achievement

This section communicates how student achievement should be identified in relation to the learning context, both quantitative and qualitative approaches are mentioned. Next, the benefits of individualized, online homework, such as performance increases, student beliefs, and attrition are discussed. Finally, the shortcomings of online homework, such as lack of performance increase, ambiguous impact upon student attitudes, and the inability to produce engagement are discussed.

Student achievement should be defined in the context of specific learning goals of a particular subject area (Guskey, 2013). In high school physics, these specific learning goals often focused on measuring student understanding of Newtonian Mechanics (Carey, 1986a; Dugger & Johnson, 1992; Moll & Milner-Bolotin, 2009). Quantitatively, the achievement of students learning introductory Newtonian mechanics has been measured with conceptual inventories that are designed to expose students' conceptual understanding of force, velocity, and acceleration (Hestenes, Wells, & Swackhamer, 1992; Rosenblatt, Sayre, & Heckler, 2008; Thornton & Sokoloff, 1998). It is important for the context of this study to know that qualitative data, in the form of interviews and inductive strategy of survey responses, can demonstrate gains and losses in student achievement (Basitere & Ivala, 2017; Sun & Wu, 2016).

Online homework benefits students. It has been shown to increase performance and can be used as a good predictor of achievement in other areas (Babaali & Gonzalez, 2015; Carey, 1986b; Lazarova, 2015; Ratniyom, Boonphadung, & Unnanantn, 2016).

Students also perceive the benefits of online homework, believing that it will help them to complete more assignments and complete them with higher scores (Callahan, 2016; Lunsford & Pendergrass, 2016; Woolley, 2015). In addition to these benefits, online homework may be able to help students stay enrolled in a course, promote risk-taking, and increase time on task (Babaali & Gonzalez, 2015; Callahan, 2016; Yuen et al., 2016). Online homework seems likely to be able to help secondary honors physics students achieve more.

Online homework is not a universally accepted solution to improving student achievement, attitude, or engagement in self-regulated learning. Online homework has been shown to cause no increase in performance and, at best, do no harm which is hardly high praise (Callahan, 2016; Lunsford & Pendergrass, 2016; Woolley, 2015). Homework's impact on student attitudes, an important part of self-regulated learning, is vague and missing from empirical studies (Cooper, Robinson, & Patall, 2006; LaRose, 2010). Students engaging metacognitively with their homework is not automatically produced by online homework but is dependent upon the way in which it is implemented for success (Lunsford & Pendergrass, 2016; Yuen et al., 2016). Though the use of online homework platforms has shortcomings, it seems that these are outweighed by the benefits.

Feedback

In this study, I posit that switching to an individualized online homework platform will result in students being given higher quality feedback which, in turn, will improve their ability to self-regulate. In the section to follow, the definition of feedback is explored followed by an examination of various types of cognitive feedback along with metacognitive feedback. Next, the impact and quality of feedback and a description of how feedback quality is measured is presented.

Definition of Feedback

Shute (2008) writes of feedback as a formative tool and defines it as "information communicated to the learner that is intended to modify his or her thinking or behavior for the purpose of improving learning" (p. 154). A more generic definition of feedback as "information provided by an agent (e.g., teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding" (Hattie & Timperley, 2007, p. 81) is also useful in the context of this study since the feedback in this study is explicitly intended to inform learners about their own performance on assignments. Hattie and Timperley's landmark article, a review of 12 meta-analyses that included nearly 200 papers, draws from Hattie's earlier work (1999) strongly describes feedback as "one of the most powerful influences on learning and achievement" (Hattie & Timperley, 2007, p. 81). Kluger and Denisi's own analysis revealed as much and highlighted that not all types of feedback are able to benefit students' performance. Over the past 30 years, various types of feedback have been categorized and their particular strengths and weaknesses identified (Kluger & DeNisi, 1996). In this study, feedback takes the form of individualized, computer-generated responses to student answers in addition to platform features accessible to students.

Description of Feedback Types

The next section will show that feedback can be classified as either 1) knowledge of results feedback, 2) knowledge of correct results feedback, or 3) elaborated feedback.

Cognitive feedback is also addressed as well as another categorization of feedback in terms of timing, and tone. Additionally, metacognitive feedback is defined and described.

Feedback that gives the learner the most rudimentary information about a task is known as knowledge of results or verification feedback. This type of feedback merely informs the learner about whether a response is correct or incorrect (Butler & Winne, 1995; Wang & Wu, 2008). Knowledge of correct results feedback gives a learner information about which responses are correct, not just letting them know if their entire answer was wrong (Dempsey, Driscoll, & Swindell, 1993; Shute, 2008). Elaborated feedback is feedback that gives the learner a more full description of why correct answers are correct and why incorrect answers are incorrect (Harks, Rakoczy, Hattie, Besser, & Klieme, 2014; Narciss & Huth, 2004).

Cognitive feedback, as described by Balzer and Doherty (1989), "refers to information about relations rather than outcomes" (p. 410). These authors categorize cognitive feedback into three types, task validity, cognitive validity, and functional validity. Task validity feedback takes the form of explicitly explaining to a learner how he or she could use contextual cues to improve their performance on a task. Next, cognitive validity feedback prompts learners to think about how contextual cues might impact their performance. Unlike task validity, cognitive validity does not explicitly explain this relationship but brings the fact that a relationship might exist to the learner's attention. Finally, functional validity feedback informs a learner of how accurately their perceived understanding compares with their actual understanding as measured by an assessment.

In addition to the previous categorizations of feedback, feedback can also be categorized in terms of being immediate, delivered soon after responses are given, and delayed, delivered after an extended period of time (Dempsey et al., 1993). Feedback can also be categorized by its specific tone such as praise, punishment, or reward (Hattie, 1999) as well as being thought of in terms of purpose such as diagnosis feedback, remediation, or correction (Hattie & Timperley, 2007). In physics particularly, many concepts build upon one other, leading many teachers to employ an approach to feedback that maintains the goal of mastery of the content (Kulik, Kulik, & Bangert-Drowns, 1990; Wambugu & Changeiywo, 2008).

Feedback does not always have to address students' cognitive thinking. Feedback can also be metacognitive in nature. Metacognitive feedback is:

> feedback that is triggered by students' learning behavior (e.g., avoiding necessary help), and not by the accuracy of their responses at the domain level. Also, metacognitive feedback delivers metacognitive content, that is, it conveys information about desired learning behavior (e.g., advising the student to ask for a hint), rather than domain knowledge. (Roll, Aleven, McLaren, & Koedinger, 2011, p. 268)

In this way, feedback has the ability to provide students with information regarding their performance as well as give them information about how to better engage with feedback and classroom assignments. The feedback used in this study is immediate, elaborated, and largely cognitive.

Feedback Impact and Quality

In this section, the quantitatively and qualitatively measured impacts of feedback are explored in addition to the identification of several characteristics of effective feedback. This section also makes the connection that quality feedback has with promoting students' engagement in SRL.

When measured quantitatively, student surveys and student performance increases are typically used to gauge the impact of feedback. Especially when paired with an online homework platform, elaborated feedback can lead to student success and promote self-evaluation if students engage with the feedback that they are given (Chen, Breslow, & DeBoer, 2018; Gutmann, Gladding, Lundsgaard, & Stelzer, 2018; Van der Kleij, Feskens, & Eggen, 2015; Vogelzang & Admiraal, 2017). In the Chen et al. study, data from how 474 introductory college physics students interacted with an online homework platform were analyzed. These students only received the knowledge of results (correct or incorrect) feedback and were still benefited by it. Imagine the impact that more robust, elaborated feedback could have on students. Elaboration in feedback, such as hints or tutorials being available, can have long term benefits for students (Leow, Lee, & Rho, 2018). Students like this feedback to be immediate (Matchett Wood & Bhute, 2019) and have strong expectations for electronic feedback when enrolled in STEM courses (El Shaer, Casanova, Freestone, & Calabrese, 2020) such as physics. Hattie (1999) found that computer-assisted feedback that offered students reinforcements related to learning goals was among the most effective types of feedback. Clearly, Hattie and Timperley's call for further research in the area of feedback paid off—students have been shown to benefit from elaborated feedback delivered via an online homework platform. I believe targeting

SRL behaviors among secondary physics students is an appropriate focus for this study and others in the future.

Qualitatively, feedback impact and quality have been measured with student surveys and interviews. Student interviews used to measure feedback can be analyzed for thematic elements that expose the quality of the feedback given by the teacher (Mills & Butroyd, 2014; Patton, 2002). Students have indicated that they enjoy timely, detailed feedback and have been observed to benefit from negative feedback even when that feedback is perceived in a negative way (ahmed Shafi, Hatley, Middleton, Millican, & Templeton, 2018). Feedback plays a crucial role in providing students with information that they will need to engage in self-regulating behaviors (Butler & Winne, 1995). Improving the quality of feedback given to physics students at LSCH should aid them in completing self-regulating behaviors and thus increase their student performance.

While feedback plays an important role in the self-regulated learning process, not all feedback has been shown to be equally effective. Specifically, structured feedback that is delivered soon after assessment can benefit students by being clearly relatable to grading policies, suggesting specific actions, and referring learners to think about their work in relation to the big picture of the course (ahmed Shafi et al., 2018; Vogelzang & Admiraal, 2017). If feedback is to be less structured or elaborated, feedback should not punish students for trying and failing, should promote behavior that demonstrates self-regulated learning, and may take the form of a discussion rather than discrete feedback (Chen et al., 2018; Engelke, Karakok, & Wangberg, 2016). The way in which feedback is perceived is important to its acceptance (Ilgen, Fisher, & Taylor, 1979) with factors such as the source, timing, and trustworthiness of the feedback playing key roles (Lowe & Shaw, 2019).

The impact of the various feedback types discussed above and the characteristics of their implementation directly enhance a student's ability to think critically about their own learning—the hallmark of self-regulated learning.

Measuring Feedback Quality

Measuring student perceptions of feedback quality can take the form of questionnaires, interview protocols, or written responses (Ali, Rose, & Ahmed, 2015; Gibbs & Simpson, 2003; Lowe & Shaw, 2019). These tools elicit responses from learners about the positive and negative qualities of the feedback they receive along with their thoughts regarding the environment in which they received the feedback. One such scale, a modified version of the FES (Steelman et al., 2004) is used in this study having been adjusted from use in a workplace setting to an educational one.

Feedback quality measurement tools aid researchers in the pursuit of understanding how learners engage with feedback based upon how that feedback is received and perceived.

Online Platforms and Self-regulated Learning

Online platforms not only make use of individualized homework to improve student achievement, but also to impact student SRL skills. Such impact can be enacted directly through online experiences that are explicitly meant to guide students through SRL phases or indirectly by giving students access to tools with which they can more accessibly engage their SRL skills. Both direct and indirect scaffolding are discussed in the following section.

Direct scaffolding of SRL

One way in which to improve SRL skills in an online science or math course is to directly scaffold them for students (Zepeda, Richey, Ronevich, & Nokes-Malach, 2015). A meta-analysis done by Greene et al. (2015) revealed that research interventions that directly scaffold SRL skills are common. These tools that more explicitly guide students in engaging in SRL seem to be effective in producing those behaviors (Johnson, 2019; Manlove, Lazonder, & Jong, 2007). The study by Manlove et al. involved seventy secondary physics students using an online platform in which SRL abilities were increased with an intervention that directly scaffolding SRL skills. This study takes a more indirect approach to impact SRL skills. The tools used in MP do not strongly present themselves in terms of SRL, but rather give students a set of tools and feedback with which they can engage their SRL skills.

Indirect scaffolding of SRL

SRL skills can also be impacted indirectly through students' interaction with an online platform (Cigdem, 2015). How such an online platform is implemented is important, but the features of the online platform do not necessarily have to explicitly scaffold an SRL skill to impact students' ability to engage in SRL (Azevedo, Ragan, Cromley, & Pritchett, 2002). The feedback provided to students both in the form of hints as well as analytical data such as progress, grades, and time spent on assignments can positively impact students' engagement in SRL (Van Horne et al., 2018). Van Horne et al. explored the use of such analytical feedback with 840 introductory chemistry students who were using Mastering Chemistry and an online dashboard of information drawn from student accounts. These students' use of the online platform and dashboard impacted both their performance and ability to engage in SRL. The current study seeks to further these findings by assessing whether the implementation of MP can impact secondary physics students' ability to engage in SRL by providing them with the feedback, features, and tools that such a platform provides.

Not all studies point to implementation alone being enough to impact SRL skills. The 83 biology students in Marsteller and Bodzin's (2019) study did now show improved SRL abilities after an online learning platform was implemented. The same is true of chemistry students engaged in virtual learning in a similar study (Eidelman & Shwartz, 2016). One important factor in the success of the implementation of such online homework and learning platforms is the role of feedback. Greene et al. note that "feedback is critical, because while SRL processes are a vital aspect of successful learning, they are not intuitive, and must be developed over time" (p. 100). In the case of this study, whether or not the feedback from the platform alone is enough to impact SRL skills among secondary physics students is being investigated.

Chapter Summary

Online homework platform features seem to be tools that are likely to promote students' SRL behaviors, particularly if students receive quality feedback, and perceive it as such, from the platform. Self-regulated learning describes the degree to which students are thinking about their own learning before, during, and after completing cognitive tasks. SRL is supported by a vast body of empirical research across multiple models. Improving SRL among secondary physics students can have positive results and this improvement can likely be achieved through the implementation of an individualized online homework platform. SRL behaviors can be observed through formal questionnaires and interview protocols alike. Though the use of individualized online homework in improving student achievement does have some shortcomings, the benefits of using individualized online homework, particularly in the area of promoting self-regulatory behaviors, seem to outweigh the downfalls. Individualized, online homework platforms have been shown to improve feedback quality. Feedback is a critical component of promoting self-regulatory behaviors in students and its quality can be measured both quantitatively in the form of questionnaires and qualitatively in the form of interviews. Traditional homework does not appear to be able to offer me the same kinds of opportunities to provide prompt, elaborated feedback to my students as does an online homework platform such as the one implemented in this study. This study makes use of the features and feedback provided by MP indirectly by simply implementing MP without giving students direct instruction on engaging SRL. Within the context of the literature, it has value in that it is taking place with secondary physics students in a rural context and that it seeks to further our understanding of how SRL skills are impacted through the feedback and features of MP while also exploring student perceptions regarding feedback quality.

CHAPTER 3

METHOD

Research Design

In this study, I collected and analyzed data regarding teaching and learning from the local context of the high school where I work. Action research describes what I completed in this study well, having been defined as:

> any systematic inquiry conducted by teachers, administrators, counselors, or others with a vested interest in the teaching and learning process or environment for the purpose of gathering information about how their particular schools operate, how they teach, and how their students learn (Mertler, 2017, p. 4).

The difference between traditional research and action research lies primarily in the audience and purpose of the research. Action research differentiates itself from traditional research in that better attention can be paid to the nuances of the environment in which the research is taking place since the researcher is usually well integrated into the surroundings (Mertler, 2017). Mills and Butroyd (2014) point out that traditional research is often hard to complete in a real-world academic setting due to the lack of control that the researcher has on the multiplicity of variables involved in such a setting. This lack of control gives rise to the flexibility that an action researcher must have in terms of data collection methods and analysis in order to have a greater impact on the environment in which the research is taking place (Creswell, 2014).

The pragmatism with which I am approaching this study also pairs well with action research. Epistemologically, action research aligns with pragmatism's marriage of reality with results, with real-world action. Perhaps the best illustration of this is the limited scope of action research. At first glance, the boundaries of local contexts, specific problems, and purposefully sampled participants may seem to weaken action research's applicability to advancing the field of educational research (Brydon-Miller, Greenwood, & Maguire, 2003). However, these boundaries are, in fact, what makes action research so good at solving localized problems and providing very real progress for the people in those locales (Greenwood & Levin, 2007).

The problem of practice that this study seeks to shed light on is directly benefited from the format of action research. Since the problem is experienced by local teachers, one of these teachers completing the research should make the results highly applicable. I, as the researcher, will be able to communicate to my school and district colleagues in a more relatable way having completed the research from within my own classroom. This kind of collaboration is in the very nature of action research and has the benefit of impacting many students with the results. Not only will my future students be benefited, but also the future students of my colleagues.

In addition to benefiting students and teachers, action research benefits me as a researcher because of its cyclical nature of improvement. Action research is much less a linear line with a distinct start and finish, and more like a circular path of data collection, adjustment, and improvement over time (Mills & Butroyd, 2014). The goal in action research is a demonstrable improvement in the environment that is the focus of the research even if that means figuring out what does not work along the way (Mertler, 2017; Mills & Butroyd, 2014). This kind of continuous improvement coupled with the highly applicable, local impact of action research makes it the best research format for this study.

My research design for this study can be categorized as a mixed-methods approach, employing both quantitative and qualitative data collection methods (Clark & Ivankova, 2015). Using a mixed-methods approach helped me answer both research questions that each look at a different way that an individualized homework platform can impact students. I used a triangulation analysis approach (Mertler, 2017) in this study. Triangulation relies on the independent analysis of quantitative and qualitative data to see if a similar conclusion can be reached from each data type. I compared my quantitative data with my qualitative data separately, to see if they were pointing toward a common result (Creswell & Clark, 2017). When both quantitative and qualitative data confirmed each other in my findings, an added strength of using a mixed-methods approach, I had increased confidence in the results of both types of data (Rudestam & Newton, 2014). I selected a mixed-methods approach for this study to maximize the amount of data that I was collecting, so as to minimize gaps in my understanding of the data, and thus, craft more complete answers to my research questions (Clark & Ivankova, 2015; Morgan, 2013; Patton, 2002).

Setting and Participants

This research took place in my honors physics classroom within the science department at LSCH in Simpsonville, SC. I am currently the only physics teacher at LSCH. LSCH is one of the largest schools GCSD, enrolling over 2,000 students each year. LSCH supports teachers in their use of technology in the classroom by offering multiple professional development opportunities during the school year and in the summer. In addition to these school-level professional development opportunities, LSCH teachers enjoy the benefits of district-wide and content-level professional developments throughout the school year and summer as well.

During the 2017-18 school year, LSCH began a technology program in which every student received a Chromebook for use at school and at home. In addition to this increase in the number of devices, LSCH has recently increased the internet bandwidth at the school. In addition to better internet access at school, GCSD began to provide wireless internet access on all the school buses in the district. As a result, LSCH students all have internet access at school, and most have access outside of school as well. These initiatives make LSCH an ideal setting for my research which required participants to have appropriate devices as well as regular access to the internet.

I teach various levels of physics (e.g., College Placement, Honors, and Advanced Placement) but I conducted this research with an Honors Physics class. This course covers Newtonian mechanics, mechanical energy, waves, and electricity and magnetism. During the fall of 2019, when this study was being carried out, Newtonian kinematics and dynamics, were the units being covered. The course is not an online course, but the course takes advantage of each student having a school-issued Chromebook by incorporating numerous virtual labs and simulations. Each student having a Chromebook allows me to make use of powerful graphing software, educational videos, and an array of sensors that connect to student devices. Our school uses the Google Classroom learning management system through which I deliver electronic content to my students.

For this study, I used the intervention of an online homework platform during a unit on kinematics and dynamics, a subset of Newtonian mechanics.

The participants in this study were 14 students from my Honors Physics class. Six of them were 12th grade students and eight were 11th grade students. The participants ranged in age from 16 to 18 years old with the mean age being 16.7 years old. These participants represent a purposive sample since I am their physics teacher, selecting only participants from my own classes (Creswell, 2014; Patton, 2002). Participants gave informed consent for this data collection at the very beginning of the study, prior to any data collection. Appendix A shows the informed consent form that was distributed to participants and Appendix B shows the University of South Carolina's internal review board letter of approval. All 14 participants signed the informed consent document. According to my personal grade book records, students in my Honors Physics class was 50% female (n = 7) and 50% male (n = 7). White students made up 71% (n = 10) of my honors classes with African American students making up the remaining 29% (n = 4) of students.

Academically, my students have completed honors Algebra II as a pre-requisite to honors physics. Most of my honors students take pre-calculus or another advanced math course while enrolled in physics during their junior or senior year.

My students had limited prior exposure to an online learning platform similar to MP. They will have had much exposure to online classroom management systems such as Google Classroom, Edmodo, or Moodle, but they have not had much prior experience with the kind of individualized assignments given by MP.

While all students (n = 14) consented to participate in the study, one student was unable to participate in the focus group interview due to a school athletic competition. Table 3.1 shows student pseudonyms aligned with gender, grade level, and ethnicity.

Table 3.1 *Student pseudonym and demographics alignment*

Student Pseudonym	**Gender**	**Grade Level**	**Ethnicity**	**Focus Group Number**
Roger	Male	11	White	1
Hannah	Female	11	White	1
Oliver	Male	12	White	1
Jack	Male	11	White	1
Jamara	Female	12	African-American	1
Theresa	Female	12	African-American	1
Sarah	Female	11	African-American	1
Larry	Male	12	White	2
Mikayla	Female	11	White	2
Peter	Male	11	White	2
Jackson	Male	11	White	2
Nathan	Male	11	White	2
Jane	Female	11	African-American	2
Rachel	Female	12	White	N/A

Note: Students are ordered by their order of speaking in their respective focus groups.

Intervention

I implemented an individualized online homework platform, MP, over the course of six weeks in the Fall of 2019. This action was justified by the ease of use, individualizable nature of MP, and district-wide access. MP provided immediate, elaborated feedback to students from a secure platform. Both MP and the device, a Chromebook, from which to access MP was provided to the participants.

In order to better understand the action taken in this study, it is important to first understand a little bit about how my physics class typically works. As a physics teacher, it is my duty to provide formative assessments to my students that help me and my students to gauge their understanding. Often, I have assigned paper and pencil assignments for which I am unable to provide elaborated feedback to each and every learner. Typically, I am only able to tell students whether their answers are right or wrong. While this feedback is immediate—in the form of a list of random, dimensionless correct answers—it does not provide students with any sort of elaboration or even a comprehensive list of answers. The action I took in this study, was to implement an online homework platform, MP, for six weeks in the Fall of 2019. This platform, a Pearson product, is a subscription-based website that was specifically designed to assess physics knowledge.

Using MP in my classroom was justified for several reasons. First, its ease of use both for students and teachers makes it an efficient way of turning in, grading, and returning homework. Students were able to check on their assignment status at any time. In addition, MP is highly individualizable for each student so that no two students ever receive the exact same assignment. MP not only assigns random question variables to students, but it also provides immediate, elaborated feedback that allows students to be given feedback that is unique to them. This kind of computer-assisted feedback has been found to be highly effective at improving student performance (Hattie, 1999). This impact is likely due to immediate, elaborated feedback's ability to promote self-regulated learning in students. Self-regulated learning was promoted by this feedback because it engages students in all three stages of self-regulated learning—planning, performing, and reflecting.

Immediate, elaborated feedback helps students in the planning stage of self-regulated learning by giving them the confidence to start an assignment even if they do not feel that they have complete mastery of the material. Knowing that they will be able to gauge their understanding of the material immediately upon starting the assignment can help students take the first step in completing an assignment. In the performing stage, the benefits of immediate, elaborated feedback are obvious. This type of feedback alerts students to possible misunderstandings they may have and points them toward a solution to correcting it without giving away the answer. This is precisely what I do with my student when giving them feedback in person. MP can also benefit students in the reflection stage of self-regulated learning as they have much easier access to all of their previous work. They can go back and review questions they have missed, see their progress over time, and view explanations and worked out solutions that they could not see in their immediate feedback. Table 3.2 summarizes how the immediate, elaborated feedback promotes self-regulated learning in students.

My school district uses a Pearson physics textbook that comes with a subscription to MP. This subscription allowed my students to freely access MP during this study. MP is typically applied on the college level (Caballero et al., 2012; Kortemeyer, 2015) in a variety of formats. The use of this platform was chosen not only to help my students within the context of my class but also to prepare them for the almost certain use of online homework platforms in future college courses. To help students learn how to use the MP platform I taught them a short, didactic overview lesson about the basics of using MP as well as an orientation assignment that allowed them to practice inputting their answers and receiving feedback. The orientation assignment was reviewable, and students were only held accountable for its completion. Figure 3.1 shows a sample of orientation instructions.

Table 3.2 *Alignment of MP Features with Impact on SRL*

Feature in MP	**Targeted SRL phase (Zimmerman, 2000)**	**Targeted SRL skills (Zimmerman, 2000)**	**How feature promotes self-regulated learning stage**
Immediate Feedback	Planning	Strategic Planning Self-efficacy Outcome expectations	Provides confidence to start assignments and knowledge on whether help is needed. The previous assignment can also help students plan for how much time is needed for the assignment.
Elaborated Feedback	Performance	Self-instruction Task Strategies Self-recording	Allows students to understand why their answers are incorrect during the assignment rather than just afterward.
Record of progress and worked out solutions	Reflection	Self-evaluation Causal attribution Adaptive	Gives students a record of their achievement including time spent and scores of previous assignments. More detailed, worked-out solutions are also provided to deepen students' understanding of their errors.

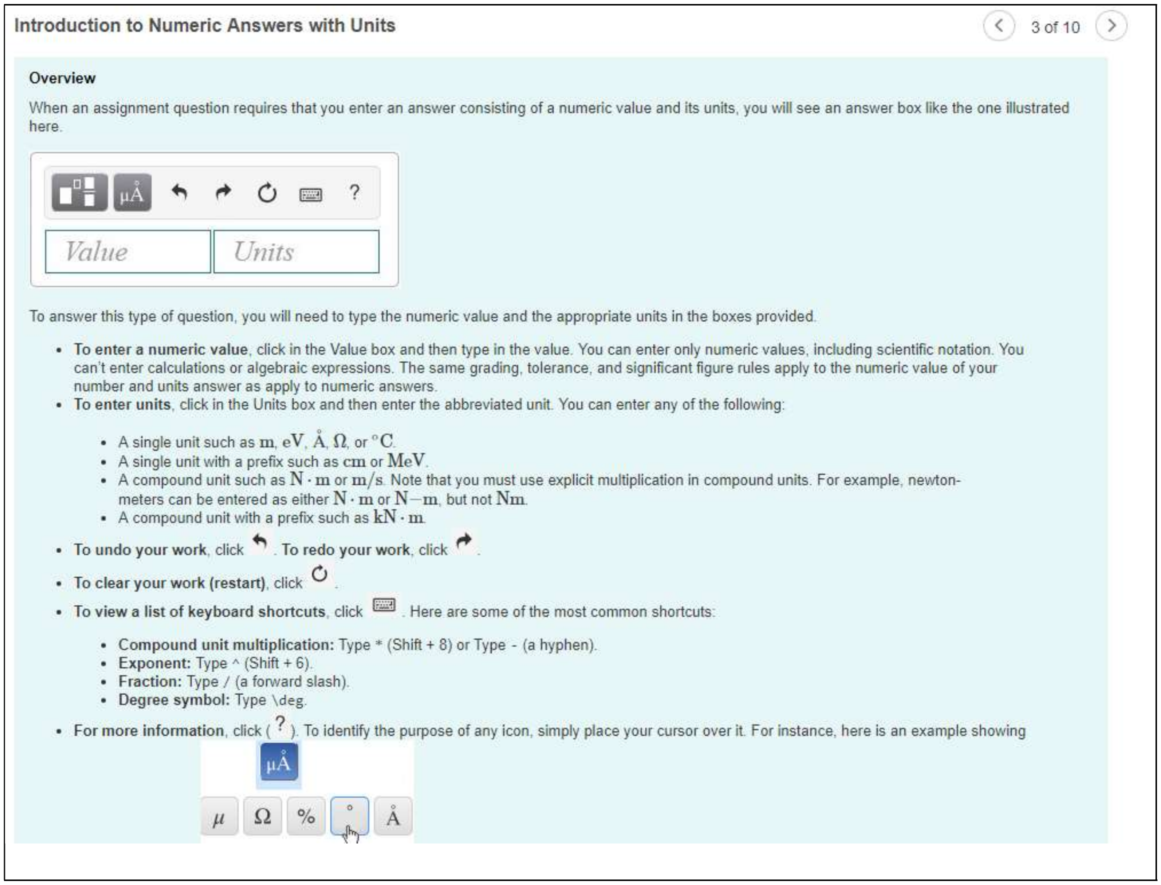


Figure 3.1. An example of MP orientation instructions.

I used six homework assignments that assess student understanding of Newtonian mechanics—specifically kinematics and dynamics. Each assignment was accessible to students at the beginning of the week with a subsequent due date at the end of the week. This due date was a recommendation, but students were only penalized if they did not have the assignments done by the end of the six weeks. The assignments were released one at a time each week but were retroactively accessible for the duration of the study. In developing my teacher-made homework assessments, I drew from a bank of open-ended textbook physics questions (Etkina, Gentile, & Van Heuvelen, 2014). The assignment questions were assembled, but not written, by me. Students were given questions that required them to have both a conceptual and mathematical understanding of combinations of position, distance, displacement, velocity, speed, acceleration, mass, and force. Each homework assignment contained five, equally weighted, untimed, free-response questions and was individualized for each learner through the randomization of problem variables. Students received questions that were nearly identical with the exception that certain variables in each question had been randomized so that each student received a unique question. For example, one student may have received a question that said, “A ball is traveling at 6 m/s . . .” while another student may have received that same question as “A ball is traveling at 4 m/s . . .”. Figure 3.2 shows an example question with a randomized velocity variable. Appendix C contains each homework assignment in full.

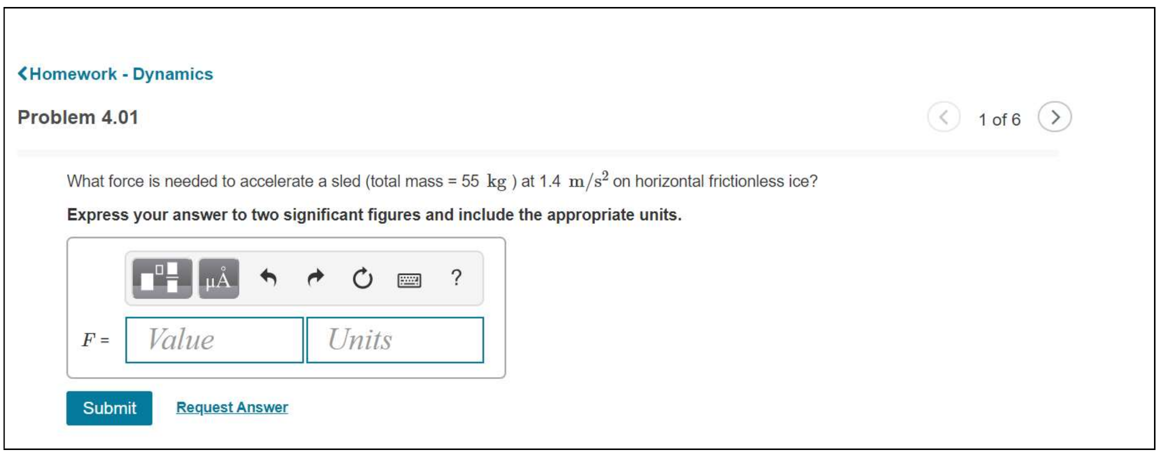


Figure 3.2. An example of an MP homework problem.

MP assignments provided immediate, elaborated feedback to students as they are completing assignments. Students knew immediately if they have answered correctly and be might given a short explanation for why their answer is incorrect. For example, a student may input a correct response without the correct units. MP will inform that student that he or she has provided the correct numerical value, but that it contains the wrong dimensions. I plan to allow each student five attempts to get the answer correct, as recommended by Kortemeyer (2015), to strike a balance between promoting concept mastery (having many tries) and limiting guesswork (having few tries). Figure 3.3 shows the kind of immediate, elaborated feedback that a student might receive after an incorrect response. Table 3.3 shows a list of the possible kinds of elaborated feedback that students might receive to a particular answer. For these questions, answers were considered correct if they are within 2% of the correct response. For example, if the correct response for a question was 100, then MP would consider any number between 98 and 102 as correct.

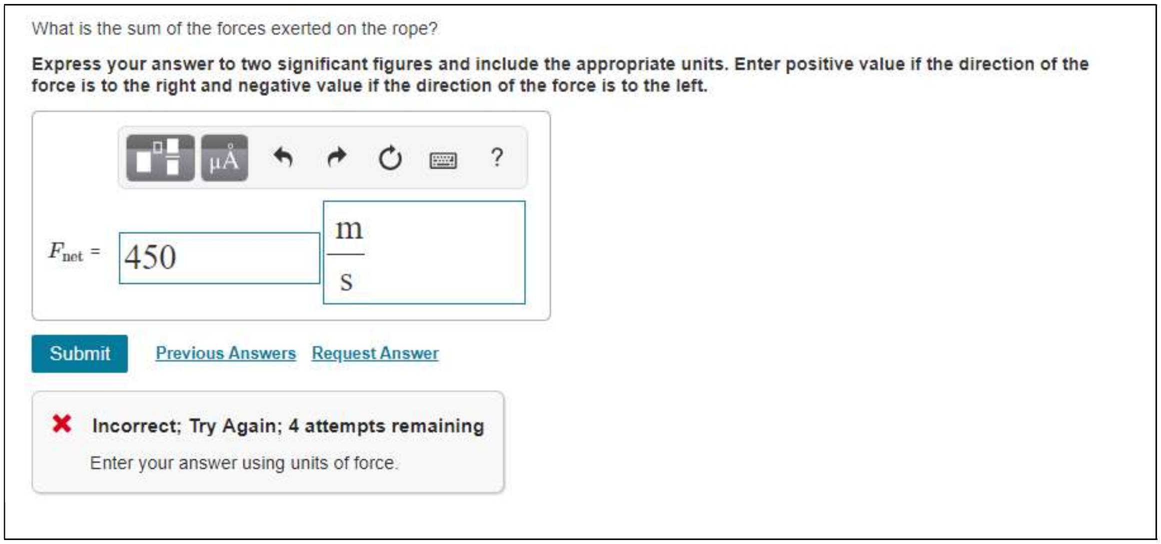


Figure 3.3. Immediate, elaborated feedback that a student might have received.

Table 3.3 *Types of Elaborated Feedback that Students may Receive*

Correct Answer	Sample Incorrect Response	Examples of Feedback Types
450 N	450 m/s	Enter your answer again using units of force.
450 N	300 N	Incorrect, Try Again
450 N	450.12345 N	Review your calculations; you may have made a rounding error or used the wrong number of significant figures.

The problem variable randomization provided by MP helps to eliminate more traditional forms of cheating by forcing students to answer unique questions. They cannot simply ask someone else what the answers are, and if they did, they would get those answers wrong. Instead, they would have to inquire about how to find the answer rather than just what the answer is. This type of system has been found to prevent cheating even when many students are participating in academic dishonesty (Basitere & Ivala, 2017; Busch, 2017).

To access the MP platform, students used their school-issued Chromebooks or other personal devices and logged on with an access code that I provided at the beginning of the study. Students needed to use either a public or home internet connection while accessing the assignments. These requirements were discussed during the participant orientation.

Each homework assignment was aligned to a South Carolina Science standard for a Physics 1 course. Some assignments aligned with multiple standards as can be seen in Table 3.4.

Table 3.4 *Weekly Intervention Activity and Standard Alignment Table*

Week	**Lesson Topic**	**Activity**	**South Carolina Physics 1 Standard**
Week 0	Introduction	Mastering Physics student orientation assigned with 1 week to complete.	N/A
Week 1	Introductory Kinematics—Defining displacement, velocity, and acceleration.	Homework Activity 1 assigned and completed by participants.	H.P.2A.3 Use mathematical and computational thinking to apply formulas related to an object's displacement, constant velocity, average velocity, and constant acceleration. Interpret the

Week	Lesson Topic	Activity	South Carolina Physics 1 Standard
			meaning of the sign of displacement, velocity, and acceleration.
Week 2	One-dimensional kinematics problem-solving skills and introduction to object in free fall.	Homework Activity 2 assigned and completed by participants.	H.P.2A.3 Use mathematical and computational thinking to apply formulas related to an object's displacement, constant velocity, average velocity, and constant acceleration. Interpret the meaning of the sign of displacement, velocity, and acceleration. H.P.2D.10 Use mathematical and computational thinking to apply $F_{net} = ma$ to analyze problems involving non-contact interactions, including objects in free fall.
Week 3	Introduction to Dynamics	Homework Activity 3 assigned and completed by participants	H.P.2B.2 Use a free-body diagram to represent the forces on an object. H.P.2D.10 Use mathematical and computational thinking to apply $F_{net} = ma$ to analyze problems involving non-contact interactions, including objects in free fall.
Week 4	Strategies for Solving Dynamics Problems	Homework Activity 4 assigned and completed by participants	H.P.2C.3 Obtain and evaluate information to compare kinetic and static friction H.P.2C.5 Use mathematical and computational thinking to apply $F_{net} = ma$ to analyze problems involving contact interactions and gravity.
Week 5	Dynamics problems involving multiple forces and the resulting motion	Homework Activity 5 assigned and completed by participants	H.P.2C.3 Obtain and evaluate information to compare kinetic and static friction H.P.2C.5 Use mathematical and computational thinking to apply $F_{net} = ma$ to analyze problems involving contact interactions and gravity.

Week	Lesson Topic	Activity	South Carolina Physics 1 Standard
Week 6	Physics investigation practices involving dynamics	Homework Activity 6 assigned and completed by participants	H.P.2C.5 Use mathematical and computational thinking to apply $F_{net} = ma$ to analyze problems involving contact interactions and gravity. H.P.1A.6 Construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.

MP is a secure website that, according to their security policy, is compliant with the Family Educational Rights and Privacy Act (FERPA) as well as the Children's Online Privacy Protection Act (COPPA) ("Pearson Privacy Policy," 2018).

I reviewed homework assignments with students weekly after assignments were due. In addition, midway through the study, I began to offer MP assignment overviews. These overviews were a sort of a preview of the assignments that simply noted which concepts in class the assignment would focus on. MP kept a live record of student responses as they progressed, so students did not need to submit the assignment as a whole, but rather submitted each attempt to each question as they moved through the assignments. Students were allowed to answer the questions in any order they chose, although some questions did require answers from previous questions in order to solve them. A late assignment penalty was automatically implemented by MP when students submitted an assignment past the deadline each week, but I set up MP in such a way so that even though students were penalized for late work, it was always beneficial to their grade to turn in an assignment no matter how late it was turned in. I chose this format to encourage students not to give up on an assignment just because they missed the deadline.

Data Collection

In this study, both quantitative and qualitative data were collected. Quantitative data from the Online Self-Regulated Learning Questionnaire (OSLQ) and Feedback Environment Scale (FES), were collected to measure students' SRL skills and their perceptions on the quality of feedback that MP was providing. Each of these measures was delivered to the participants with Google Forms, an online survey tool. Qualitatively, student focus groups were conducted to further establish SRL skills and student perceptions of the quality of feedback MP was providing. Table 3.5 shows the research questions of this study aligned with data sources.

Table 3.5 *Research Question and Data Source Alignment*

Research Question	Data Source
R1. How and to what extent does the implementation of individualized online homework and feedback impact self-regulated learning among Honors Physics high school students?	Focus Group Interviews OSLQ
R2. How does the implementation of individualized online homework impact students' perception of the feedback quality provided by an individualized online homework platform?	Focus Group Interviews FES

Quantitative Data

OSLQ. The OSLQ was designed to measure student self-regulated learning in courses that are completely, or in part, offered online (Barnard et al., 2009). My course was not considered to be a completely online course, but using MP as an online homework platform makes this measure appropriate for my class. The OSLQ contains 24 items ranked on a Likert-type scale from strongly agree (5) to strongly disagree (1). The OSLQ measures self-regulatory behaviors on these six subscales: 1) environment structuring, 2) goal setting, 3) time management, 4) help seeking, 5) task strategies, and 6) self-evaluation. The original OSLQ questions were worded for courses that are mainly offered online, so a modified version of the items as needed was used to better fit the context of my course and this study. The modifications mainly involved removing the word “online” from the items that reference the course that students were taking. An example question from the modified OSLQ on the goal setting subscale reads, “I set goals to help me manage studying time for my courses.” The original OSLQ questions and their modifications for this course can be viewed in Appendix D. The OSLQ pretest was administered in this study on September 26th, 2019 with all participants (*n* = 14) completing the questionnaire on that day. All participants completed the OSLQ posttest on November 25th, 2019. The internal consistency of scores on the OSLQ is reported to have an alpha level of .90 with subscale Chronbach’s alpha ranging from .67 to .90 (Barnard et al., 2009). The construct validity of the measure was confirmed with confirmatory factor analysis that included confirmations from chi-square, chi-square ratio to degrees of freedom, root mean square error of approximation, Non-Normed Fit Index, and Comparative Fit Index analyses.

FES. An adapted version of the FES (Steelman et al., 2004) was used to assess students’ perceptions of feedback quality. Instead of modifying the FES to fit teacher feedback quality as Borup, West, and Thomas (2015) have done previously, I modified it to suit the feedback quality provided by MP. Each of the five items in the modified FES was scored on a Likert scale that ranged from (1) strongly disagree to (7) strongly agree.

Steelman et al. reported the internal consistency reliability of the FES questions as .92 and the test-retest reliability as .64. Steelman et al. also reported the concurrent validity of the measure used in this study as .76 with a predictive validity of .67. An example question from the modified FES reads, "Mastering Physics gives me useful feedback about my homework performance." Appendix E shows the original FES questions along with the modifications made for this study. The FES was administered in this study on September 26th, 2019. All participants (n = 14) completed the questionnaire on that day.

Qualitative Data

Focus Group Interviews. Interviews can be a powerful tool in qualitative research (Creswell, 2014). I used a semi-structured focus group interview format (Mertler, 2017) that allowed me to ask the participant interviewees a series of consistent, foundation questions while also giving me the freedom to ask additional questions as needed to get a clearer picture of what the respondents actually meant or to probe for additional relevant information. These focus group interviews allowed me to gain insight into what my students thought and felt (Mills & Butroyd, 2014; Patton, 2002) about their engagement in SRL and their perception of the quality of feedback given to them by MP. Figure 3.4 shows a sample focus group question. The full focus group interview protocol and its alignment with the research questions of this study can be found in Appendix F.

3. Tell me how you go about completing the MP homework assignments?
    a. Can you give me examples of what happens when you get the answers right?
    b. Can you give me examples of what happens when you get the answers wrong?
        i. When you get an answer wrong, do you read the feedback text generated by MP? Why or why not?
        ii. Does using MP make you more careful in crafting your answers? Why or why not?

Figure 3.4 Sample Focus Group Question

Since these thoughts and feelings were not directly observable, the focus group interviews enabled me to delve into the student experience and extract a deeper understanding than could have been gotten with a survey alone (Mertler, 2017). This particular format was chosen for its ability to stimulate quality conversations and elicit a wide range of views in a small amount of time (Mack, Woodsong, MacQueen, Guest, & Namey, 2005). I conducted and recorded two focus groups with the interviewees being selected randomly from the honors physics course that I taught during the 2019-2020 school year. The focus groups were approximately 45 minutes long and occurred after students had completed the dynamics unit of my honors physics course and completed the posttests associated with this study. The focus groups addressed how MP had impacted students' ability to engage in SRL behaviors and their perceptions of the quality of feedback given to them by MP regarding their homework. The focus group interview protocol and its alignment with the research questions of this study can be found in Appendix F.

Data Analysis

The data that I obtained for this research came from a variety of sources both quantitative and qualitative. I treated the analysis of this data from a triangulation mixed-methods (Mertler, 2017) point of view so that both the quantitative and qualitative data are treated similarly in their weight and collection sequence. In this way, I hoped to maximize the strength of my research by employing the unique advantages of each method (Best & Kahn, 2006; Creswell, 2014). Table 3.6 shows which sources of data I plan to use in answering each of my research questions along with how I analyzed that data.

The variables that I have measured were selected to identify whether or not the implementation of an individualized, online homework platform can enhance the SRL skills that a student already possesses by making it easier to engage in SRL behaviors through access to quality feedback. Suppose, for example, that a student is completing a traditional physics homework assignment by answering questions out of a book with paper and pencil. Often, that student would not know whether their answers were correct until they receive their grade. This is often much later in time and sometimes all they can tell is whether the answer is right or wrong. Not only is it harder for the student to engage in SRL in this scenario, but it is also harder for the teacher to provide the kind of feedback that would help the student engage in SRL behaviors. Now consider if that same student were given an immediate, elaborated feedback response such as "Your answer is incorrect, please consider units of measurement". Even though that identical student possesses equal SRL skills, I believe they are more likely to use those skills in the second scenario because of the feedback they have received. This is how this study uses the data I have collected to answer my research questions.

Table 3.6 *Research Question, Data Source, and Data Analysis Alignment*

Research Question	Data Source	Data Analysis
R1. How and to what extent does the implementation of individualized online homework and feedback impact self-regulated learning among Honors Physics high school students?	Focus Group Interviews OSLQ	Descriptive Statistics (mean, median, standard deviation) Inferential Statistics (paired t-test) Inductive analysis
R2. How does the implementation of individualized online homework impact students' perception of the feedback quality provided by an individualized online homework platform?	Focus Group Interviews FES	Descriptive Statistics (mean, standard deviation) Inductive analysis

Quantitative data

Two sources of quantitative data were analyzed in this research study: OSLQ (Barnard et al., 2009), and FES (Steelman et al., 2004).

Surveys Instruments. The OSLQ and FES are Likert-type surveys that were analyzed descriptively using the statistical software Jasp to tabulate responses and calculate the mean, median, and standard deviation of the pretest and posttest responses.

Jasp was also be used to run a paired sample t-test (Salkind, 2010) to analyze the pretest and posttest results with an alpha level of .5 on the OSLQ.

Qualitative data

The qualitative data for this study were drawn from two focus group interviews that I conducted with two groups of students in my honors physics classes. These interviews were approximately 45 minutes in length during which time field notes were also being taken. The interviews were audio-recorded and transcribed. After transcription, the qualitative analysis software Atlas.ti was used to code the documents into codes and categories which were then developed into themes. The focus groups were inductively analyzed (Creswell, 2014; Mertler, 2017; Patton, 2002) through a process of taking small pieces of the text and building them into larger categorical and thematic ideas. After coding, Atlas.ti was again used to tabulate the codes and group them into meaningful categories with the help of Microsoft Excel (Meyer & Avery, 2009). These categorized codes along with the interview field notes and excel spreadsheets were developed into a few themes that helped me to answer my research questions. This data was formatted graphically to help me inductively take the small, coded qualitative data and build it into larger, more descriptive themes (Patton, 2002). Extensive quotations and textual evidence were used to support these themes. Evidence from interviews as well as clear category descriptions is also provided to further support the development of thematic answers to the research questions. This qualitative analysis enabled me to provide thick, rich descriptions of the qualitative data and functioned in concert with my quantitative analysis to provide me with a clearer understanding of the impact of an online homework platform in an honors physics classroom.

The quantitative data and qualitative data were analyzed independently and combined into a cohesive description of the intervention's impact. After data was collected and analyzed, I looked for areas in which the two types of data overlapped and point to similar conclusions. These areas of similarity became the most salient evidence in my conclusion.

Procedures and Timeline

I conducted this study in four phases over the course of 25 weeks beginning in the Fall of 2019 and continuing until the Spring of 2020. During each phase, I reassessed my timeline to ensure that I had enough time to collect and analyze my data. Phase 1 focused on participant identification and orientation. Phases 2 and 3 focused on data collection and analysis. Finally, Phase 4 focused on member checking and communication of my findings. Table 3.7 shows a summary timeline of my actions.

Table 3.7 *Timeline of Planned Actions*

Phase	Planned Actions	Time
Phase #1 Establishing Participants	1. Identify Participants 2. Deliver Consent/Assent forms 3. Obtain Participant Consent/Assent from collected forms 4. Online Homework Platform Orientation	5 Weeks
Phase #2 Collecting Data	1. Administration of pretest (OSLQ) 2. Delivery of six MP assignments. 3. Administration of posttests (OSLQ and FES) 4. Conduct 2 focus group interviews	8 Weeks
Phase #3 Analyzing Data	1. Score OSLQ and FES 2. Perform descriptive statistical analysis on OSQL and FES. 3. Performed inferential paired t-test on OSLQ. 4. Transcription, coding, and inductive analysis of student interviews	8 weeks
Phase #4	1. Present results to participants	4 Weeks

Communicating Results	2. Member checking 3. Present results to school administration and science department 4. Submit a proposal to present findings at the AECT conference

Phase 1

Phase 1 started in the fall of 2019. I began by identifying the participants of this study. I sought participants from my honors physics class in a large South Carolina high school by presenting my study during the first week of classes of the 2019-20 school year. After I had identified potential participants, I delivered consent/assent forms to be taken home with them. Each form clearly described the study and requested both parental and student signatures. Once consent and assent were obtained, I gave students an orientation of the intervention tool—an online homework platform, MP. This orientation walked them through their role in the study and its purpose. In addition, I assigned participants an orientation assignment from MP that explained how to use the system, input responses, and troubleshoot problems. Phase 1 took about five weeks to complete.

Phase 2

To begin phase 2, I administered the OSLQ as a pretest followed by six MP assignments delivered over the course of six weeks. This allowed students one week to complete each assignment. The week after the MP assignments were finished, I administered the OSLQ posttest and the FES and began conducting two focus group interviews over the course of two weeks. The focus groups did not begin until the OSLQ posttest and FES had been completed.

Phase 3

I started Phase 3 by scoring the OSLQ pretest and posttest and the FES. Each MP assignment was computer-graded as students completed each question during Phase 2. Along the way, they were given immediate, elaborated, and question-specific feedback about their performance. I also began transcription and coding of the two focus group interviews after scoring the instruments. My goal was to have all the transcriptions and coding in place during the first four weeks of this eight-week phase. The remaining four weeks were used to perform inductive analysis of the student interview transcripts.

Phase 4

In addition to communicating with my USC doctoral committee, I also had planned on performing a thorough member checking with my students. However, COVID-19 closures prevented me from having complete member checking performed on my findings, and I was only able to allow my students to review the transcription documents to ensure that their words were accurately ascribed. I have also been accepted to present the findings of this study at the AECT conference in the fall of 2020.

Rigor and Trustworthiness

This research study utilized both qualitative and quantitative data collection methods. In order to ensure the validity and reliability of these methods and their analysis, I employed specific practices to strengthen the tie between my data collection, results, and reality (Mertler, 2017). This included the use of triangulating the data, taking advantage of my prolonged exposure to the research site, member checking, peer debriefing, and thick, rich description.

Triangulation. Triangulation is a process of using multiple, diverse sources of data to inform the results of a study, and plays a valuable role adding credibility to my research (Patton, 2002). This method of ensuring rigor and trustworthiness helped my research by not allowing any one data collection method to weigh too heavily on the results. Mertler (2017) points out that triangulation is inherently present in a mixed-methods study due to the varying types of methods used. In this study, multiple data collection methods, both quantitative and qualitative, were used to inform the findings. The quantitative data includes the administration of the OSLQ and the FES, while the qualitative data was drawn from student focus group interviews.

Member checking. Member checking was supposed to play a larger role in establishing trustworthiness in this study than was able to be accomplished. Member checking was supposed to involve participants in the study in confirming my analytical conclusions (Mertler, 2017; Shenton, 2004). Due to COVID-19, I was unable to have member checking performed on my analytical findings and was only able to have members check the data in the form of transcripts from the focus groups.

Peer debriefing. Peer debriefing is the process of giving the research to another individual before the final report is completed so as to gain perspective and catch errors (Mertler, 2017). This strategy helped me to present a clearer picture of my findings by having those findings challenged and clarified through the inquiry of my dissertation chair, Dr. Arslan-Ari (Creswell, 2014).

Thick, rich description. Thick description is detailed writing in which a researcher seeks to communicate, in writing, an accurate portrayal of what happened during the research process (Creswell, 2014). So powerful is this detailed description, which includes participant quotations, that Patton (2002) claims it is "the foundation of qualitative reporting" (p. 503). Such description helped me to use words to paint a precise picture of the research process and incorporate the viewpoints of myself and my participants. This description serves to promote understanding on the part of the reader in convincing them of the validity of the results (Shenton, 2004).

Plan for Sharing and Communicating Findings

Sharing the design, method, and results of this study is an important practice for furthering strengthening the body of knowledge in the field of education. Sharing details about the study aids this free flow of ideas by allowing others to make judgment calls about the quality of the study for themselves (Creswell, 2014). Informing others of the study and then receiving feedback from them may also help to raise new questions, inspire new areas of research, or solve existing problems. I will share the design, method, and results of my study with my future students, in the form of an interactive lecture, my colleagues, in the form of a professional development, and my principal in the form of a one-on-one meeting. Finally, I will present my findings at the 2020 AECT conference where my presentation has already been accepted.

I had originally planned on sharing the findings of my research with my student participants when the study is complete. COVID-19 and its large impact on my school district have prevented that from occurring. Instead, I am planning to share the results with my future students to inform them of how their voices are being heard and acted on. These findings will be delivered in the form of a short, in-class presentation after which I will invite discussion about the study. I plan to present the findings this way so as to hear my students' reflection upon the study and its findings. This two-way communication furthers the action research cycle and will perhaps lead me to include additional recommendations to my principal and perhaps uncover new problems to study for the future.

In addition to sharing my findings with students, I plan to share these results with my colleagues in the science department at LSCH through a departmental professional development offering. My department head is highly supportive of a collaborative department atmosphere and has encouraged departmental professional development. I believe that my colleagues would benefit greatly from hearing the results of this study considering our school's transition to using personalized learning devices during the 2017-18 school year. Their feedback would also serve to further the action research cycle in helping me to uncover more problems and inspire them to solve problems of their own. Their feedback will also help me present my findings to our school principal, Dr. Bryan Skipper. To this end, I have already begun to work with our instructional coach on scheduling this professional development opportunity.

I plan to present the findings of this research to my principal in a one-on-one meeting in which I will walk him through my findings and their implications for my classrooms and the classrooms of my colleagues. This meeting will serve to spark new ideas between us in enhancing the learning experience of each student.

In addition to sharing my findings on the local level, I plan to share them at the 2020 national AECT conference. I have already proposed a presentation on these findings as a collaboration between Dr. Asrlan-Ari and myself. The proposal has been accepted and we plan to present in October of 2020.

Sharing the results of a study is an important aspect of the action research process, but the potential threat of a breach of confidence is ever-present. To thwart any inappropriate sharing of participant information, I plan to withhold all the names of my participants including blacking out their names on turned in work, the use of pseudonyms on transcript conversations, and redacting email addresses included in their login information that may be present on any presentation material.

CHAPTER 4

ANALYSIS AND FINDINGS

The purpose of this action research was to evaluate the impact of MP, an individualized online homework platform, on students' self-regulated learning skills and perceptions of feedback quality. This research aimed to answer the following research questions: 1) How and to what extent does the implementation of individualized online homework and feedback impact self-regulated learning among Honors Physics high school students? and 2) How does the implementation of individualized online homework impact students' perception of the feedback quality provided by an individualized online homework platform? The qualitative and quantitative data collected in this study were carefully analyzed according to the details explained in this chapter. Quantitative findings of the two instruments used in this study are discussed first followed by a description of the qualitative analysis method employed. Finally, qualitative findings are presented in three themes.

Quantitative Findings

The FES and OSLQ were used in this study to measure students' perceptions of feedback quality and SRL behaviors respectively. The following section presents the results of these measures.

FES

A modified version of the FES (Steelman, et al., 2004) was administered to assess students' perceptions of feedback quality from the MP homework platform. The FES consists of five items scored on a seven-point Likert type scale that ranged from (1) strongly disagree to (5) strongly agree. The survey was administered one week after the intervention. The internal consistency reliability of this test was not tested due to the small number of participants (n=14), though Steelman et al. (2004) reported the internal consistency reliability of the FES questions as .92 and the test-retest reliability as .64. Steelman et al. also reported the concurrent validity of this measure as .76 with a predictive validity of .67. Appendix E shows the original FES questions with the modifications made for this study. Descriptive statistics for the FES indicated that the mean was 2.88 with a standard deviation of 1.14.

OSLQ Pretest-Posttest

In order to measure students' SRL behaviors, a modified version of the OSLQ was administered. This test contains 22 items categorized into the following subscales: goal setting (5 items), environment structuring (4 items), task strategies (3 items), time management (2 items), help seeking (4 items), and self-evaluation (5 items). The OSLQ contains 24 items ranked on a Likert type scale from strongly disagree (1) to strongly agree (5), and was also administered one week after the intervention. A reliability test was not run on the OSLQ due to the small sample size. The internal consistency reliability scores of the OSLQ is reported as Cronbach's alpha level of .90 with subscale Chronbach alpha scales ranging from .67 to .90 (Barnard, et al., 2009). The construct validity of the measure was confirmed with confirmatory factor analysis that included confirmations from chi-square, chi-square ratio to degrees of freedom, root mean square error of approximation, Non-Normed Fit Index, and Comparative Fit Index analyses.

Descriptive statistics. Upon completion of the administration of the OSLQ, descriptive statistics were run on the pretest and posttest data using Microsoft Excel to determine the mean and standard deviation of each subscale as follows: goal setting pretest (M = 3.71, SD = .85), goal setting posttest (M = 3.56, SD = .98), environment structuring pretest (M = 4.34, SD = .53), environment structuring posttest (M = 4.17, SD = .64), task strategies pretest (M = 2.98, SD = 1.07), task strategies posttest (M = 2.90, SD = .94), time management pretest (M = 3.29, SD = 1.07), time management posttest (M = 3.04, SD = 1.03), help seeking pretest (M = 3.34, SD = .71), help seeking posttest (M = 3.25, SD = .74), self-evaluation pretest (M = 3.59, SD = .84), and self-evaluation posttest (M = 3.41, SD = .67). Table 4.1 displays the descriptive statistics of this measure.

Table 4.1 *OSLQ Descriptive Statistics*

Subscale	M	SD
Goal Setting Pretest	3.71	.85
Goal Setting Posttest	3.56	.98
Environment Structuring Pretest	4.34	.53
Environment Structuring Posttest	4.17	.64
Task Strategies Pretest	2.98	1.07
Task Strategies Posttest	2.90	0.94
Time Management Pretest	3.29	1.07
Time Management Posttest	3.04	1.03
Help Seeking Pretest	3.34	.71
Help Seeing Posttest	3.25	.74
Self-Evaluation Pretest	3.59	.84
Self-Evaluation Posttest	3.41	.67

Inferential statistics. The Shapiro-Wilk test was used to check the normality distribution of the differences between pre and post scores for each subscale. The results of this test indicated a normal distribution of the pre-post pair differences, $p > 0.05$. To detect significant differences between the subscale pretests and posttests, a paired t-test was run on each subscale with a Bonferroni adjusted alpha level of .008 calculated by dividing the alpha level of .05 by the number of comparisons. When the goal-setting pretest results ($M = 3.71$, $SD = .85$) were compared with the posttest results ($M = 3.56$, $SD = .98$), no significant difference was found, $t(13) = 1.30$, $p = .22$. The environmental structuring pretest ($M = 4.34$, $SD = .53$) and posttest ($M = 4.17$, $SD = .64$) also indicated no significant difference, $t(13) = 1.5$, $p = .16$. Likewise, the task strategies pretest ($M = 2.98$, $SD = 1.07$) and posttest ($M = 2.90$, $SD = .94$) did not show a significant difference $t(13) = .67$, $p = .51$. The time management pretest ($M = 3.29$, $SD = 1.07$) did not significantly differ from the posttest ($M = 3.04$, $SD = 1.03$) $t(13) = 1.61$, $p = .13$. There was also no significant difference found between the help seeking pretest ($M = 3.34$, $SD = .71$) and posttest ($M = 3.25$, $SD = .74$) $t(13) = .21$, $p = .84$. Finally, the self-evaluation pretest pretest ($M = 3.59$, $SD = .84$) and posttest ($M = 3.41$, $SD = .67$) did not significantly differ $t(13) = 1.31$, $p = .21$. The results of these tests are shown in Table 4.2.

Table 4.2 *OSLQ Subscale Paired t-test Results*

Subscale	**Pretest**		**Posttest**		***t*(13)**	***p***
	M	*SD*	*M*	*SD*		
Goal Setting	3.71	.85	3.56	.98	1.30	.22
Environment Structuring	4.34	.53	4.17	.64	1.5	.16
Task Strategies	2.98	1.07	2.90	.94	.67	.51
Time Management	3.29	1.07	3.04	1.03	1.61	.13
Help Seeking	3.34	.71	3.25	.74	.21	.84
Self-Evaluation	3.59	.84	3.41	.67	1.31	.21

Note: N=14. Significance α level = .008

Qualitative Findings and Interpretation

The analysis of the qualitative data collected in this study is discussed in the following section. A description of focus group formatting, verbatim transcription and memo writing is followed by a description of peer debriefing and how two rounds of coding, including sentence by sentence coding, were performed. A description of how categories were formed and developed into themes concludes this section.

Analysis of Qualitative Data

Focus group interviews. Interviews can be a powerful tool in qualitative research (Creswell, 2014). In this study, I used a semi-structured focus group interview format (Mertler, 2017) that allowed me to ask the participant interviewees a series of consistent, foundation questions while also giving me the freedom to ask additional questions as needed to get a clearer picture of what the respondent actually meant or to probe for additional relevant information. The focus groups allowed me to gain insight into what my students thought and felt (Mills & Butroyd, 2014; Patton, 2002). The first (n = 6) and second (n = 7) focus groups elucidated student experiences in a way that allowed me to better understand their thoughts and feelings (Mertler, 2017). Interviewees were randomly assigned to their focus groups which lasted approximately 45 minutes each. The focus groups took place about one week after the MP assignments were completed and were structured around questions regarding students' SRL skills and perceptions of MP feedback quality. The focus group interview protocols can be viewed in Appendix F.

Transcription and memo writing. The qualitative data for this study was drawn from two focus group interviews that I conducted with students in my honors physics classes. These interviews were approximately 45 minutes in length during which time field notes were also taken. The focus groups were audio-recorded and transcribed via a transcription service called GMR Transcription. After the commercial transcription was complete, I reviewed each transcription myself to check for accuracy. In addition, all of the participants that were involved with the focus groups (n = 13) were involved in member checking the transcripts.

Once I was confident that I had accurate transcriptions, I read through each transcript and listened to each focus group recording twice. I did this over a ten-day period, leaving gaps between each reading or listening to allow time for my brain to fully process the information. This initial review of the data over a short period of time was critical in helping me become familiar with the data and to start thinking about the big messages that my students were trying to communicate.

I took an inductive approach to analyzing this data which means that I attempted to build a set of whole, cohesive findings from the body of data itself (Creswell, 2014; Patton, 2002; Saldaña, 2014). I started this process by familiarizing myself with the data, I began my initial coding process. During this process, I tried to keep a consistent journal for myself. Originally, I wanted to force myself into using just one platform for simplicity's sake but found myself jotting down thoughts as they occurred. At times, I used my iPhone's Notes App to do this as can be seen in Figure 4.1. At other times, I used an iPad app called Paper to jot down notes. See Figure 4.2 for a screenshot of the Paper app. The most frequent place where I jotted down notes was in the qualitative data analysis software Atlas.ti. I used the program's memo feature to record my thoughts during coding. Figure 4.3 shows a screenshot of this kind of memo. These notes and memos helped me to organize my thoughts during all phases of coding and allowed me to immediately capture my thinking—an invaluable tool for any qualitative research (Charmaz, 2006; Gordon-Finlayson, 2010).

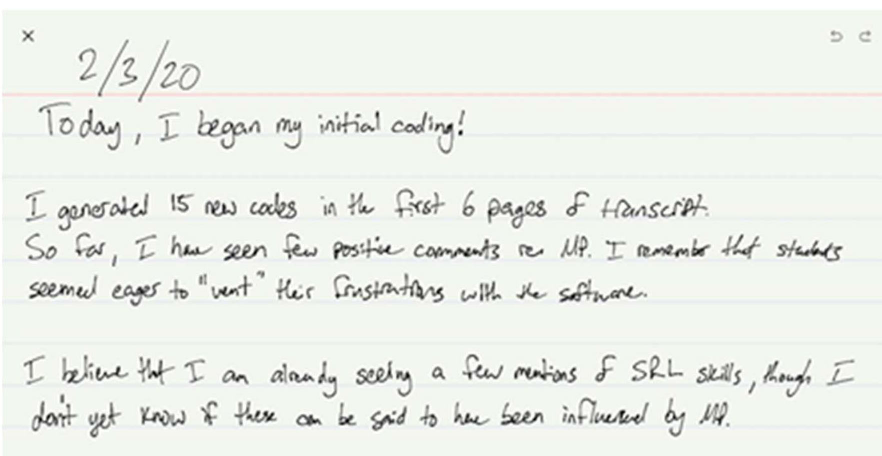
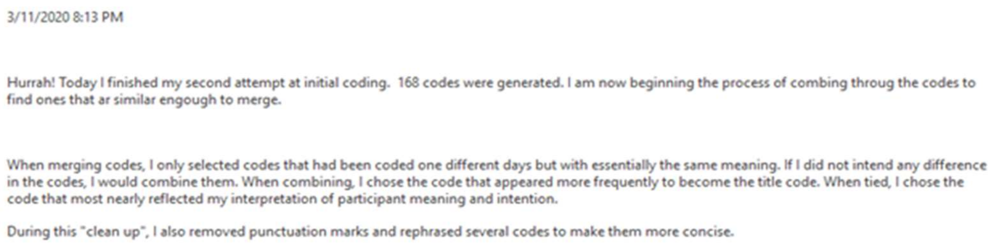


Figure 4.1. iPhone Notes journaling.



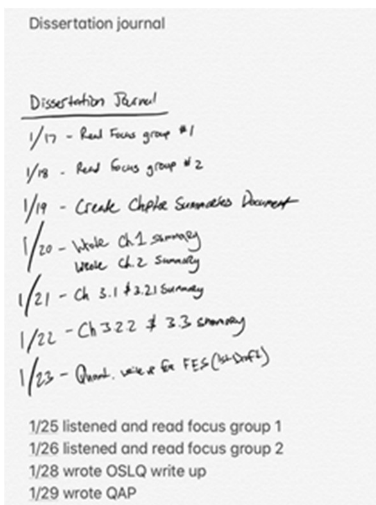
3/11/2020 8:13 PM

Hurrah! Today I finished my second attempt at initial coding. 168 codes were generated. I am now beginning the process of combing throug the codes to find ones that ar similar engough to merge.

When merging codes, I only selected codes that had been coded one different days but with essentially the same meaning. If I did not intend any difference in the codes, I would combine them. When combining, I chose the code that appeared more frequently to become the title code. When tied, I chose the code that most nearly reflected my interpretation of participant meaning and intention.

During this "clean up", I also removed punctuation marks and rephrased several codes to make them more concise.

Figure 4.2. iPad Paper app journaling.



Dissertation journal

Dissertation Journal

1/17 - Read Focus group #1

1/18 - Read focus group #2

1/19 - Create Chapter Summaries Document

1/20 - Wrote Ch.1 summary
Wrote Ch.2 Summary

1/21 - Ch 3.1 & 3.21 Summary

1/22 - Ch 3.22 & 3.3 summary

1/25 listened and read focus group 1
1/26 listened and read focus group 2
1/28 wrote OSLQ write up
1/29 wrote QAP

Figure 4.3. Journaling in Atlas.ti.

Peer debriefing. On three separate occasions, I had the opportunity to meet with my dissertation chair, Dr. Ismahan Arslan-Ari through the video conferencing tool Blackboard Collaborate. One of these meetings took place during my first round of coding, another after my first round of coding, and the other during my second round of coding. During these sessions, Dr. Arslan-Ari would provide feedback to me regarding my coding and categorization processes. In addition to these sessions, peer debriefing occurred in the form of email exchanges between Dr. Arslan-Ari and myself along with the use of a collaborative Google Doc page where we could communicate through comments on the page. Each of these channels of communication provided me with a robust feedback system though which my thinking could be challenged and my skills honed (Hail, Hurst, & Camp, 2011). These meetings had the biggest impact upon my first round of coding where Dr. Arslan-Ari was able to take a close look at my codes and guided me to see that I was thinking too categorically while coding. Her input helped me to look at the transcription texts for what they said rather than thrust upon them the thematic elements that I had in my head from familiarizing myself with the data. The end result of this was an initial coding phase where I carefully combed through the data sentence by sentence sorting many phrases into codes.

First cycle coding. The first cycle of coding is the researcher's first analytical step into the data—a step that will be followed by numerous revisits to the same data (Saldaña, 2015). During this cycle, I chose to employ what Saldaña refers to as initial coding. This type of coding involved the breaking down of bodies of data, such as interview transcripts, into discrete pieces that can be analyzed for patterns. As an elemental method, initial coding serves the researcher by allowing him or her to sort through small elements of the data, in this case, text, for use in discovering emergent categories later in the second cycle of coding. In this study, initial coding involved the researcher reading each transcript line by line and assigning short, descriptive markers called codes to small phrases or entire sentences. Even though initial coding is most often connected with the first stages of a grounded theory study (Charmaz, 2014), it can be used merely as a first cycle coding method that is not followed by the collection of more data (Saldaña, 2015). In other words, even though initial coding is often followed by more data collection, it does not have to be followed by more data collection to be useful.

During this first round of coding, I initially generated a total of 30 codes after completing the first transcript. These codes were broad in nature and my peer debriefing with Dr. Arslan-Ari helped me to see that these codes were too general. A list of these codes can be seen in Table 4.3. Figure 4.4 shows a screenshot of my coding software in use.

Table 4.3 *List of First Round Codes*

First Round Codes		
Anti-SRL #1 Preparation	Information Relay	Negative MP Formatting
Anti-SRL #2 Monitoring	Helpful	Technical Difficulties
Anti-SRL #3 Reflection	Joking	MP Suggestion
Confusion	Lack of feedback.	Security
Difficulty	Like Technology	SRL #1 - Preparation
Dislike Technology	I had no one to explain it to me.	SRL #2 - Monitoring
Easy to use	MP Comparison	SRL #3 - Reflecting
Frustration	MP Routine	Teacher Assistance
It's like doing a crossword puzzle in an	Positive Attitude Regarding Feedback	No. But I'd find questions like it. And
Mastering Physics is like this rigid like prison	Negative attitude regarding feedback	We just – we didn't know where we were g

Note: Coding software limited the number of characters each code could contain, so some codes are cut off.

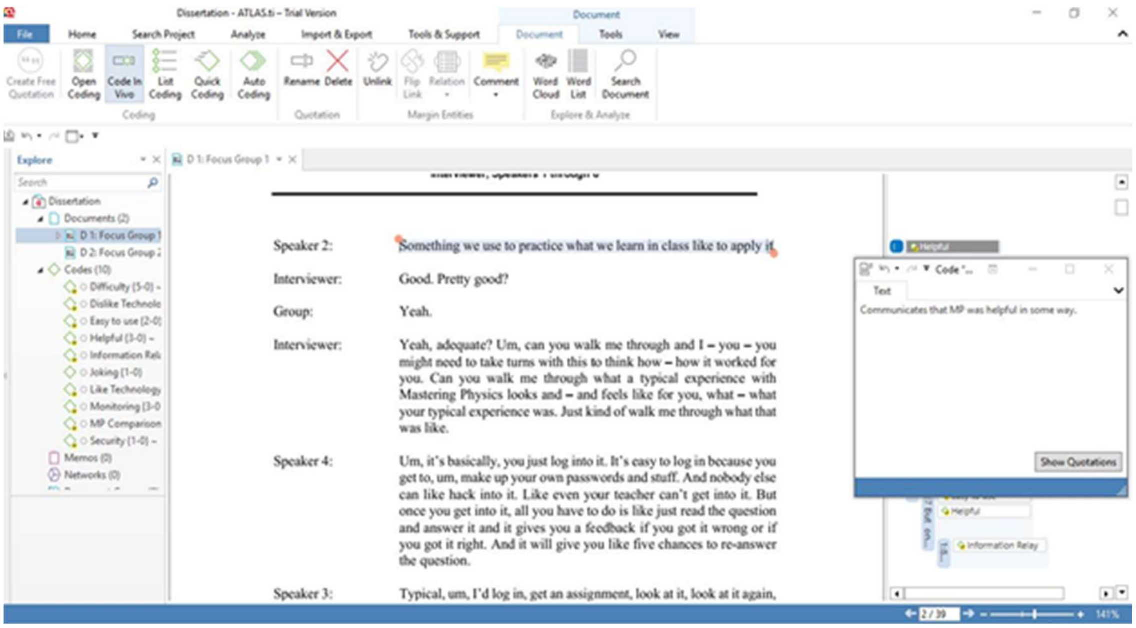


Figure 4.4. Screenshot of coding in progress.

A memo I wrote on 2/15/2020 indicates how I planned to go about correcting the broad nature of these codes. In that memo I said,

> Dr. Arslan-Ari emailed me today and gave me some advice that my codes might be a bit too broad. I think I may have been fitting statements into categories that I had made in my mind when I read through my data multiple times. I will finish the first round of coding today and then plan to code more specifically. (Dissertation Memo, 2/15/2020)

This broad coding was likely due to my familiarity with the data and a result of my brain already having formed patterns in my mind from this familiarity. Dr. Arslan-Ari's feedback helped me to realize that I was not necessarily wrong for already having an idea for where the data might lead, but that I should instead be looking for the nuggets of information that would build those categories and themes from the ground up. It is interesting to note how these first 30 codes are similar to the categories that were later generated by my second round codes. This was a revelation for me that made my second round of coding much richer. For example, broad codes such as “SRL #1 Preparation” in my first round of coding became far more specific such as “I create reminders for myself to complete MP” in my second round of coding.

Second round of first cycle coding. After realizing that my first attempt at first-cycle coding was too broad, I revisited the data in an attempt to more narrowly capture what my participants had expressed. During this round of coding, I generated nearly 200 codes. After completing this second attempt of first cycle coding, I merged codes together that I felt did not have a big enough difference between them. An example of this type of merging can be seen in Figure 4.5 where the code “Attempted MP on my own” and “Attempted alone” were merged. A few of the second-round codes were in vivo while the rest were simply small summary words or phrases that I used to capture the essences of what was being communicated in the transcripts. This, along with discarding a few codes that I deemed to be irrelevant due to their infrequency and low quality, resulted in a final coding list of 115 codes. Table 4.4 lists the new codes that were generated during first cycle coding.

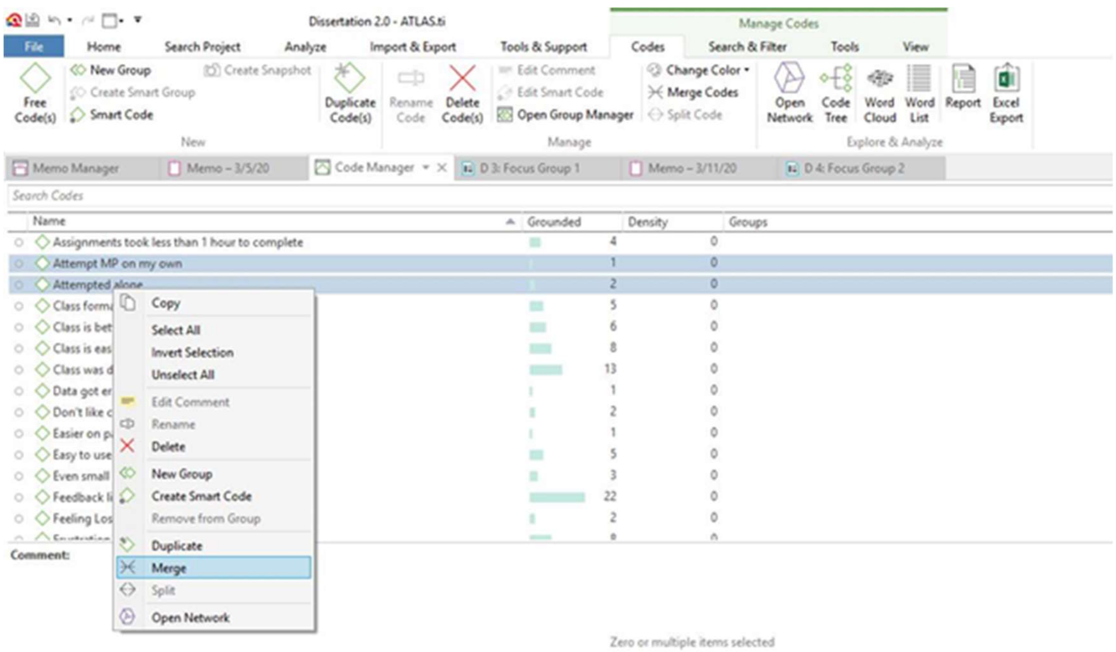


Figure 4.5. Code merging.

Table 4.4 *New First Cycle Codes*

New First Cycle Codes		
You cannot cheat on MP	I only look at the final score	MP helped me understand physics
All of MP is frustrating	I received help from others on MP	MP helped me with a problem in class
Annoyed by MP	I reviewed my average assignment time	MP helps me turn in assignments on time
Answering MP questions	I reviewed my scores	MP helps you with physics

Answering MP questions correctly makes me feel good	I set aside time to complete MP	MP hints help solve problems
Assignments took 1 hour to complete	I skipped questions in MP	MP is boring
Assignments took less than 1 hour to complete	I try to do what I think is right.	MP is forgettable
Attempt MP on my own	I use MP assignments to help me complete other MP assignments	MP is frustrating
Class formatting is easier	I use the internet to look up how to do it	MP is hard
Class is better than MP	I used "extra time" to complete MP	MP is hard to get used to
Class is easier than MP	I want to be successful at MP	MP is impossible
Class was different from MP	I was less likely to complete homework because it was on MP	MP is like busy work
Data got erased	I wasn't aware of all MP features	MP is like homework from other classes
Easier on paper	I wish MP didn't tell me which answers were right and wrong	MP is like this rigid like prison
Easy to use	I wish MP had more hints	MP is not fun
Even small hints help	I wish we could have worked in groups	MP is not time consuming
Feedback limited to right and wrong	I would rather work longer on problems that I understand	MP is out of the way
Frustration increased over time	Individualized questions helped up do the work	MP is proof that teacher will never be automated

Giving Up	Initially MP was easy	MP is time consuming
Had to change password	It is easy to miss MP feedback	MP is too advanced
Had to restart an MP assignment	It made me like very anxious	MP is too hard for high school
Having 5 chances helped me complete MP	Joking	MP is too hard to be helpful
I anticipated on getting them all wrong	Just started trying random numbers	MP is too narrow
I create reminders for myself to complete MP	Logging In	MP is used to practice or apply ideas from class
I did MP by myself	Most online homework is on Google Classrom	MP is visually plain
I did not care	MP Assignments do not relate to each other	MP keeps you confident
I did not ignore MP feedback	MP could be improved	MP makes me more careful
I did not refer to notes	MP diagrams are confusing	MP makes me not care
I did not review how long I spent on each assignment	MP did not help me complete assignments on time	MP needs good wifi to work
I did not review scores	MP did not help me think critically	MP overviews helped
I do MP anywhere	MP did not help me understand physics	MP problems got harder over time
I do MP at home	MP does not explain feedback	MP score does not reflect my physics knowledge

I do MP at school	MP does not give feedback	MP takes a short time to complete
I do MP in my bedroom	MP does not make me more careful in answering my questions	MP was enjoyable
I do not like computer work	MP does not prepare me	MP wording is confusing
I do not set aside time to complete MP assignments	MP does not see our work	Not having numerical answers would be easier
I do think about MP after completing it	MP does things automatically	Not knowing where to start
I don’t know what I’m doing	MP feedback did not help me catch errors	Physics class is not easy
I don't do MP when I am tired	MP feedback does not make assignments easier to begin	Question about Interview
I don't like to spend a lot of time on homework	MP feedback is clear	Question formatting makes MP hard
I don't think about MP after completing it	MP feedback is confusing	Ready for MP to be over
I don't usually use my Chromebook for homework	MP feedback is not enough	Requesting Answers
I had no idea what I was doing wrong.	MP feedback is somewhat helpful	Requesting hints
I ignored MP feedback	MP feedback makes assignments easier to begin	Security
I like computer work	MP gave feedback about rounding	Seeking teacher help
I like that MP helps with rounding	MP gave feedback about units	Trouble getting answer from MP

I look through notes for help	MP gives feedback	Trouble Loading MP
I made multiple attempts to complete MP assignments	MP has glitches	Trouble Logging In to MP
I make connections between MP questions	MP helped me catch errors on assignments	Trouble with Chromebook
I multitask while doing MP	MP helped me think about my answers	You can look at previous MP scores

Second cycle coding. After peer debriefing confirmed that my first cycle codes were usable, I began the process second cycle coding where I sorted my 150 codes into categories. For many qualitative researchers, the categorization of codes is often a visual process (Patton, 2002; Saldaña, 2015). The same was true for me albeit digitally. I began by placing all of the codes into a network view in Atlas.ti. I then manually dragged each code into piles that seemed to fit together to me. Figure 4.6 shows the codes completely unorganized and then organized into piles. Some piles were easier to create than others. For example, I designed the focus group questions to provide data regarding how students' SRL behaviors were impacted while using MP. Codes that came from answers to these questions were easier to categorize because the questions that students were responding to were already organized along these lines. Other codes were more difficult in that unexpected answers and topics of conversation arose. For example, 47 different quotations were coded that had to do with comparing MP with other activities that my students had performed in class. I had not planned on asking them about these activities. Rather, they arose as a natural outcropping of the conversation we were having.

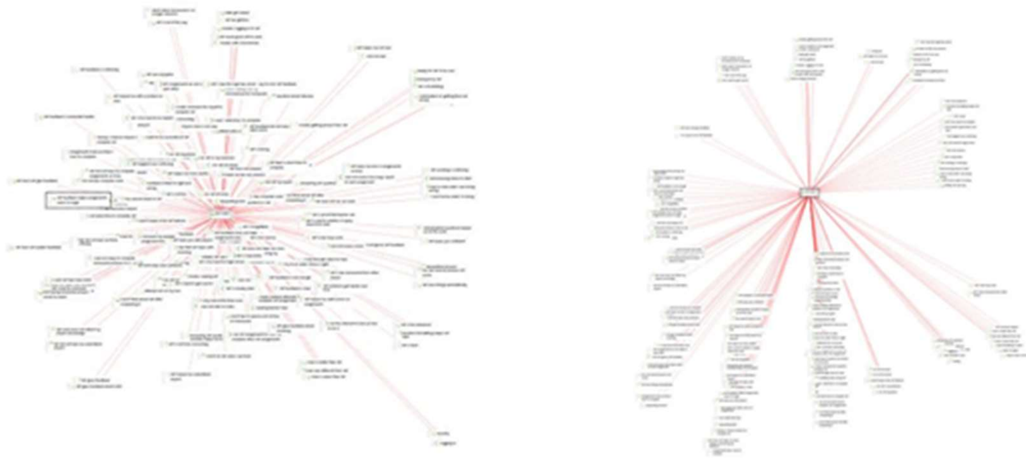


Figure 4.6. Forming codes into related piles.

Next, these piles were assigned colors and given names that described their grouping. Figure 4.7 shows the progression of assigning colors and naming categories. Figure 4.8 shows a closer view of one of the categories.

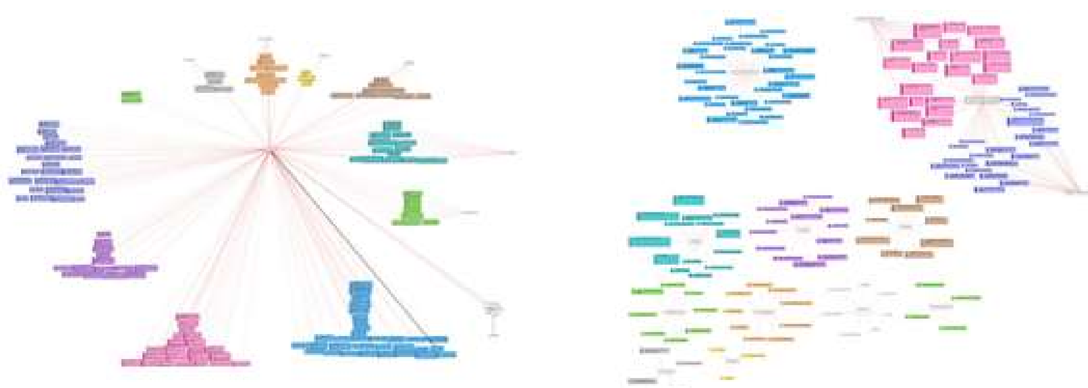


Figure 4.7. Category color coding and naming.

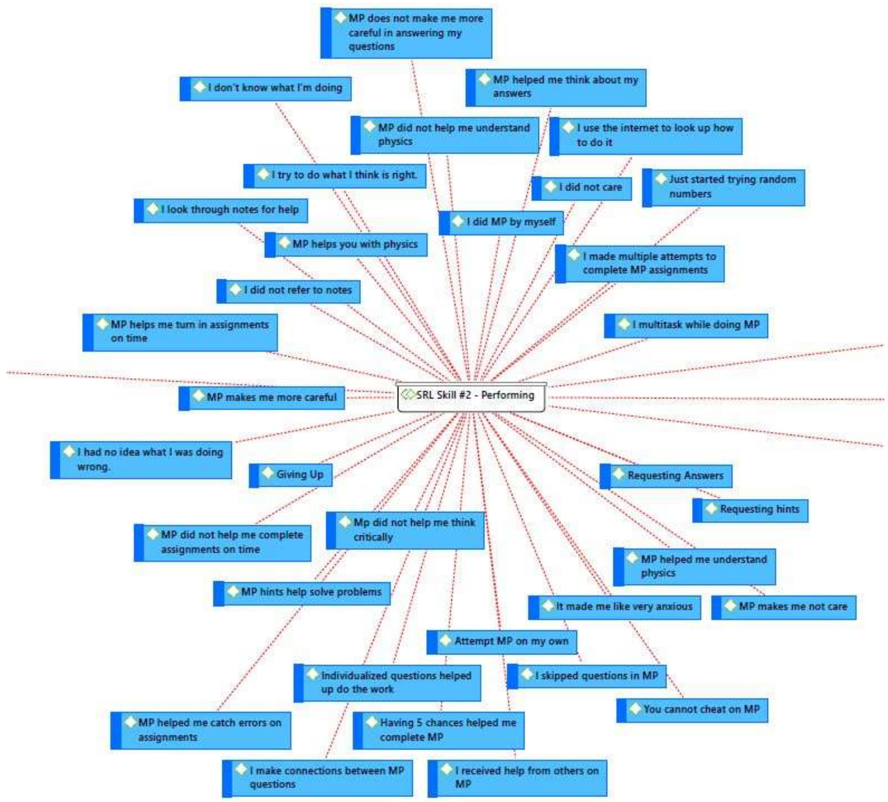


Figure 4.8. A closer view of a named and color-coded category.

Appendix G shows enlarged views of each category. Through this process, 12 categories were generated. They are as follows: +SRL Phase 1, -SRL Phase 1, +SRL Phase 2, -SRL Phase 2, +SRL Phase 3, Technical Difficulties, Inconvenience, Frustration, Difficulty, Comparison to Class, Positive Perception of Feedback, Negative Perception of Feedback, and Irrelevant. I planned to not include the Irrelevant category in my findings but found it important to keep them on my code map as a sort of reference for what made the codes in the other categories so helpful. For example, codes that I had originally thought would be helpful such as "I multitask while doing MP" or "I do MP in my bedroom" had more to do with the way in which students engaged with MP procedurally, but not in the way that their learning behaviors changed. Since my research questions were seeking the later rather than the former, these codes were cast aside. The final code map can be seen in Figure 4.9. Each color in Figure 4.9 denotes a different category with the exception of the red and blue categories. These codes were part of my SRL categories, and I decided to split them into positive and negative impacts after seeing them grouped together on the code map.

Figure 4.9. Final code map.

Once my codes were categorized, I began to search for themes that emerged from the data. I spent a few days just reading my codes, categories, and original transcripts in order to help wrap my mind around what the data was saying. During this time, I sat in on a few dissertation defenses in preparation for my own. It was during these observations that I noticed how the doctoral candidates that I watched abstracted from data to themes. One of their main tools in this endeavor was, of course, their research questions. Soon after these observations, I reread my categories through the lens of my research questions and immediately spotted three emerging themes: SRL impact, platform problems, and feedback failure. Figure 4.10, 4.11, and 4.12 show a visual grouping of these codes by themes.

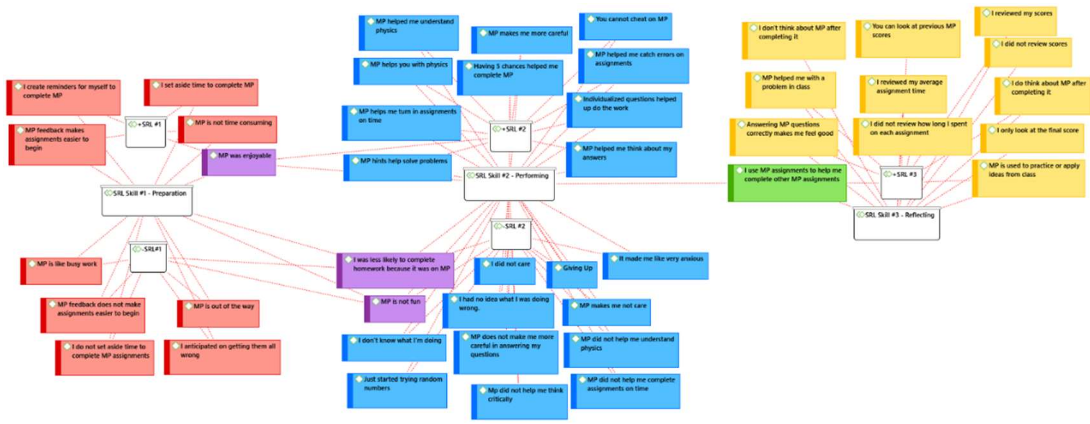


Figure 4.10. Theme 1 Code Map.

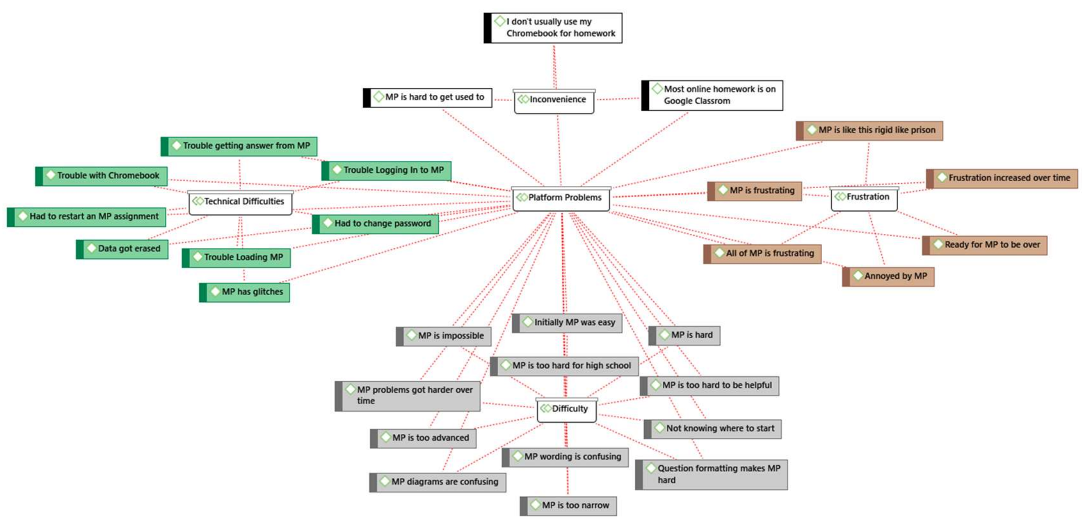


Figure 4.11. Theme 2 Code Map.

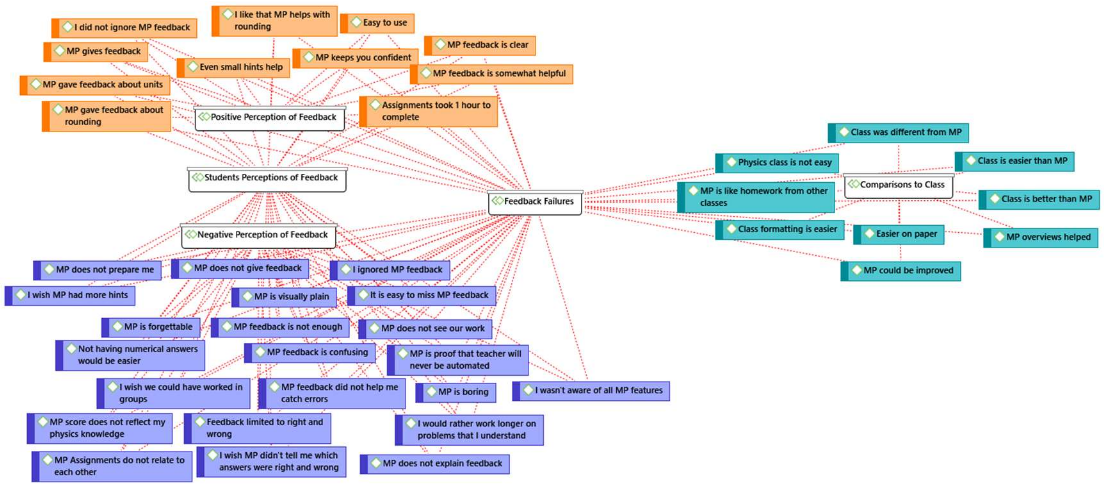


Figure 4.12. Theme 3 Code Map.

Visualizing this data helped me to appreciate the inductive nature of qualitative analysis in building from small, coded elements into larger, more descriptive themes (Patton, 2002). I found the code map to be extremely helpful in categorizing my data, but not very helpful in reviewing how source quotations supported the emergent themes. After making my final code map, I placed my codes into Microsoft Excel and Google Sheets to better show how meaningful themes had emerged from the direct quotations that I had coded (Meyer & Avery, 2009). Figure 4.13 shows a screenshot of these helpful spreadsheets. The following section more fully describes how each theme is supported by its categories, codes, and source quotations from the transcripts.

Category	Number of Codes	Code	Quotes	Literature Comparisons
Technical Difficulties	8	Data got erased	data got erased	[illegible]
		Had to change password	**Yeah. I've had to change my password five times.** Like and – and the same password every single time. I don't know what's up with it. Yeah. I have – like I keep having to change it but I change it to the same thing it was before. But it wasn't working when I log in Yeah, I had to do that once. Yeah. It says this password is – or username is incorrect and I go change password. And then, it emails me and all of that stuff	
		Had to restart an MP assignment	I had to like restart the whole thing I've only done like one or two of them but still, I had to go back through. And then, when I refreshed it, it was a whole new set of numbers.	
		MP has glitches	But then, you go to put another answer and you click submit and you see correct from the last one and then, like – and then, it glitches. It was like I think after I got the five, I think it was when it started glitching on me last night. Unless it glitches out. Temporarily down. One time, I – well, you guys, I don't know. I took web design so you guys might not know. But, uh, when I – a couple of times I It was just straight up text like just like regular text. One time, uh, I put in the answer and it said like unable to – The same thing as him. It was – like for the past two days, it hadn't been working for me. The first time I could tell it was a Mastering Physics thing is because every other website I tried going on worked No, okay. So, what happened is I could get into the log in and I would – was able to log in. But the next – the page – um, when	[illegible]
		Trouble getting answer from MP	Or if it tells me it's like correct, it won't tell me – like sometimes it like hasn't shown me the answer for it and I'll be like what is it Or like sometimes, it will say it's wrong **Or like, um, sometimes when you're requesting – when you just cannot find the answer and request it, like the reques** Yeah. I've had a couple of times when it was it's taken like a couple of clicks to like get it to work. Some – some of mine were like that. **Yeah, it eventually worked but it was hard – it was hard to find.** Oh, yeah. It eventually did. It was slower but yeah.	
		Trouble Loading MP	Oh, yeah. It eventually did. It was slower but yeah. Sometimes, it doesn't load all of the way So, I remember one time, I logged in and I went to click on an assignment and I clicked on the assignment and then, I finished **I've had to refresh the page like a lot of times for it to like – or like if I go to submit my answer, it takes like a long time**	

Figure 4.13. Spreadsheet organization of themes, categories, codes, and quotations.

Presentation of Findings

The qualitative findings of this study are included in the section below. They are drawn from two 45-minute interviews that were conducted with nearly all of my participants (*n* =13). The transcripts were coded as described in the qualitative data analysis method section. In total, 12 categories subsumed 115 codes that helped me to see the emergence of four themes. Each of these themes is stated as an assertion, and Table 4.5 shows how these assertions are supported by the categories and a few pieces of sample evidence.

Table 4.5 *Assertions, Categories, and Evidence Alignment*

Assertion	Categories	Example Evidence
1) The MP platform did make some positive impact on student SRL behaviors. However, these were outweighed by the negative SRL behaviors produced by MP.	a) Positive SRL Skill #1 - Forethought	• "I always set reminders on my phone like every Friday" - Peter • "I knew I would need a certain amount of time to do it" - Larry

b) Negative SRL Skill #1 - Forethought	• "Like you're kind of be like oh, Mastering Physics is due like at the end of the week. And I was like oh, great. I forgot that even existed" - Larry • "I anticipated on getting them all wrong" - Roger
c) Positive SRL Skill #2 - Performing	• "[MP] makes me a little bit more careful also because knowing like each one that I get wrong, that's like a grade deduction - Hannah • MP made students "want to do it on time more because of the due dates that it gave" - Peter
d) Negative SRL Skill #2 - Performing	• "It's literally like it's a back and forth with you and the computer. Like after a while, it's just okay, I'm not getting this right so I'm going to guess until I get it right or either guess until I run out of tries.- Theresa • "It's like what's the point in trying if you're going to get it wrong either

		way" - Jamara
	e) Positive SRL Skill #3 - Reflecting	● "I think it's like oh, I did bad on this. What's this assignment about? I should review that a bit more" - Jack ● "You do get a sense, I guess when it's electronic like that and you know you got it right, you do get a sense of accomplishment from like getting it right" - Larry
2) The MP platform was plagued with user issues that exasperated students and deteriorated MP's effectiveness.	a) Technical Difficulties	● "I've had to refresh the page like a lot of times for it to like – or like if I go to submit my answer, it takes like a long time for me tell if it's like correct or wrong." - Hannah ● You go to put another answer and you click submit and you see correct from the last one and then, like – and then, like it glitches and says incorrect again."

		Jamara
	b) Inconvenience	• "[MP is] not something we use as frequently as the rest of the stuff so it's just in the back of our mind" - Mikayla • "I know it's not a lot and I know it won't take me long to get it done so I push it away more and it's like I forget about it" - Larry
	c) Difficulty	• "I understand what happens in class. And then, I get in Mastering Physics and it's worded so different that I can't understand what it's saying." - Roger • "It's like doing a crossword puzzle in another language" - Jamara
	d) Frustration	• "The thing about Mastering Physics that frustrated me so much is it's like other homework" - Jamara • "Mastering Physics is like this rigid like prison." - Larry

3) Students did not perceive the feedback provided by MP as high quality feedback.	a) Comparison to Class	• "If it doesn't look like what you did in class then, I start requesting answers." - Jane
	b) Positive Perception of Feedback	• "If it gave me feedback, I normally used it." - Roger • "It's just like oh, here's your – you're either rounding wrong or you're using the wrong units." - Larry
	c) Negative Perception of Feedback	• "The feedback was normally never there." - Roger • "When we got it correct or if we got it wrong, it didn't tell us why we got it wrong." - Hannah

This chapter will detail each theme and category that supports it. It is important to point out that all of the quotations in this chapter reference students' exact words and not the words of the researcher. To enhance the confidentiality of this study, pseudonyms have replaced students' actual names, although gender-appropriate names were selected.

Theme 1 | SRL impact. Self-regulated learning theory describes how students engage with their own thinking before, during, and after completing cognitive tasks (Schunk & Zimmerman, 2012). SRL can be categorized in three phases--forethought, performing, and reflecting. During each of these phases two categories of tasks, each with multiple individual characteristics, are identified by Zimmerman (2000). Table 4.6 shows these characteristics and their categorization within each phase.

Table 4.6 *SRL Phase and Characteristics Alignment*

Phase	Characteristics
Forethought	● Task Analysis ○ Goal setting ○ Strategic planning ● Self-Motivational Beliefs ○ Self-efficacy ○ Outcome expectations ○ Task interest or value ○ Goal orientation
Performing	● Self-Control ○ Self-instruction ○ Imagery ○ Attention Focusing ○ Task Strategies ● Self-Observation ○ Metacognitive monitoring ○ Self-recording
Reflecting	● Self-Judgement ○ Self-evaluation ○ Causal attribution ● Self-Reaction ○ Self-satisfaction or affect ○ Adaptive or defensive

This theme is made up of categories that show both the positive and negative impacts that using MP had on student SRL behaviors. The categories in this theme are organized by SRL skills as follows: 1) SRL Phase #1 – Forethought, 2) SRL Phase #2 – Performing, 3) SRL Phase #3 – Reflecting. The findings in this theme show that the MP platform did make some positive impact on student SRL behaviors. However, these were outweighed by the negative SRL behaviors produced by MP.

SRL phase #1 – forethought. It is well established that students who show the characteristic behaviors of the first SRL phase see positive achievement impacts as a result (Bembenutty, 2009; Schunk, 2020; Zimmerman, 2000). The findings in this study weakly demonstrate how using MP might provide some positive impacts on students' ability to engage in SRL behaviors, but more strongly show negative evidence of these behaviors. In this category, nine instances of positive impact were documented compared to 14 negative instances. Many of the negative student perceptions regarding MP as being boring and not at all fun contribute to the negative metacognitive findings (Pekrun, Goetz, Daniels, Stupnisky, & Perry, 2010). This category and its two subcategories were made up of codes that communicated how a student engaged in planning or thinking ahead about the MP work they were going to complete. Codes both positive (n =9) and negative (n =14) can be seen, but along with being more numerous, the negative responses were stronger and more directed toward the MP platform.

Positive planning. During the six weeks in which students were using MP, they claimed to have demonstrated behaviors that aligned with the forethought phase of SRL. Comments such as Peter saying, "I always set reminders on my phone like every Friday" and Larry's, "I knew I would need a certain amount of time to do it" indicated that students were planning ahead while using MP. However, few students seemed to tie these behaviors directly to the MP platform itself making it difficult to determine whether these behaviors were impacts of MP or, more likely, the result of students with strong SRL skills who happen to be using MP. In other words, students made no indication that the MP platform itself helped them with their strategic planning.

Negative planning. Unlike the category above, students readily seemed to connect the negative impact on their ability to engage in SRL with the MP platform itself. Larry claims that MP was “out of the way” and “it’s just not fun” seemed to reflect what demotivated students from planning to work on the assignments. Larry continued, “Like you’re kind of be like oh, Mastering Physics is due like at the end of the week. And I was like oh, great. I forgot that even existed”. Students claimed that they were less likely to complete the homework because it was on MP and that the feedback that MP provided did not make assignments easier to begin. One such example of negative planning came when Roger said he, “anticipated on getting them all wrong”. So while it does not seem that MP caused any of the positive planning behaviors that I observed, it certainly seemed to contribute to the negative ones. In addition, the negative comments that my students made covered nearly all of the characteristics of the SRL forethought phase. From the negative outcome expectations to Roger’s dismal “busy work” view of the value of MP, students indicated they were more negatively impacted by MP than positively impacted.

SRL phase #2 – performing. The performing phase of SRL includes behavioral characteristics displayed by students while they are completing learning activities (Zimmerman, 2012). Performing is the doing of the homework and was where I believed the largest impact would be when planning this study. This category and its two subcategories subsume codes that indicate that a student is engaging in the SRL planning phase by mentioning an action or thought that aligns with the characteristics of this phase (Zimmerman, 2000). Numerically, this was the largest category within this theme as well as being the most explicit in terms of students expressing themselves. This category seems to mirror the theme of which it is part by showing both positive and negative SRL impacts but showing more emphasis on the negative impacts. In this category, the number of positive expressions coded (n = 42) is close to the number of negative expressions coded (n = 49), but the negative expressions seem to be of a more passionate quality as discussed below. While SRL behaviors are already difficult for high school physics students to engage in (Neber & Schommer-Aikins, 2002), the students seemed to attribute their problems with the performing phase as being connected with the MP platform and not merely the content.

Positive performing. Students indicated that MP positively impacted their ability to engage in metacognitive monitoring. They referenced MP giving them multiple chances, and helping them to catch small errors. Hannah said that "[MP] makes me a little bit more careful also because knowing like each one that I get wrong, that's like a grade deduction" demonstrating that MP does help them monitor their thinking. Just like this category, however, this positive feedback was paired with negative comments as well. Consider how this student describes this positive and negative tension while talking about how MP progressively deducts points:

Hannah: So, like from that like 100 percent, [the MP assignment score] goes down to like 80, 70 Like all – like down each one I get wrong.

Roger: Each – each one you miss, yeah. It –

Hannah: And so, it makes me a little bit more careful but also a little bit like should I just request the answer and just get it over with. You know?

This tension was echoed by Larry pointing out that MP "helps me catch errors in the fact that I know it's wrong. . .but it doesn't help me correct the error." One place in which MP did seem to shine in engaging performing phase characteristics was in providing students with more concrete task strategies and self-recording. For example, Peter said that MP made them “want to do it on time more because of the due dates that it gave”. In addition, 12 quotations were coded that mentioned students using the MP assignments to help them with future assignments. This occurred both on the assignment level where students were using previous questions to answer new ones as well as over the course of all six assignments.

Other positive statements from students focused on the help they received from MP hints. Only two questions had the kind of feedback that students were looking for, which is discussed in the next theme, but when the elaborated feedback was helpful, students seemed to thoroughly enjoy it. A surprising finding was that students also appreciated the randomization of the problems. For example, Hannah said:

> I think it’s better that it was randomized, honestly, because then it taught us like how to like actually do the work. But then, like so everyone knew how to actually do it but it’s just different for everyone else. So, we see like different numbers.

This appreciation for the questions being randomized was echoed by students who acknowledged that they could not cheat using MP, but would have been forced to find how to do problems themselves as opposed to just copying answers from others. Combine this with their praise for having multiple chances to complete their work, which has been shown to help students achieve more (Kortemeyer, 2015), and it is clear that the MP platform did have some qualities that helped students in the performing phase of SRL.

Negative performing. While students were able to enumerate the positive impacts that MP had on their performance ability, they were also able to enumerate the negatives--and these with more direct sentiments. The largest code within this category was titled giving up and contained 18 instances where students indicated that MP made them want to just give up on the assignment. Theresa expressed her feelings as:

> It's literally like it's a back and forth with you and the computer. Like after a while, it's just okay, I'm not getting this right so I'm going to guess until I get it right or either guess until I run out of tries.

This feeling seemed to stem from the way in which MP presented them with the wrong answers. One student indicated this by saying that "a lot of times, I've lost faith in the thing and just skipped it." The "thing" here being MP and the "it" being the assignment. The way in which MP shows students they are wrong and the progressive way in which points are deducted with each attempt made for negative metacognitive monitoring experience witnessed by Jamara:

> Yeah. I feel as if like you start here like caring about your grade and stuff and you get a green check but it doesn't move up or down at all. And then, when you get an X, it like – then, you get a checkpoint and it just doesn't even out and you keep getting X and X and X until it's like I give up.

Even though students felt that MP's prohibition of cheating was a positive feature, such aggravating experiences drove some to look up answers elsewhere on the internet. This kind of behavior is expected but can produce the exact opposite of what students are hoping to achieve (Kashy, Albertelli, Bauer, Kashy, & Thoennessen, 2003). Even with the ability to look things up and the safety of multiple tries, Peter reported that "I got worried" and Jack said, "It made me like very anxious". These feelings turned into behaviors when Jack said that "after a while, I just started trying random numbers." Students indicated that assignments being on MP specifically made them less likely to complete the assignments. Students, like Jamara, felt defeated saying, "It's like what's the point in trying if you're going to get it wrong either way". All students (N=14) ended up submitting their assignments, but upon further examination, there were a few students who simply pressed the submit button without actually attempting to answer the questions. This only happened on seven assignments between three students. When asked why this was, students referenced other, more pressing, obligations that kept them from attempting the assignments. They submitted them so that I would see that they were finished with them. So even though students did report that MP made them less likely to complete homework, they did, by and large, submit and complete their assignments. This discrepancy can likely be explained by students wanting to please me and responding to my in-class reminders.

While MP isn't an instructional platform as much as it is an assessment platform students seemed to have wanted MP to help them learn physics and at least expected it to help them a little bit. This expectation likely came from the few times they did receive hints from the system but was certainly not met for Larry who said, "I never said oh, I can't wait to do the Mastering Physics. It's going to help me learn what I don't know. I never felt that way, no." So while some positive impacts on SRL behaviors could be tied to the MP platform. It appears that the negative impacts were more powerful in the minds of students.

SRL phase #3 – reflecting. Self-reflection is the third phase of SRL and can be recognized when students engage in self-judgment or self-reaction (Schunk & Zimmerman, 2012). This phase can be of particular benefit to secondary physics students (Li et al., 2018). This category includes codes where students displayed self-judgment or self-reaction behaviors in relation to using MP. Interestingly, only positive impacts were reported by students across 31 instances of expression.

Positive reflecting. The categories prior to this one present a mostly negative picture of students' perception of MP and its impact on their SRL behaviors. All the difficulty that students experienced, however, seemed to have made the reward of completing an assignment or answering a question correctly all the more potent. In the words one self-satisfied Larry: "when you type in that answer for the first try and you get it right the first time, oh, my – that feeling, I love that, man. That's – that's a good feeling." This feeling was later tied to MP being electronic when Larry said, "You do get a sense, I guess when it's electronic like that and you know you got it right, you do get a sense of accomplishment from like getting it right." This positive self-satisfaction was one of the strongest positive responses that I received from my students. The ability to go back and review the scores for assignments gave students another ability to engage in self-evaluation by using MP in a way that they couldn't have done as easily with paper and pencil homework. When asked about MP's relationship to how they were doing in my physics course, Jack replied, "I think it's like oh, I did bad on this. What's this assignment about? I should review that a bit more." This showed that students were able to use MP to both evaluate their understanding and direct their review of the content.

In addition to helping students in self-evaluation and contributing to their self-satisfaction, students also reported that MP helped them answer questions on other assignments and portions of assignments. For example, Theresa claimed that,

> When I moved on to another Mastering Physics problem, I would sometimes refer back to my work for the problem before that or problems before that that I've done to get me or to push me in the right direction of solving that problem because sometimes, um, the problems build upon themselves. So, like for an assignment, you could get the first problem have something to do with finding like forces. And then, the next problem has something to do with kinematics.

In this instance, the student takes connected topics (kinematics and forces) and shows how they used one MP question to help them solve another. Even when students got the answers to questions wrong, the feedback they received included the correct answer and could help them with future questions. This could not be accomplished with paper and pencil homework and is illustrated by Peter who remarked, "When I requested the answer, all of – one of the problems before, I'd usually get the next one right just because I knew what to plug in." Peter is referring to problems that might employ a variable they found in a previous question. MP's ability to give students answers as they work through the problems keeps them from getting a domino effect of problems wrong where one incorrect answer triggers many more. MP's positive impact on the self-reflection phase of SRL seems to be a redeeming quality of MP.

The absence of negative reflecting. When students engaged in the self-reflection phase of SRL, they reported only positive effects with no negative comments on their engagement with self-reflection or self-judgment. This is likely because the reflection phase of SRL had to do with behaviors that did not always involve directly interacting with MP. For example, students said that MP helped them answer questions in class and helped them to practice or apply ideas from our class. This sort of interaction is not direct use of MP, but is more distant and based more on the physics content than MP itself. Zimmerman and Tsikalas (2005) studied a variety of computer-based learning environments and noticed that many of them only support SRL behaviors in one particular area. It seems that MP falls into this category and strongly supports the reflective phase, but struggles to support students in the others without also leaving them with a negative perception.

Students did report positive impacts on their self-judgement and self-reaction. These positive notes, however, seem to be shadowed by a dislike for MP itself and the way in which students interact with it.

Theme 2 | platform problems. The first theme of my findings answered most directly how specific SRL skills were impacted by implementing the MP platform. During my focus groups, it became clear that I was also going to learn how this might have happened. After all, MP is designed to be a helpful tool and is meant to go a long way in helping students to master physics as its eponymous name implies. The theme of platform problems that arose from my qualitative data has to do with student experiences that highlight what it was actually like to use the software as a student. These experiences were largely negative as indicated by the title of this theme. The collective voice of the students can be heard in this theme that the MP platform was plagued with user issues that frustrated students and deteriorated MP's effectiveness.

This theme differs from the negative aspects of the first and final theme in these findings in that it specifically focuses on issues that students faced with the interface or nature of MP. It does not, for example, have to do with their perception of the quality of the feedback they received or the way in which MP affected their behaviors. Rather, this theme explores the issues that may have led to these other thematic findings.

Even though elements such as frustration can serve as a motivation for students to be more metacognitively active, it can also hinder them from doing so (Artino Jr & Jones II, 2012). In this study, it seems that the latter was true. In fact, this engagement and positive learning experience along with ease of access were one of the intended outcomes listed by the creators of MP (Pearson, 2018).

These student experiences should not be ignored in forming the findings of this study. This theme subsumes four categories: 1) technical difficulties, 2) inconvenience, 3) frustration, and 4) difficulty. The nature of these categories and their meanings is discussed in the following sections.

Technical Difficulties. The category called technical difficulties included all codes that dealt with any failings of either the MP platform or the devices and networks used to access MP. None of these difficulties prevented participants from accessing MP for very long, but they caused slight barriers to their use of MP. The codes in this category did not contain any excerpts where students were experiencing trouble due to user-errors, but only when they were experiencing errors that seemed outside of their control. Not every fault here can be attributed to the MP platform, although some can. Regardless, students expressed their frustration with any part of the MP experience as being related to MP.

Students frequently mentioned the technical difficulties during the interview. Nearly all (N=12) indicated at least some kind of technical problem. Consider the interaction below where all participants in a single focus group indicated a problem:

Theresa: Sometimes, [MP] doesn't load all of the way. Um, yeah. So, I remember one time, I logged in and I went to click on an assignment and I clicked on the assignment and then, I finished the assignment like completed it and then pressed the arrow button to go to the next one. And it was like it can't load. It couldn't load the next question or wouldn't come up. And I would have to like reload it and then, log out and then, log back in.

Interviewer: Yeah. But just by show of hands, how many has that happened to at least once? Really? That's everybody for the person listening to the recording. All of the hands are raised.

Imagine the frustration generated by such an experience. Other kinds of technical difficulties arose as well. Roger indicated that he, "had to change [his] password five times" while Hannah said that "it takes like a long time for me to tell if it's like correct or wrong". Forty-six different times students indicated that their experience was tainted by technical difficulties. These ranged from small glitches to student data getting erased causing work to have to be redone. In addition to students expressing their technical difficulties explicitly within the transcript of the focus group, there were a few times when this occurred in a more audible, less textual way. For example, consider the extended conversation below that directly followed the above interchange. Here, focus group one is discussing problems surrounding requesting answers from MP. Notice the variety of speakers as well as the transcriptionists indication of crosstalk:

Hannah: I've had to refresh the page like a lot of times for it to like – or like if I go to submit my answer, it takes like a long time for me tell if it's like correct or wrong.

Interviewer: Mm-hmm.

Hannah: Or if it tells me it's like correct, it won't tell me – like sometimes it like hasn't shown me the answer for it and I'll be like what is it then.

Jamara: Or like sometimes, it will say it's wrong.

Hannah: Mm-hmm.

Jamara: But then, you go to put another answer and you click submit and you see correct from the last one and then, like – and then, like it glitches and says incorrect again.

Hannah: Mm-hmm.

Jamara: And then, you get incorrect –

Hannah: It glitches.

Jamara: -- and then, you put in the same thing again and it just takes forever to load and say correct.

Jack: Or like, um, sometimes when you're requesting – when you just cannot find the answer and request it, like the requested answer doesn't come up either.

Oliver: Yeah. I've had a couple of times when it was it's taken like a couple of clicks to like get it to work.

Jack: Yeah. It like has to reload the whole thing and then, the section where –

Interviewer: Are there – are there sometimes where you never were able to see the requested answer?

Jack: Some – some of mine were like that.

Interviewer: Some of yours? Anybody else's? You were never able to see –

[Crosstalk]

Roger: Yeah, it eventually worked but it was hard – it was hard to find.

Hannah: Oh, yeah. It eventually did. It was slower but yeah.

This crosstalk is the sort of energetic bubbling of words that emerges from the mouths of excited teenagers. To me, it indicated that the nerve of common experience had been struck and that these students were resonating, quite literally, with their shared thoughts. Technical difficulties certainly struck a chord with the students.

Inconvenience. The inconvenience category, the smallest in this theme, contains three codes that shed light on an additional piece of MP problems that students experienced. This category included statements (n =5) from students that did not indict MP itself, but rather the way in which the use of MP interacted with their other online ecosystems and experiences. Since our school district provides every secondary student with a Chromebook, nearly every teacher makes use of the Google Classroom website for organizing content and homework assignments. The problem that arose for the students was that MP was completely separate from their other school-related work. Larry stated that “my stuff that isn’t paper that is online is all through Google Classroom”. This out-of-the-way nature of MP combined with the assignments being relatively short made MP “easy to push back” for Peter to the point of forgetting about it as mentioned by Larry who said, “I know it’s not a lot and I know it won’t take me long to get it done so I push it away more and it’s like I forget about it”. In addition to technical difficulties, the perceived inconvenience of students like Mikayla who said, “[MP is] not something we use as frequently as the rest of the stuff so it’s just in the back of our mind” adds just another small barrier to their more full engagement with MP.

Difficulty. The difficulty category was limited to codes that contained references to the challenging nature of the content as opposed to technical difficulties or annoying features of MP itself. I carefully selected the MP questions to align with the South Carolina high school physics standards and chose them based upon the level of difficulty that I believed Honors Physics students should receive. However, discrepancies in how students and instructors perceive question difficulty are commonplace and are linked to lower achievement (Lingard, Minasian-Batmanian, Vella, Cathers, & Gonzalez, 2009). Each of the codes in this category made reference to a particular characteristic of the MP questions themselves. There were over 60 instances where students referenced how difficult MP was for them.

My students said that MP was mainly difficult because of the confusing nature of the wording of the problems. Consider the following separate quotations that all show how students viewed MP problems as being hard to understand:

Oliver:	. . .it's like so different in the way it's worded. It's kind of hard to read it, you know.
Jamara:	Well, I feel like it's not harder but it's more like confusing because like it's worded differently sometimes. It's just the language.
Roger:	I understand what happens in class. And then, I get in Mastering Physics and it's worded so different that I can't understand what it's saying.
Jamara:	It's like English work for math or something.
Jamara:	It's like doing a crossword puzzle in another language.

It was interesting to me to see that students did not attribute this difficulty so much to the content as they did to the wording of the questions. Students seemed confident in the material but unable to decipher the way questions were being asked.

Now, students believed that they were attempting difficult questions to begin with. Roger saying that "I feel like I'm a sophomore in college. I really think that Mastering Physics is not something that a physics honors class should be doing", and "It's worded like an SAT problem" demonstrates that students thought of these questions as difficult to begin with, but that they could have been made doable if the wording had been changed to more easily reveal the underlying physics concepts being assessed. Theresa nicely summarized this:

> The questions make it hard. Well, they don't make it hard but like the way the question is formatted, it makes it difficult to pull up the variables that you need and like the information that you actually need to solve the problem.

Theresa did not believe that the underlying physics skills needed to solve the problem were hard, but that how this information was communicated obscured what the question was asking. At first, I chalked up these statements to high school students just struggling with word problems as many normally do. However, when I began to compare these questions with other questions I have given to my Honors Physics classes, it became apparent that MP questions seemed to cause students more trouble. Figure 4.14 shows a question that I have used for many years with my students without detecting any problems with the wording while Figure 4.15 shows a very similar question from the third MP assignment that my students complete. Both questions seem to have very similar wording and require similar physics skills that would be expected of any secondary physics students. The questions only differ in terms of the object that is being featured in the prompt as well as the given variables.

34. A shell is fired from the ground with an initial speed of 1.70×10^3 m/s (approximately five times the speed of sound) at an initial angle of 55.0° to the horizontal. Neglecting air resistance, find

a. the shell's horizontal range

b. the amount of time the shell is in motion

Figure 4.14. Previous Honors Physics Question.

The archerfish spits at land-based insects to cause them to fall into the water, where they are easy prey.

If the archerfish spits its water 45 degrees from the horizontal aiming at an insect 2 m above the surface of the water, how fast must the fish spit the water to hit its target? The insect is at the highest point of the trajectory of the spit water. Use $g = 10\ \mathrm{m/s^2}$.

Figure 4.15. Question from an MP assignment.

In light of this, my students' statements regarding difficulty seem to be influenced somewhat by the fact that they are delivered to them via the MP platform.

Frustration. The frustration category was perhaps the most passionately communicated concept in my focus group interviews. While I only coded 36 instances of textual evidence, it is almost impossible not to hear the frustrated way in which teenagers might have the following interchange:

Larry:	Mastering Physics is like this rigid like prison.
Mikayla:	You're not wrong.
Larry:	And it's just not fun.

The codes in this category encompassed text that expressed annoyance or frustration with the MP platform as a whole. It is interesting to note that these codes did not include expressions of how difficult the material was, as indicated by the category following this section, but rather included frustrations with MP itself. While frustration is a common experience during the integration of classroom technology (Hove & Corcoran, 2008; Potts & Potts, 2017), and it can hardly be said that MP was intended to be fun, my students were not mainly frustrated by the content of MP as much as MP itself. They indicated that this frustration made them less likely to complete their homework. Part of my intention in choosing MP for my classroom use was to give my students a tool to be able to check to see if they were doing this write without needing to be present. While this did occur, my students, like Theresa, viewed this as "a back and forth with you and the computer" that ends with "guess[ing] until I get it right or either guess[ing] until I run out of tries". So, this frustration with MP did not just present a barrier to students wanting to engage with MP, but also pushed them to simply guess at correct answers rather than attempt solutions.

It could be reasonably expected that students would find MP initially frustrating, but grow to like it more over time simply through familiarizing themselves with MP through mere exposure (Zajonc, 1968). One could also reason that students will like MP initially, but that the novelty will wear off and lead to increased frustration (Gravetter & Forzano, 2018). My findings are not consistent with either one of these reasonable predictions. My students said that they were frustrated with MP at the beginning, middle, and end of their experiences. Consider the interchange below that features multiple students as well as the crosstalk discussed previously. Both are indications of a nerve being struck regarding a shared experience:

Interviewer: Gotcha. Um, can you tell me about a time when working with Mastering Physics frustrated you?

Theresa: All the time.

[Crosstalk]

Jack: Every time.

Roger: Every single question, every single time I open the computer and clicked on the picture that said Mastering Physics.

Theresa: Well, actually, I say after – after Assignment 2. Assignment 3, 4, 5, and 6 aggravated the mess out of me.

Interviewer: What part was the most frustrating?

Theresa: All of it.

The frustration with homework is a societal trope that was not lost on these students. In fact, Jamara said, "The thing about Mastering Physics that frustrated me so much is it's like other homework". This sentiment was shared by other students who expressed typically enjoying other forms of physics homework. The frustration that my students reported was born from the technical difficulties, inconvenience, and challenging questions that my students experienced. These factors created a sense of annoyance and aggravation that leads me to conclude that the MP platform was plagued with user issues that exasperated students and deteriorated MP's effectiveness.

Theme 3 | Feedback Failures. The final theme of this study's findings revealed what students thought about the feedback provided to them from MP. Feedback is "one of the most powerful influences on learning and achievement" (Hattie & Timperley, 2007, p. 81) and MP was chosen for this study, in part, for its ability to provide physics students with timely feedback that students seem to enjoy (Matchett Wood & Bhute, 2019). The three categories that make up this theme subsume codes that relate to ways in which students perceived the quality of the feedback they received from MP. These categories are 1) Comparisons to class, 2) Positive Perceptions of Feedback, 3) Negative Perceptions of Feedback. Students expressed their feelings both directly and through a comparison to other activities they had done in physics class. Students seemed to have high expectations for the feedback that they were hoping to receive. These unmet expectations manifested themselves in comparisons to other class activities as well as negative comments regarding the MP feedback. While students did express some positive perceptions of feedback quality, the largest category in this study with 22 codes demonstrated that students did not perceive the feedback provided by MP as high-quality feedback.

Comparisons to Class. This category was an unexpected emergence from the focus groups. No focus group questions were planned to probe students' thoughts on how MP compared to other types of physics homework that we had done in class, yet 46 instances of students' comments on this comparison were recorded. Echoing their negative thoughts regarding the formatting of questions in MP from the previous theme, Hannah felt that "It's just the way you format it that makes it easier for us to understand." This attitude regarding how questions and concepts were formatted in class impacted students as they completed MP as can be seen in the exchange below:

Interviewer:	Good. Um, can you describe your thought process while you're completing a Mastering Physics problem? So, here's the problem. You read it. What's your thought process?
Jane:	If it doesn't look like what you did in class then, I start requesting answers. I mean –
Peter:	And hope I get it right.
Jane:	Yeah.

This snippet demonstrates that students were comparing their MP experience to what they saw in my class as a gauge for whether or not they would understand it. When I first heard this sentiment, I chalked it up to my class material being easier or simpler despite trying to select MP questions with an appropriate difficulty level. The next exchange showed this was not correct. My students did not believe that class material was easier:

Interviewer:	So, you're saying you feel like you understand the material but because of the way that Mastering Physics presents itself to you, presents the material to you that it – that's

where – that's where the fall – it's not that oh, I really just don't understand kinematics.

Oliver: Yeah.

Roger: Yeah. Like I was saying, if every Mastering Physics problem was worded like the concept builders, Turd-the-Target or what you – how you word it in class, I would get 100's on all of them.

Jamara: I wouldn't say it's like – I wouldn't say your class is easyat all. It's just interesting. Like that's why it's so different from every other class at [this school]. Like when they would go to Mastering Physics and I feel like it's homework for every other class.

It bears pointing out what is meant by "Turd-the-Target". This is a game simulation from a website another physics online homework platform. Students referred to Turd-the-Target and the other activities we completed using this website as concept builders (CB). CB were mentioned by students on eight separate occasions--each time comparing CB more favorably than MP. I did not set out to have students compare MP to anything else they had experienced in my class, but many felt passionate about how CB had helped them. One reason for this attitude was that CB offered what students perceived to be a more robust feedback system. In one of the simulations, students needed to determine an unknown variable of an object's motion. If they were incorrect, they saw the object sail over the target or miss under the target. How far off they were indicated how close they were to the answer. After each try, the problem variables would change causing students to have to try again. Even though MP was able to tell students whether they were right or wrong, CB made them more aware of how close their answer was to being correct. In an end-of-year reflection assignment that simply asked students to reflect on what helped them learn this year and what did not, Sarah said, “In my opinion, the concept builders helped me learn physics. It helped because it made me think about the situation on how to solve the problems.” Other students commented on how the CB had helped them as well. MP wasn’t let off the hook in this assignment, Hannah nicely summarized what three other students voluntarily brought up:

> I think just about every activity helped me with physics except Mastering Physics which was just difficult to navigate and use overall, but everything else in this class has taught me a wide understanding of Physics and some of the subjects within it. The only issue with Mastering Physics was difficulties with getting answers wrong for an answer submitted that's very similar to the “real” answer when in fact that answer submitted wasn’t technically wrong there is just room for different numbers to be placed (example: if you had to round up or down a number or if you didn’t round at all they’d be right but they’re different numbers), and then another issue would be there was minimal help and actual instruction in its problems.

This extended quotation nicely demonstrated how students, when comparing MP to my class, felt. Hannah ranks MP as the least helpful to her learning of Physics and directly ties this to the way in which feedback regarding her answers was delivered to her.

Positive Perception of Feedback. MP presented students immediate feedback regarding whether or not their answers were right or wrong and if their incorrect answers were because of rounding of significant figures errors. Less often, and depending on the question, students were given more elaborate feedback in the form of a hint. This category contained 11 codes that acknowledged the existence of MP feedback or contained positive attitudes toward it. These codes subsumed 70 instances of students expressing a positive perception of the feedback they received from MP. The existence of feedback was included as a positive perception due to many students having an initial misunderstanding of what constituted feedback. In this study, like others (Glover & Brown, 2006), students appreciated the immediacy of the feedback and knowing whether it was right or wrong. Also, like other students, my students said they benefited more from the elaborated feedback (Van der Kleij et al., 2015).

My students appreciated the ease with which they could access the feedback information from MP. This included their previous scores, time spent on assignments, and other data. The feedback that was the focus of this study was the kind that was given to students when submitting an answer. Regarding this feedback, Roger said, "if it gave me feedback, I normally used it" while other students indicated that even small hints were helpful. In general, students thought that the feedback provided by MP was clear. Larry indicated that "if you're talking about textual feedback being like the units or the sig fig rounding then, yeah, I mean, because that's – there's not much for it to be clear about." This is certainly positive thought regarding the feedback, but you can clearly hear the qualification that Larry is using. In fact, 18 different quotations were coded in this category in which students gave a positive description about the feedback provided by MP, but did so with some sort of qualification. Consider the following quotation from various portions of the focus groups where students qualified their positive statements:

Hannah: It's like hovering over you the entire time that you're working. I wouldn't want that.

Theresa: Well, with rounding, I feel like that's easy to fix. But like if I get the whole entire number wrong, it's just like what – what did I – where did I go wrong.

Larry: Well, yeah, because there's not much for it to be clear about. It's just like oh, here's your – you're either rounding wrong or you're using the wrong units.

Mikayla: I mean, it tells you you're wrong and you have a couple more tries left but it doesn't tell you how you're wrong, what you did wrong.

These qualifications point to the lack of strength that students' positive perceptions carried in their minds. They clearly recognized a few positive aspects of MP feedback, but it was couched in terms of its inadequacies.

While conducting the focus groups, it became apparent that some of the praise for MP's feedback came after I pointed out the boundaries of what feedback was. Some students did not, at first, perceive MP telling them that the answer was right or wrong as feedback. To students who had mainly had experience with paper and pencil problems, such as myself, knowing whether or not you are right or wrong seems like wonderful feedback. My students, however, have had quite a bit of experience with online platforms including the CB in my class. Perhaps the charm of immediate feedback has worn off for them. My students did have positive statements to make about MP's feedback features, but they rarely went beyond the level of calling MP's feedback anything more than somewhat helpful.

Negative Perceptions of Feedback. Online homework platforms are not necessarily viewed as better or worse by students (Demirci, 2007), but online learning platforms typically are viewed positively (Chandra & Fisher, 2009). Often, online homework fairs either favorably or equally among students in terms of perception and performance when compared to paper-based homework (Hauk et al., 2015; Hernandez-Julian & Peters, 2012; Matchett Wood & Bhute, 2019). However, since my students were not comparing their homework to a paper-based option, perhaps they were unaware of what to compare MP too, and thus viewed it so negatively along with the aforementioned reasons. The negative perceptions of feedback category was the largest category derived from the data in this study. With over 145 negative expressions organized into 22 codes, it carries the most numerical weight in these findings. This category subsumed codes where students expressed a negative perception of the feedback generated for them by MP.

One reason that students did not view the feedback given to them as being high quality was that they did not view what they were receiving from MP as feedback in the first place. In designing this study, the MP feedback identified related to information about correctness, and elaboration on rounding errors, significant figure errors, and occasionally hints. Students, on the other hand, did not seem to count this as feedback. Several students claimed that MP did not provide them with feedback of any kind:

Oliver: I know that if I get it wrong, there's going to be like feedback to like kind of help push me in the right direction.

Roger: The feedback was normally never there.

Mikayla: No. We don't get feedback, not really.

Jamara: The main problem is when [feedback is] there though because it never was.

These students are receiving feedback as identified by the researcher, but are not recognizing these experiences as receiving feedback. When asked plainly what they thought about feedback from MP, students curtly replied that they did not receive any feedback. It became apparent that when students heard the word feedback, they were looking for something more. Hannah put it this way, "when we got it correct or if we got it wrong, it didn't tell us why we got it wrong." Even after explaining what I meant by feedback, Larry said, "what you're saying about the feedback if I'm getting it right or wrong, that's obviously feedback. But it's not enough." Larry's "not enough" is a condensed version of how every student expressed their view of MP feedback. Students even went so far as to offer suggestions on how MP could be improved. For example, Jamara suggested that "I feel like instead of it saying incorrect, you have three more tries, it could say incorrect, you have three more tries. And also, here's a hint." While some students did receive helpful hints from MP, Larry's "never enough" seemed to be the prevailing view.

The desire of MP to have more hints was directly expressed by students and was compounded by the fact that students took the introductory MP assignment that indicated that they would receive hints. I required students to complete the introductory training assignment but did not intentionally lead them to believe that this introductory assignment would reflect every question they would encounter on my assignments. There were several other features covered in the introductory assignment that were not included on their questions. In the following section, Mikayla mentions how frustrating this was and indicated that her MP experience would have been improved had she had the hints:

Mikayla:	It – it bothers me that when we were doing our introductory assignment, not like Assignment No. 1 but how to work Mastering Physics, it said there was going to be hints if you needed it and there were no hints throughout the rest of it.
Interviewer:	Gotcha.
Mikayla:	So, I feel like with those hints, we would have been able to do it easier.

Perhaps my students who have been exposed to numerous types of online learning platforms have developed a palate for more elaborated feedback. Explanations were what they were looking for rather than just an indication of correctness. Even more elaborate help with rounding or significant figures was not considered beneficial as can be seen in this interchange:

Interviewer:	Okay. So, did that – did knowing that you're going to be able to know if you're doing it right help you start the assignments?
Larry:	No.
Peter:	Sort of.
Larry:	Kind of. It doesn't really affect –
Peter:	Because even after you get it wrong, you still don't know the answer.

Mikayla: Exactly. You don't know.

Jane: You have four more tries left.

Mikayla: I mean, it tells you you're wrong and you have a couple more tries left but it doesn't tell you how you're wrong, what you did wrong. And when you get it right, the most feedback I got was oh, you rounded differently.

Larry: Yeah, yeah, yeah, yeah.

My students seemed to view MP as inadequate. Perhaps not having to complete as much paper-based homework has made them unaware of how nice some of MP's features are, or perhaps they struggled with the material enough to feel underserved by a system that did not explain their errors to them. In terms of both frequency and content, students did not perceive the feedback provided by MP as high-quality feedback.

CHAPTER 5

DISCUSSIONS, IMPLICATIONS, AND LIMITATIONS

The purpose of this action research was to evaluate the impact of MP, an individualized online homework platform, on students' self-regulated learning skills and perceptions of feedback quality in a South Carolina high school. This chapter was written to answer the research questions proposed at the beginning of this study. The findings from the previous chapter asserted that: 1) the MP platform did make some positive impact on student SRL behaviors, but these impacts were outweighed by the negative SRL behaviors produced by MP, 2) the MP platform was plagued with user issues that exasperated students and deteriorated MP's effectiveness, and 3) students did not perceive the feedback provided by MP as high-quality feedback. Using these findings in conjunction with the findings from the quantitative data, a discussion of the research questions is given. Following this, the implications of this discussion are given in terms of personal, contextual, and future implications. Finally, the limitation of the study are discussed and closing thoughts by the researcher are given.

Discussion

Research Question 1: How and to what extent does the implementation of individualized online homework and feedback impact self-regulated learning among Honors Physics high school students?

Upon beginning this research, I was curious to see whether merely implementing an online homework platform and the feedback it provided would positively impact students' ability to engage in SRL behaviors. A clear tie between the characteristics at the heart of SRL and science student achievement exists (Schraw et al., 2006) and can be of particular benefit to science students who are directly taught SRL skills (Seraphin et al., 2012). Conversely, reduced ability to engage in SRL behaviors can be seen among students who experience a more rigid environment in which to explore science (Neber & Schommer-Aikins, 2002). This study was designed to determine if the implementation of MP might enhance students' ability to engage in SRL due to the feedback that it provides. Online platforms can make engaging in SRL behaviors easier for students by providing them with tools to measure their progress, make multiple attempts on problems, and receive immediate, elaborated feedback (DiBenedetto & Bembenutty, 2013; Jacobson & Archodidou, 2000; Tabuenca et al., 2015). The findings of both the qualitative and quantitative data in this study were used to draw conclusions regarding 1) SRL Phase #1 – Forethought 2) SRL Phase #2 – Performing 3) SRL Phase #3 – Self-Reflection. The conclusions drawn about each of these phases are discussed below.

SRL Phase #1 – Forethought. Planning for cognitive activity can have large benefits to student achievement (Bembenutty, 2009; Schunk & Zimmerman, 2012). The students in this study reported that they did not at all enjoy using the MP platform itself, irrespective of the content it was covering. Larry indicated that he "forgot MP even existed" while Roger "anticipated on getting them all wrong". This lack of motivation and dismal view of MP kept students from engaging strongly in the forethought stage of SRL. Results of the paired sample t-test for the OSLQ subsections of goal-setting and environment-structuring support the qualitative findings that MP did not make a positive impact by showing non-significant differences between pretest and posttest scores. I did not record personal conversations apart from the focus group interview but can certainly recall students chattering amongst themselves about their forgetfulness surrounding MP. Unlike the students who connected MP directly to their negative forethought phase experiences, the few students that indicated that they positively engaged in the forethought phase of SRL did not connect this positivity with MP itself. These positive comments seem more likely to be the result of honors students engaging with MP while already possessing advanced SRL skills.

SRL Phase #2 – Performing. Like the forethought stage, the performing SRL stage demonstrated that students did experience some positive impacts in this area, but mainly expressed their negative feelings and actions towards the characteristic SRL performance behaviors. Unsurprisingly, students did appreciate having five chances to answer questions correctly (Kortemeyer, 2015). They also indicated that MP helped them in a variety of other ways, but with little enthusiasm or specificity. Negative performance characteristics were vocalized more frequently and with greater passion. Jack's "It made me like very anxious" and Larry's "I never said oh, I can't wait to do the Mastering Physics. It's going to help me learn what I don't know. I never felt that way, no" indicates the ways in which the performance phase of SRL was hindered. The results of quantitative data collected through the OSLQ support these qualitative findings. The task-strategies and time-management subsections of the OSLQ align with the characteristics of the SRL performance phase. Neither the paired sample t-test for the task-strategies subsection nor the time-management subsection revealed a significant difference. It does not seem that the implementation of MP was able to positively impact students' ability to engage in the SRL performance phase.

SRL Phase #3 – Self-reflection. Reflecting upon cognitive activity can have a sizable effect on student achievement (Hattie, 2008; Yan, 2020) among secondary physics students (Nikou & Economides, 2016). In this study, students made only positive remarks about MP's impact upon their ability to self-reflect. Larry's remarks that "you do get a sense of accomplishment from like getting it right" especially "when it's electronic like that and you know you got it right" point to the fact that the MP platform's immediate feedback did provide students with a strong sense of personal achievement. This MP feature did more than just cause students to celebrate. Jack's "I did bad on this. What's this assignment about? I should review that a bit more" directly points to how MP can be used to engage students in the third SRL phase.

Despite these positive remarks, the OSLQ subsections that align with the self-reflection phase did not show a significant difference between pretest and posttest scores. Neither the self-evaluation subsection nor the help-seeking subsection revealed a significant impact. There is an apparent discrepancy between seeing only positive comments regarding the self-reflection phase of SRL, but not detecting any significant positive impact in the aligned OSLQ subsections. This discrepancy lies right at the heart of the assertion for Theme 1 of the qualitative findings—the MP platform did make some positive impact on student SRL behaviors. However, these were outweighed by the negative SRL behaviors produced by MP. Without the negative experiences that students had, perhaps a single significant difference on the OSLQ pre-post scores would have been detected.

Students had a negative experience with MP largely due to the way in which MP presented itself. Every student found themselves frustrated by at least one experience with technical difficulties that ranged from minor inconveniences to major losses in work. Despite having questions that were very similar to what they had experienced in class, they perceived the MP questions as being more difficult. These factors, along with feelings of being inconvenienced by MP, contributed to MP's positive impacts being negated in the eyes of students with Roger saying, "I really think that Mastering Physics is not something that a physics honors class should be doing." What positive impact on SRL might have been made by MP was lost due to platform problems.

Research Question 2: How does the implementation of individualized online homework impact students' perception of the feedback quality provided by an individualized online homework platform?

Feedback is a powerful tool for a teacher (Harks et al., 2014; Hattie, 2008; Hattie & Timperley, 2007). With such a large impact, it is important for students to perceive of this feedback as being high quality. MP provides elaborated feedback in an online setting that could impact student achievement (Chen et al., 2018; Gutmann et al., 2018; Van der Kleij et al., 2015; Vogelzang & Admiraal, 2017). Whether or not students viewed this feedback as high-quality was part of the focus of this study. This section answers this question with two subsections: 1) perceptions of feedback and 2) class comparisons.

Perceptions of Feedback. Participants in this study did not perceive the feedback they received as high quality. This was evidenced directly by students offering commentary about the feedback they received. Mikayla nicely condensed these feelings when she said:

> I mean, it tells you you're wrong and you have a couple more tries left but it doesn't tell you how you're wrong, what you did wrong. And when you get it right, the most feedback I got was oh, you rounded differently.

This statement demonstrates that Mikayla understood the correctness feedback she was receiving and that the feedback was elaborated by the indication of rounding errors. Yet, she still did not believe this was good feedback. She wanted MP to explain exactly where she went wrong and how to correct it much the way that the research on formative feedback recommends (Narciss & Huth, 2004; Shute, 2008). Larry said as much when he said, "what you're saying about the feedback if I'm getting it right or wrong, that's obviously feedback. But it's not enough." Students knew that what they were receiving and how it could help them, but still did not view this as high-quality. The FES results also support this assertion. The low scores on this survey (M = 2.88, SD = 1.14) indicate that students did not view the feedback they received from MP as high-quality.

There were moments when students did express positive feelings towards MP feedback. These instances, however, were plagued by students not perceiving correctness information, rounding information, and significant figure information as feedback in the first place. This may be due to the introductory assignment providing them with a more robust hint feature. This hint feature was not included on every question in my assignments and students seemed to think of that as a lack of feedback, even though the hints provided to them both in my assignments and the introductory assignment were in no way tied to their responses. It seems that the less elaborated feedback provided to students was viewed negatively, in part, because of their previous exposure to the kind of feedback that MP could provide. Since they did not get this feedback on every question, students felt like they were missing out. Besides the fact that students did not always think of feedback in the same way that the researcher did, they also often qualified their positive experiences with MP feedback. Theresa expressed this qualification even while stating that MP could help her fix a problem, "Well, with rounding, I feel like that's easy to fix. But like if I get the whole entire number wrong, it's just like what – what did I – where did I go wrong." In other words, Theresa knew that MP feedback about her rounding might help her get the right answer, but because MP could not point out where she went wrong if she had a completely incorrect answer, she did not view the rounding feedback as being very helpful, high-quality feedback.

Class Comparisons. The above section shows how students directly made comment about the feedback that MP provided to them. However, students also indirectly displayed their views through the comparisons they made between MP and other activities we had performed in class. CB and specifically the Turd-the-target simulation were the main points of comparison. CB did provide correctness feedback but did not provide students with direct textual feedback about specific problems. Instead, it would direct them to a series of links to online textbook pages. The Turd-the-target simulation was pointed to by students as being extremely helpful. It is interesting to note that the feedback provided by this simulation is highly unique. Students attempt to launch an object at a target by solving for a particular variable such as height or velocity. After plugging in their number they are able to tell if they are correct by whether or not they hit the target, but they are also able to tell how close they were to getting the correct answer when they answered incorrectly. This information was given to them by the display of how far off their object was from hitting the target. This visual cue gave them information as to whether their answer was much too large, much too small, or somewhere in between. Visual feedback has been used in physics instruction (Rodrigues & Carvalho, 2014; Yuksel et al., 2019), but its use with an online homework platform in the way that CB uses it remains unstudied.

Students also felt that MP was unlike other homework that we had done in class through CB, and more like their homework from other classes that they viewed as being work for the sake of work. Despite past classes having very similar homework problems, putting these questions on MP seemed to make students feel that what they were doing on MP was unlike what they were learning in class. Students viewed classwork more favorably and had numerous suggestions for how MP could be improved. These views point to the idea that students did not view the feedback they received from MP as high-quality feedback.

Implications

The personal growth that I have experienced as a result of conducting this study cannot be underestimated. In addition to my personal growth, I hope this action research will benefit those in my particular context of teaching secondary physics. Finally, I hope that my research will inspire new questions to fuel future research for myself and my colleagues. This section details the implications that this study has produced in three areas: 1) personal implications, 2) implications for teaching secondary physics, and 3) implications for future research.

Personal Implications

In college, my introductory physics instructors used a similar platform to MP. In fact, it was alike in nearly every way. I remember my frustrations as a student and heading to my professor's office with a group of fellow, and thoroughly confused, students for help with our homework. We were offered none and our questions were usually never answered even after assignment due dates had passed. The platform itself was of little help. I recalled these experiences when I began teaching physics and was eager to find a way to use an online homework platform without causing my students the same duress that I had experienced. This study has helped me in that journey and has manifested itself in three main areas of understanding: 1) SRL insight 2) level differences, 3) the power of CB, and 4) student voices.

SRL insight. Before completing this study, I believed that students' SRL skills would improve simply through the implementation of an online homework platform. To me, the characteristics of Zimmerman's (2000) self-regulated learner seemed to be more easily achievable if learners had access to the tools that an online homework platform could provide. This study has helped me to see that merely the implementation of a platform is not sufficient in helping students engage in SRL. Rather, these skills are more likely to improve when they are taught directly (Nichols et al., 1997; Seraphin et al., 2012). For me, this means that I need to give strong consideration to how I am directly teaching my students to engage in SRL.

Level differences. Prior to this study, I had only ever used MP with my AP physics classes. I chose my honors class for this study because of the slower pace that this course takes in developing the content that my MP assignments were about. The six-week MP study would have been too long to spend on the kinematics and dynamics units in AP physics. One lesson that I took away from completing this study was that choosing to use MP with my honors class made a large difference. I continued to use MP with my AP students but chose to back off of using it a little bit this year as I was spending so much time on MP with my honors class. I solicited feedback from my AP class after a particularly challenging test and they all agreed right away that they wanted me to provide them more MP assignments. They said that MP really helped them gauge their progress and understand the material—MP was doing everything for them that its creators had claimed it would (Pearson, 2018). I was in disbelief since at this point in the year I had already completed my focus groups and knew that my honors classes were really having a hard time with MP. At this point in the study, I looked back at the types of questions that my AP students were answering compared to my honors classes. As expected, the AP questions were much more difficult, but both classes were receiving the same kind of feedback. The AP students were not receiving questions that happened to provide more feedback. This surprise made me wish that I had deliberately chosen only questions with all the possible feedback options for my students. While my AP students thoroughly enjoyed the feedback they were getting from MP, perhaps my honors students would have had more benefit had I focused on picking more questions that contained the kind of feedback they were looking for. This study helped me to realize the important role that elaborated feedback plays. MP has the capability to offer feedback with research-based characteristics such as elaborated tutorials on how to complete problems (Shute, 2008). For me, these characteristics have become far more important since the completion of this study, particularly when choosing which platforms to use with the different levels of my class. Hattie and Timperley's (2007) model of feedback suggests that feedback answer these three questions: 1) where am I going? 2) how am I going?, and 3) where to next?. This model also indicates that some learners, such as those in my honors physics class, and perhaps in the secondary context in general, may need more of a support structure for the feedback they receive. The level difference may divide students along thinking differences that change the way in which they engage with feedback (Butler & Winne, 1995). This may explain the different responses that I received from my honors and AP classes.

The power of CB. CB came up in my results organically from students in the form of unsolicited praise. Even in my end of the year surveys that were not included in this study, students sang unprompted praise for CB and its ability to help them understand physics. While I am eager to give MP another try, being careful to select feature-rich questions, I could not help but be amazed at how this free platform had made such a large impact on students. I often get asked by new physics teacher what sorts of websites can help them provide quality instruction. Many of these teachers do not have the kinds of resources that my district is able to provide its students. I am happy to be able to now send them the recommendation of CB with strong reasons as to why it works and what students think of it. Despite being free and likely used by many thousands of physics teachers, I could not find any studies that have been done on the learning gains that might be affected by CB.

Student voices. This study has grown me personally by making me more aware of how important student voices are in the classroom. Their perspectives on the tools being used in class are valuable and, in this study, often revealed issues that I would not have recognized without them. There is, of course, some sense in which students cannot be given complete control over their learning experiences, but this study has cemented in my mind that listening to their feedback is vital to improving their experiences and helping them to achieve to their fullest potential. Assuming that students do not like a particular instructional strategy or method just because they are students is unfair and unhelpful. My students' suggestions for improvements to MP indicate that the adaptive learning features of MP, that were not offered to them, may have benefited them more. Adaptive learning systems are able to provide feedback that is tailored to each learner's needs (Graf, 2011).

Implications for Teaching Secondary Physics

As a secondary physics teacher performing action research within my own classroom, this study has been particularly enlightening. The results of this study and corresponding literature highlight thee main takeaways for secondary physics teaching seeking to implement an online homework platform such as MP into their courses: 1) implementation considerations, 2) question selection, 3) setting feedback expectations, and 4) SRL in the physics classroom.

Implementation. Online homework platforms should not be carelessly incorporated into the secondary physics classroom. Careful attention to how the platform is implemented and used is important. Kortemeyer's (2015) suggestion of allowing five attempts for university students seemed to be appropriate for my study. If I were to use MP again for my honors physics classes, I would consider adding a few additional tries and removing any sort of penalty. This would be to remove the anxiety that my students experienced. Perhaps adjusting the number of allowed attempts throughout the course would be appropriate as students become more familiar with MP and the content. The creators of MP recommend four main ways of effectively implementing MP in the classroom: 1) require students to complete the work. 2) give the assignments at least a 10% value. 3) assign due dates. 4) use MP as a formative tool. (Pearson, 2018). These recommendations are important. My students remarked that they appreciated the due dates and were motivated by its requirement and grade. They mentioned that MP was able to allow them to reflect upon their learning which is one of the goals of formative assessment (Sarwar & Trumpower, 2015).

Question selection. MP is a platform that works with a wide variety of physics textbooks. Each of these textbooks is unique and contains a variety of question types that may or may not take advantage of all the feedback features of MP. The particular textbook that my students were using did not include very many questions that utilized these features. This may be likely because the book was a first edition and that I had chosen a narrow band of content from which to draw questions within the curriculum. Secondary physics teachers whose schools or districts are purchasing MP should consider selecting a majority of questions that utilize most, if not all, of the feedback features in MP. One example of this is the hint feature. While some of the questions delivered to my students during this study did contain a hint feature, many did not. The use of hints in MP has been shown to have a positive impact on student performance (Leow et al., 2018) and if MP is to be used in the secondary classroom, questions with this feature should be sought out for maximum effectiveness.

Setting feedback expectations. My students held strong views when comparing their experience with the introductory assignment and their actual experience within our six week graded assignments. Having seen many additional features of MP in the introductory assignment, their expectations for the kinds of tutorial help they would receive were very high. When their particular questions did not always have all these features, they were left disappointed and felt as if the feedback they experienced was robbed of quality. Undergraduate STEM students have been shown to have stronger expectations regarding electronic feedback (El Shaer et al., 2020), and this may likely be the case with secondary physics students as well. Secondary physics teachers should be careful to avoid setting high expectations for feedback that may not be met by MP. A good strategy would be to carefully explain what kinds of feedback to expect and not expect for each type of assignment within a course.

SRL in the physics classroom. MP and other online homework platforms are a much more efficient way for teachers to assign, grade, and give feedback than traditional paper-and-pencil assignments. The implementation of these platforms, however, should not replace investigation and exploration in the physics classroom. So while such platforms may be a place where students can use their SRL skills, secondary physics teachers should be careful to implement them in such a way so that they do not sacrifice inquiry-based activities. Doing so could cause what Neber and Schommer-Aikins (2002) refer to as "motivational disadvantages for self-regulated learning in physics for high school students" (p. 70). These disadvantages occur when students perceive that they are offered decreased levels of investigation in the science classroom. Teachers should use online homework platforms such as MP to enhance student experiences and make use of the additional time they will gain to plan and implement exploratory and inquiry-based activities.

Implications for Future Research

The deluge of technological tools in the area of physics education is made greater by the falling cost of student devices and internet access. In 2017 almost 64% of children were reported as having internet access at home (*Digest of education statistics*, 2018). This unprecedented access to technology and the internet makes the future seem bright for physics education. This section details four implications for future research in this area: 1) MP achievement impact on the secondary level, 2) simulation-based feedback, 3) feedback comparisons and 4) SRL in secondary physics.

MP achievement impact on the secondary level. MP has mainly been used and studied in the university context (Leow et al., 2018; Pearson, 2018). If used on the secondary level, its use has been primarily limited to the AP classroom. With many high schools now entering a one-to-one technology setting, the use of MP's impact on student achievement on the secondary level should be explored. In addition, this study only used a six-week intervention period. Future researchers should consider using longer intervention periods to further deepen our understanding of MP's impact on the secondary level.

Simulation based feedback. This study's findings showed that my students greatly enjoyed the use of CB—particularly simulation-based questions. Simulations are often used as an inquiry environment that can promote student engagement (Wen et al., 2020) and achievement (Rutten, Van Joolingen, & Van Der Veen, 2012) as opposed to an assessment platform. My students organically presented me with feedback both within the context of this study and beyond that they learned a great deal from these simulations.

More research on simulation-based questions as assessment tools and their effect on the learning gains of secondary physics students is needed.

Feedback comparisons. Quality feedback is a powerful tool in the pursuit of higher student achievement (Hattie & Timperley, 2007; Shute, 2008). As more and more quality feedback is presented to students, feedback that was once effective may begin to lose its novelty. The effect that being exposed to high-quality feedback has on how students engage with other kinds of feedback they are receiving is a topic that needs to be investigated further.

SRL in secondary physics. For many high school students, physics is a daunting class that lives up to its reputation of difficulty. Possessing SRL skills in the physics classroom can lead to higher achievement for physics students (Achufusi-Aka & Offiah, 2010; Nichols et al., 1997; Schraw et al., 2006; Seraphin et al., 2012). Since SRL skills contribute to student success in physics, further understanding of how science teachers can best teach students to use these skills is needed. Physics students would be well-served by teachers who know how to develop SRL skills in their students and capitalize on the SRL skills their students already possess.

Limitations

The limitations identified in this section are not meant to negate or cast doubt upon the findings. Rather, they are intended to better help the reader contextualize and place the findings in their proper place. Two areas of limitations are identified in this section: 1) limitations of methodology and 2) limitations of findings.

Limitations of Methodology

Action research can produce lasting organizational change and engages practitioners in a cycle of improvement and problem solving (Mertler, 2017). However, action research along with the specific methods and tools used to carry it out has limitations that ought to be considered.

One way in which this study was limited was in the use of student interviews in the form of focus groups. Schmuck (2006) points out that interviews such as the ones completed in this study struggle in that 1) they fail to equally represent all participants, 2) participants may not be completely forthcoming for fear of reprisal, and 3) participants cannot remain completely anonymous. The instruments used in this study are also limited in that they were modified to fit the context of this study. Small sample sizes (N=14) and the self-reporting nature of the OSLQ and FES also limited this study. Small sample sizes may not be large enough to completely answer a research question and self-reported measures can undermine the validity of the results (Northrup, 1997). This study was conducted over a limited time with participants using MP for just six weeks. This short exposure time further limits the study. Complete member checking, as I had intended, was also limited in this study. Due to COVID-19, I was unable to have study members review the complete findings of the study. Finally, this study was also limited in that the researcher was also the classroom teacher where the research was taking place. This dual-role has advantages (Mertler, 2017), but can also be a source of bias.

Limitations of Findings

The findings of this study are limited in that they cannot be generalized to other populations or contexts. Action research is strong in its ability to affect organizational change but the downside is that it is unable to be broadly applied (Mertler, 2017). The findings of this study are also limited in that they only apply to my context and with the teacher-made assignments that I assembled. This is particularly true of the question selection in MP itself. Choosing questions that all had the same level of feedback as the introductory assignment questions may have resulted in students viewing the feedback they received from MP as higher quality.

Conclusion

COVID-19 may have changed education for many years to come. In my district alone, over 10,000 students shifted to a remote learning format in just a few days. Such a dramatic shift resulted in teachers scrambling to find online platforms for activities they had never had to offer online before. This sudden demand put many educational technology tools on display. It appears that this shift will have lasting effects into the Fall of 2020 and likely beyond. In the coming years, it will become even more important that educational technologists continue to explore, through research, how to improve the experiences of online students. Feedback will play a central role in this change. Without as many face-to-face interactions with their students, teachers will need to take purposeful and research-based action to ensure that students are able to make full use of the electronic feedback they are given. SRL skills will quickly become even more necessary for student success in an environment where their activities are more in their control. Some educators likely view this shift and bleak and foreboding. The students that participated in this study have shown me otherwise. They have helped me to recognize that their educational experiences matter beyond just shaping them. They are also valuable in helping to shape the experiences of future students for generations to come. I plan to be among those listening to their voices and enacting change for the better.

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APPENDIX A

INFORMED CONSENT FORM

UNIVERSITY OF SOUTH CAROLINA

CONSENT TO BE A RESEARCH SUBJECT

21st Century Physics Homework: A Mixed-Methods Approach Evaluating How An Individualized Online Homework Platform Can Help Students Self-Regulate and Provide Quality Feedback, Among Secondary Physics Students in South Carolina

KEY INFORMATION ABOUT THIS RESEARCH STUDY:

You are invited to volunteer for a research study conducted by Scott Buhr. I am a doctoral candidate in the Department of Education, at the University of South Carolina. The University of South Carolina, Department of Education is sponsoring this research study. The purpose of this action research is to evaluate the impact of Mastering Physics, an individualized online homework platform, on students' self-regulated learning skills and perceptions of feedback quality in a South Carolina high school. You are being asked to participate in this study because you are an honors physics student. This study is being done in a large South Carolina high school and will involve approximately 30 volunteers. This form explains what you will be asked to do, if you decide to participate in this study. Please read it carefully and feel free to ask questions before you make a decision about participating.

PROCEDURES:

If you agree to participate in this study, you will be asked to do the following:

1. Complete an Online Homework Platform Orientation assignment.
2. Take the following pretests:
    A. Online Self-Regulated Learning Scale (A survey about your learning)
    B. Feedback Environment Scale (A survey about your learning environment)
3. Complete 6 online homework assignments.
    A. Assignments will be delivered once a week for 6 weeks.
    B. Assignments will take approximately 30 minutes to complete.
4. Take the Following Posttests:
    A. Online Self-Regulated Learning Scale (A survey about your learning)
    B. Feedback Environment Scale (A survey about your learning environment)
5. Participate in a focus group with the researcher that will last approximately 45 minutes.

DURATION:

Participation in the study involves the completing of pretests, posttests, homework assignments and interviews over a period of 8 weeks.

RISKS/DISCOMFORTS:

Loss of Confidentiality:

There is a low risk of a breach of confidentiality, despite the steps that will be taken to protect your identity. Specific safeguards to protect confidentiality are described in a separate section of this document.

BENEFITS:

Taking part in this study is not likely to benefit you personally. However, this research may help researchers understand if a connection exists between individualized online homework platforms and how students learn and perceive cheating.

COSTS:

There will be no costs to you for participating in this study other than possible costs related to transportation to and from the research site.

PAYMENT TO PARTICIPANTS:

You will not be paid for participating in this study.

INCIDENTAL FINDINGS:

Your information or biospecimens collected as part of the research study will not be used or distributed for future research studies.

CONFIDENTIALITY OF RECORDS:

Unless required by law, information that is obtained in connection with this research study will remain confidential. Any information disclosed would be with your express written permission. Study information such as assignment grades, survey responses, and interview transcripts will be securely stored in locked files and on password-protected computers. Results of this research study may be published or presented at seminars; however, the report(s) or presentation(s) will not include your name or other identifying information about you. Individual identities will remain strictly confidential.

VOLUNTARY PARTICIPATION:

Participation in this research study is voluntary. You are free not to participate, or to stop participating at any time, for any reason without negative consequences. In the event that you do withdraw from this study, the information you have already provided will be kept in a confidential manner. If you wish to withdraw from the study, please call or email the principal investigator listed on this form.

There is no penalty for not participating, and participants may withdraw from the study any time without penalty.

I have been given a chance to ask questions about this research study. These questions have been answered to my satisfaction. If I have any more questions about my participation in this study, I am to contact Scott Buhr at 864-355-3552 or email sbuhr@greenvilleschools.us.

Questions about your rights as a research subject are to be directed to, Lisa Johnson, Assistant Director, Office of Research Compliance, University of South Carolina, 1600 Hampton Street, Suite 414D, Columbia, SC 29208, phone: (803) 777-6670 or email: LisaJ@mailbox.sc.edu.

I agree to participate in this study. I have been given a copy of this form for my own records.

______________________	______________________
Signature of Subject / Participant Parent	Date
______________________	______________________
Signature of Qualified Person Obtaining Consent	Date

OR

I do NOT agree to participate in this study.

______________________	______________________
Signature of Subject / Participant Parent	Date
______________________	______________________
Signature of Qualified Person Obtaining Consent	Date

*For Minors 13-17 years of age:

My participation has been explained to me, and all my questions have been answered. I am willing to participate.

______________________________	____________
Print Name of Minor	Age of Minor
______________________________	____________
Signature of Minor	Date

APPENDIX B

IRB APPROVAL LETTER

UNIVERSITY OF
SOUTH CAROLINA

OFFICE OF RESEARCH COMPLIANCE

INSTITUTIONAL REVIEW BOARD FOR HUMAN RESEARCH
APPROVAL LETTER for EXEMPT REVIEW

Scott Buhr
218 Foxhound Rd
Simpsonville, SC 29680 USA

Re: **Pro00088880**

Dear Mr. Scott Buhr:

This is to certify that the research study ***21st Century*** **Physics Homework: A Mixed-Methods Approach Evaluating How An Individualized Online Homework Platform Can Provide Quality Feedback And Help Physics Students in South Carolina Engage in Self-Regulated Learning Secondary** was reviewed in accordance with 45 CFR 46.104(d)(1), the study received an exemption from Human Research Subject Regulations on **4/30/2019**. No further action or Institutional Review Board (IRB) oversight is required, as long as the study remains the same. However, the Principal Investigator must inform the Office of Research Compliance of any changes in procedures involving human subjects. Changes to the current research study could result in a reclassification of the study and further review by the IRB.

Because this study was determined to be exempt from further IRB oversight, consent document(s), if applicable, are not stamped with an expiration date.

All research related records are to be retained for at least three (3) years after termination of the study.

The Office of Research Compliance is an administrative office that supports the University of South Carolina Institutional Review Board (USC IRB). If you have questions, contact Lisa Johnson at lisaj@mailbox.sc.edu or (803) 777-6670.

Sincerely,
Lisa M. Johnson

ORC Assistant Director and IRB Manager

University of South Carolina ● 1600 Hampton Street, Suite 414 ● Columbia, South Carolina 29208 ● 803-777-7095
An Equal Opportunity Institution

APPENDIX C

HOMEWORK ASSIGNMENTS

Assignment 1

Problem 1.32

Description: A car starts from rest and reaches the speed of v m/s in t s. (a) What can you determine about the motion of the car using this information? (b) Find the average acceleration of the car.

A car starts from rest and reaches the speed of 12 $\mathrm{m/s}$ in 26 s.

Part A

What can you determine about the motion of the car using this information?

Check all that apply.

ANSWER:

- [x] the distance the car has traveled in 26 s
- [x] average acceleration
- [ ] the final location where the car goes
- [ ] the fuel comsumption

Problem 1.35

Description: A bus leaves an intersection accelerating at + 2.0 m/s^2. (a) Where is the bus after t s? (b) What assumption did you make? (c) If this assumption is not valid, would the bus be closer or farther away from the intersection compared to your original ...

A bus leaves an intersection accelerating at $+2.0\ \mathrm{m/s^2}$.

Part A

Where is the bus after 4.9 s?

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$x = \quad t^2 = 24\,\mathrm{m}$

Part B

What assumption did you make?

ANSWER:

- (selected) the bus starts from rest at the intersection
- the speed of the bus was constant before the intersection
- the acceleration of the bus was $-2.0\ \mathrm{m/s^2}$ before the intersection
- the bus reaches maximum possible acceleration at 4.9 s

Part C

If this assumption is not valid, would the bus be closer or farther away from the intersection compared to your original answer?

ANSWER:

- (selected) farther
- closer

Problem 1.38

Description: While cycling at speed of v m/s, Lance Armstrong starts going downhill with an acceleration of magnitude a m/s^2. The descent takes 10.0 s. (a) What can you determine about Lance's motion using these data? (b) Taking downward direction to be...

While cycling at speed of 9.0 $\mathrm{m/s}$, Lance Armstrong starts going downhill with an acceleration of magnitude 1.2 $\mathrm{m/s^2}$. The descent takes 10.0 s.

Part A

What can you determine about Lance's motion using these data?

Check all that apply.

ANSWER:

- [ ] air resistance
- [ ] the height of the descent
- [x] the speed of the cyclist at the end of the descent
- [x] the distance traveled during this time interval

Part B

Taking downward direction to be positive, find the speed of the cyclist at the end of the descent.

Express your answer with the appropriate units.

ANSWER:

$v = \ v + 10a = 21.0\,\frac{\mathrm{m}}{\mathrm{s}}$

Part C

Find the distance traveled during this time interval.

Express your answer with the appropriate units.

ANSWER:

$x = \ \frac{a \cdot 100}{2} + 10v = 150\,\mathrm{m}$

Problem 1.46

Description: The fast server in women's tennis is Venus Williams, who recorded a serve of 130 (mi)/h (209 (km)/h) in 2007. (a) If her racket pushed on the ball for a distance of d m, what was the average acceleration of the ball during her serve? (b) What was ...

The fast server in women's tennis is Venus Williams, who recorded a serve of 130 $\mathrm{mi/h}$ (209 $\mathrm{km/h}$) in 2007.

Part A

If her racket pushed on the ball for a distance of 0.13 m, what was the average acceleration of the ball during her serve?

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$a = \frac{58.1^2}{2d} = 1.3\times10^4 \frac{\mathrm{m}}{\mathrm{s}^2}$

Part B

What was the time interval for the racket-ball contact?

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$t = \frac{2d}{58.1} = 4.5\times10^{-3}\,\mathrm{s}$

Problem 1.65

Description: You accidentally drop an eraser out the window of an apartment h above the ground. (a) How long will it take for the eraser to reach the ground? (b) What speed will it have just before it reaches the ground? (c) If you multiply the time interval...

You accidentally drop an eraser out the window of an apartment 13 m above the ground.

Part A

How long will it take for the eraser to reach the ground?

Express your answer to three significant figures and include the appropriate units.

ANSWER:

$t = \sqrt{\frac{2h}{9.80}} = 1.63\,\mathrm{s}$

Part B

What speed will it have just before it reaches the ground?

Express your answer to three significant figures and include the appropriate units.

ANSWER:

$v = 9.80\sqrt{\frac{2h}{9.80}} = 16.0\,\frac{\mathrm{m}}{\mathrm{s}}$

Part C

If you multiply the time interval answer from the first part and the speed answer from the second part, why is the result much more than 13 m ?

ANSWER:

- (selected) The speed in the second part represents the maximum speed of the eraser.
- The speed in the second part represents the average speed of the eraser.
- The speed in the second part represents the minimum speed of the eraser.

Assignment 2

Problem 3.62

Description: Daring Darless wishes to cross the Grand Canyon of the Snake River by being shot from a cannon. She wishes to be launched at ## degree(s) relative to the horizontal so she can spend more time in the air waving to the crowd. (a) With what...

Daring Darless wishes to cross the Grand Canyon of the Snake River by being shot from a cannon. She wishes to be launched at 60 $^\circ$ relative to the horizontal so she can spend more time in the air waving to the crowd.

Part A

With what minimum speed must she be launched to cross the 520-m gap?

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$$v_0 = \sqrt{\frac{520 \cdot 9.8}{\sin(2\theta)}} = 77\,\frac{\mathrm{m}}{\mathrm{s}}$$

Also accepted: $\sqrt{\frac{520 \cdot 9.8}{\sin(2\theta)}} = 76.7\,\frac{\mathrm{m}}{\mathrm{s}}$

Problem 3.63

Description: A football punter wants to kick the ball so that it is in the air for ## s and lands ## m from where it was kicked. Assume that the ball leaves 1.0 m above the ground. (a) At what angle should the ball be kicked? (b) With what initial ...

A football punter wants to kick the ball so that it is in the air for 4.5 s and lands 45 m from where it was kicked. Assume that the ball leaves 1.0 m above the ground.

Part A

At what angle should the ball be kicked?

Express your answer using two significant figures.

ANSWER:

$$\theta = \operatorname{atan}\left(\frac{0.5 \cdot 9.8 t^2 - 1}{x}\right) = 65\ ^\circ$$

Part B

With what initial speed should the ball be kicked?

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$$v_0 = \frac{x}{t\cos\left(\operatorname{atan}\left(\frac{0.5 \cdot 9.8 t^2 - 1}{x}\right)\right)} = 24\,\frac{\mathrm{m}}{\mathrm{s}}$$

Also accepted: $\frac{x}{t\cos\left(\operatorname{atan}\left(\frac{0.5 \cdot 9.8 t^2 - 1}{x}\right)\right)} = 24.0\,\frac{\mathrm{m}}{\mathrm{s}}$

Problem 3.65

Description: An airplane is delivering food to a small island. It flies 100 m above the ground at a speed of v. (a) Where should the parcel be released so it lands on the island? Neglect air resistance. (b) Should the parcel be released earlier or later if ...

An airplane is delivering food to a small island. It flies 100 m above the ground at a speed of 170 $\mathrm{m/s}$.

Part A

Where should the parcel be released so it lands on the island? Neglect air resistance.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$$x = v\sqrt{\frac{2 \cdot 100}{9.8}} = 770\,\mathrm{m}$$

Also accepted: $v\sqrt{\frac{2 \cdot 100}{9.8}} = 768\,\mathrm{m}$

Part B

Should the parcel be released earlier or later if the air resistance is considered?

ANSWER:

- ○ the parcel should be released earlier
- ◉ the parcel should be released later

Problem 3.69

Description: Robin Hood wishes to split an arrow already in the bull's-eye of a target 40 m away. (a) If he aims directly at the arrow, by how much will he miss? The arrow leaves the bow horizontally at v.

Robin Hood wishes to split an arrow already in the bull's-eye of a target 40 m away.

Part A

If he aims directly at the arrow, by how much will he miss? The arrow leaves the bow horizontally at 42 $\mathrm{m/s}$.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

Δy = $\frac{1}{2}\cdot 9.8\left(\frac{40}{v}\right)^2$ = 4.4m

Also accepted: $\frac{-1}{2}\cdot 9.8\left(\frac{40}{v}\right)^2$ = -4.4m, $\frac{-1}{2}\cdot 9.8\left(\frac{40}{v}\right)^2$ = -4.44m, $\frac{1}{2}\cdot 9.8\left(\frac{40}{v}\right)^2$ = 4.44m

MCAT (R) Prep: Archerfish

Description: Translational motion is explored through a multiple-choice problem in the context of the spitting of an archerfish. MCAT Content Category 4a: Translational Motion.

The archerfish spits at land-based insects to cause them to fall into the water, where they are easy prey.

Part A

If the archerfish spits its water 60 degrees from the horizontal aiming at an insect 1 m above the surface of the water, how fast must the fish spit the water to hit its target? The insect is at the highest point of the trajectory of the spit water. Use g = 10 $\mathrm{m/s^2}$.

ANSWER:

- (selected) 5.2 $\mathrm{m/s}$
- 10 $\mathrm{m/s}$
- 2.3 $\mathrm{m/s}$
- 4.5 $\mathrm{m/s}$

Assignment 3

A World-Class Sprinter

Description: Find the force exerted by a sprinter on the starting blocks, given the sprinter's mass and acceleration.

World-class sprinters can accelerate out of the starting blocks with an acceleration that is nearly horizontal and has magnitude 15 $\mathrm{m/s^2}$.

Part A

How much horizontal force F must a sprinter of mass 55 kg exert on the starting blocks to produce this acceleration?

Express your answer in newtons using two significant figures.

Hint 1. Newton's 2nd law of motion

According to Newton's 2nd law of motion, if a net external force F_{net} acts on a body, the body accelerates, and the net force is equal to the mass m of the body times the acceleration a of the body:

$$F_{\mathrm{net}} = ma.$$

ANSWER:

F = $m_0\cdot 15$ = 830 N

Part B

Which body exerts the force that propels the sprinter, the blocks or the sprinter?

Hint 1. How to approach the question

To start moving forward, sprinters push backward on the starting blocks with their feet. Newton's 3rd law tells you that the blocks exert a force on the sprinter of the same magnitude, but opposite in direction.

ANSWER:

- (selected) the blocks
- the sprinter

To start moving forward, sprinters push backward on the starting blocks with their feet. As a reaction, the blocks push forward on their feet with a force of the same magnitude. This external force accelerates the sprinter forward.

Problem 2.21

Description: Four people participate in a rope competition. Two of them pull the rope right, exerting forces of magnitude 330 N and 380 N . The other two pull left, exerting forces of magnitude ## N and ## N. (a) What is the sum of the forces...

Four people participate in a rope competition. Two of them pull the rope right, exerting forces of magnitude 330 N and 380 N . The other two pull left, exerting forces of magnitude 350 N and 400 N .

Part A

What is the sum of the forces exerted on the rope?

Express your answer to two significant figures and include the appropriate units. Enter positive value if the direction of the force is to the right and negative value if the direction of the force is to the left.

ANSWER:

F_{net} = $330 + 380 - F_3 - F_4$ = -40 N

Problem 2.22

Description: During a practice shot put throw, the ##-kg shot left world champion C. J. Hunter's hand at speed v. While making the throw, his hand pushed the shot a distance of Deltax. (a) Describe all the physical quantities you can determine using this...

During a practice shot put throw, the 7.9-kg shot left world champion C. J. Hunter's hand at speed 13 m/s . While making the throw, his hand pushed the shot a distance of 1.5 m .

Part A

Describe all the physical quantities you can determine using this information.

Check all that apply.

ANSWER:

- [x] the average acceleration of the shot during the throw
- [ ] the length of the hand
- [ ] the angle of the shot
- [x] the time it takes to accelerate the shot
- [x] the average force exerted on the shot by hand

Part B

Determine the average acceleration of the shot.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$a = \frac{v^2}{2\Delta x}$ = 56.3 $\frac{m}{s^2}$

Also accepted: $\frac{v^2}{2\Delta x}$ = 56 $\frac{m}{s^2}$

Part C

Determine the time it takes to accelerate the shot.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$t = \frac{2\Delta x}{v}$ = 0.23 s

Also accepted: $\frac{2\Delta x}{v}$ = 0.231 s

Part D

Determine the average force exerted on the shot by hand.

Express your answer to three significant figures and include the appropriate units.

ANSWER:

$F_{H\ on\ S} = \frac{mv^2}{2\Delta x}$ = 450 N

Also accepted: $\frac{mv^2}{2\Delta x}$ = 445 N

Problem 2.24

Description: You record the displacement Delta x_0 of an object as a constant force is exerted on it. (a) If the time interval during which the force is exerted n2, how does the object's displacement change? The new displacement is Delta x_1. (b) Explain how...

You record the displacement Δx_0 of an object as a constant force is exerted on it.

Part A

If the time interval during which the force is exerted doubles, how does the object's displacement change? The new displacement is Δx_1.

Express your answer using two significant figures.

ANSWER:

$\frac{\Delta x_1}{\Delta x_0}$ = $n1^2$ = 4.0

Part B

Explain how your answer changes if air resistance is considered.

ANSWER:

- (selected) The displacement would be smaller than the displacement obtained in previous part
- The displacement would be greater than the displacement obtained in previous part
- The displacement would be the same as the displacement obtained in previous part

Problem 2.29

Description: Spider-Man holds the bottom of an elevator with one hand. With his other hand, he holds a spider cord attached to a ##-kg box of explosives at the bottom of the cord. (a) Determine the force that the cord exerts on the box if the elevator is at ...

Spider-Man holds the bottom of an elevator with one hand. With his other hand, he holds a spider cord attached to a 68-kg box of explosives at the bottom of the cord.

Part A

Determine the force that the cord exerts on the box if the elevator is at rest.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$F_{\mathrm{C\ on\ B\ 1}}$ = $m \cdot 9.8$ = 670 N

Also accepted: $m \cdot 9.8$ = 666 N

Part B

Determine the force that the cord exerts on the box ifthe elevator accelerates up at 4.0 $\mathrm{m/s^2}$.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$F_{\mathrm{C\ on\ B\ 2}}$ = $m(a+9.8)$ = 940 N

Also accepted: $m(a+9.8)$ = 938 N

Part C

Determine the force that the cord exerts on the box if the upward-moving elevator's speed decreases at a rate of 4.0 $\mathrm{m/s^2}$.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$F_{\mathrm{C\ on\ B\ 3}}$ = $m(9.8-a)$ = 390 N

Also accepted: $m(9.8-a)$ = 394 N

Part D

Determine the force that the cord exerts on the box if the elevator falls freely.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$F_{\mathrm{C\ on\ B\ 4}}$ = 0 N

Assignment 4

Problem 2.30

Description: A farmer pushes his ##-kg wagon along a horizontal level icy road, exerting a ##-N horizontal force on the wagon. Ignore friction and air resistance. (a) Determine the acceleration of the wagon. (b) Would the number be higher or lower if the...

A farmer pushes his 510-kg wagon along a horizontal level icy road, exerting a 145-N horizontal force on the wagon. Ignore friction and air resistance.

Part A

Determine the acceleration of the wagon.

Express your answer to three significant figures and include the appropriate units.

ANSWER:

$a = \frac{F}{m} = 0.284 \frac{\mathrm{m}}{\mathrm{s}^2}$

Part B

Would the number be higher or lower if the friction and air resistance were considered?

ANSWER:

- higher
- lower (selected)

Part C

If the wagon started at rest, how fast was it moving after being pushed for 5.3 s ?

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$v = \frac{F}{m}t = 1.5 \frac{\mathrm{m}}{\mathrm{s}}$

Also accepted: $\frac{F}{m}t = 1.51 \frac{\mathrm{m}}{\mathrm{s}}$

Problem 2.31

Description: The downward acceleration of a ##-kg stuntwoman near the end of a fall from a very high building is a. (a) What resistive force does the air exert on her body at that point?

The downward acceleration of a 55-kg stuntwoman near the end of a fall from a very high building is 6.2 $\mathrm{m/s^2}$.

Part A

What resistive force does the air exert on her body at that point?

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$F = m(9.8 - a) = 200\,\mathrm{N}$

Also accepted: $m(9.8 - a) = 198\,\mathrm{N}$

Problem 2.32

Description: (a) Estimate the average force that a baseball pitcher's hand exerts on a 0.145-kg baseball as he throws a ##-m/s pitch. Assume the pitcher accelerates the ball through a distance of 3.0 m, from behind his body to where the ball is released and...

Part A

Estimate the average force that a baseball pitcher's hand exerts on a 0.145-kg baseball as he throws a 35-m/s pitch. Assume the pitcher accelerates the ball through a distance of 3.0 m, from behind his body to where the ball is released and ignore the air resistance.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$F = \frac{0.145v^2}{2 \cdot 3.0} = 30\,\mathrm{N}$

Also accepted: $\frac{0.145v^2}{2 \cdot 3.0} = 29.6\,\mathrm{N}$

Problem 2.33

Description: A 2.1 * 10^4-kg jet airplane shown in goes from zero to v in Deltax during takeoff from the flight deck of an aircraft carrier. Ignore air resistance. (a) What physical quantities can you determine using this information? (b)...

A 2.1×10^4-kg jet airplane shown in goes from zero to 235 $\mathrm{km/h}$ in 78 m during takeoff from the flight deck of an aircraft carrier. Ignore air resistance.

Part A

What physical quantities can you determine using this information?

Check all that apply.

ANSWER:

- [ ] the height of the flight
- [ ] the distance of the flight
- [x] the acceleration time interval
- [x] the average acceleration
- [x] the average net force acting on the airplane during the takeoff

Part B

Determine the average acceleration.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$a_x = \frac{v^2}{2\Delta x} = 27 \frac{\mathrm{m}}{\mathrm{s}^2}$

Also accepted: $\frac{v^2}{2\Delta x} = 27.3 \frac{\mathrm{m}}{\mathrm{s}^2}$, $\frac{v^2}{2\Delta x} = 27 \frac{\mathrm{m}}{\mathrm{s}^2}$

Part C

Determine the acceleration time interval.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$\Delta t = \frac{2\Delta x}{v} = 2.4 \mathrm{s}$

Also accepted: $\frac{2\Delta x}{v} = 2.39 \mathrm{s}$, $\frac{2\Delta x}{v} = 2.4 \mathrm{s}$

Part D

Determine the average net force acting on the airplane during the takeoff.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$F = \frac{2.1 \cdot 10^4 v^2}{2\Delta x} = 5.7 \times 10^5 \mathrm{N}$

Also accepted: $\frac{2.1 \cdot 10^4 v^2}{2\Delta x} = 5.74 \times 10^5 \mathrm{N}$, $\frac{2.1 \cdot 10^4 v^2}{2\Delta x} = 5.7 \times 10^5 \mathrm{N}$

Problem 2.34

Description: The Lunar Lander of mass m made the last x of its trip to the Moon's surface in t, descending at approximately constant speed. The Handbook of Lunar Pilots indicates that the gravitational constant on the Moon is 1.633 N/kg. (a) Determine...

The Lunar Lander of mass 1.9×10^4 kg made the last 140 m of its trip to the Moon's surface in 110 s, descending at approximately constant speed. The *Handbook of Lunar Pilots* indicates that the gravitational constant on the Moon is 1.633 N/kg.

Part A

Determine the average speed.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$v = \frac{x}{t} = 1.3\frac{\mathrm{m}}{\mathrm{s}}$

Also accepted: $\frac{x}{t} = 1.27\frac{\mathrm{m}}{\mathrm{s}}$

Part B

Determine the upward force required to descend at a constant speed.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$F = m\cdot1.633 = 3.1\times10^4\mathrm{N}$

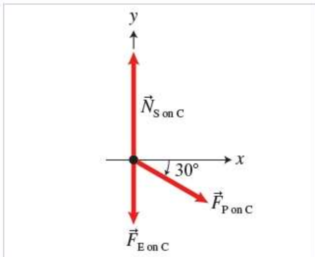
Also accepted: $m\cdot1.633 = 3.10\times10^4\mathrm{N}$

Assignment 5

Problem 3.01

Description: Determine the x- and y- components of each force vector shown in . Suppose that ns=## N, fp=## N, and fe=## N. (a) Determine the x- and y- components of the force (N_vec)_(S on C). (b) Determine the x- and y- components of the force...

Determine the x- and y- components of each force vector shown in . Suppose that $N_{\mathrm{S\ on\ C}}$ = 280 N, $F_{\mathrm{P\ on\ C}}$ = 220 N, and $F_{\mathrm{E\ on\ C}}$ = 160 N.



Part A

Determine the x- and y- components of the force $\vec{N}_{\mathrm{S\ on\ C}}$.

Enter the x and y components of the force separated by a comma. Express your answer using three significant figures.

ANSWER:

$N_{\mathrm{S\ on\ C}\ x}, N_{\mathrm{S\ on\ C}\ y}$ = $0, ns$ = 0, 280 N

Part B

Determine the x- and y- components of the force $\vec{F}_{\mathrm{P\ on\ C}}$.

Enter the x and y components of the force separated by a comma. Express your answer using three significant figures.

ANSWER:

$F_{\mathrm{P\ on\ C}\ x}, F_{\mathrm{P\ on\ C}\ y}$ = $fp\cos(30), -fp\sin(30)$ = 191, -110 N

Part C

Determine the x- and y- components of the force $\vec{F}_{\mathrm{E\ on\ C}}$.

Enter the x and y components of the force separated by a comma. Express your answer using three significant figures.

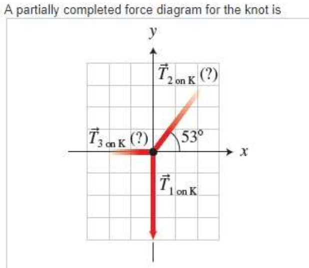
ANSWER:

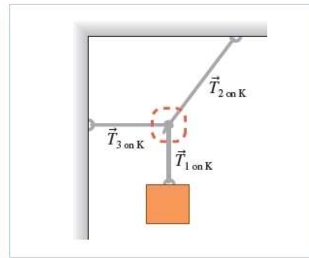
$F_{\mathrm{E\ on\ C}\ x}, F_{\mathrm{E\ on\ C}\ y}$ = $0, -fe$ = 0, -160 N

Problem 3.07

Description: Three ropes pull on a knot shown in . The knot is not accelerating. A partially completed force diagram for the knot is shown in the figure . Use Newton's second law to determine the magnitudes of the forces that ropes 2 and 3 exert on the ...

Three ropes pull on a knot shown in . The knot is not accelerating. A partially completed force diagram for the knot is shown in the figure . Use Newton's second law to determine the magnitudes of the forces that ropes 2 and 3 exert on the knot. Suppose that $T_{1\text{ on K}}$ = 500 N .





Part A

Determine the magnitude of the force that rope 2 exerts on the knot.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$T_{2\text{ on K}} = \dfrac{t1}{\sin(53)} = 630\,\mathrm{N}$

Also accepted: $\dfrac{t1}{\sin(53)} = 626\,\mathrm{N}$

Part B

Determine the magnitude of the force that rope 3 exerts on the knot.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$T_{3\text{ on K}} = \dfrac{t1}{\sin(53)}\cos(53) = 380\,\mathrm{N}$

Also accepted: $\dfrac{t1}{\sin(53)}\cos(53) = 377\,\mathrm{N}$

Problem 3.19

Description: At the start of his race, an ##-kg runner pushes against the starting block, exerting an average force of ## N. The force that the block exerts on his foot points 20 degree(s) above the horizontal. (a) Determine the horizontal speed of the...

At the start of his race, an 83-kg runner pushes against the starting block, exerting an average force of 1700 N . The force that the block exerts on his foot points 20° above the horizontal.

Part A

Determine the horizontal speed of the runner after the force is exerted for 0.29 s .

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$v = \dfrac{F\cos(20)\,t}{m} = 5.6\,\dfrac{\mathrm{m}}{\mathrm{s}}$

Also accepted: $\dfrac{F\cos(20)\,t}{m} = 5.58\,\dfrac{\mathrm{m}}{\mathrm{s}}$

Problem 3.23

Description: You agree to build a backyard rope tow to pull your siblings up a 20-m slope that is tilted at ## degree(s) relative to the horizontal. You must choose a motor that can pull your m-kg sister up the hill. (a) Determine the force that...

You agree to build a backyard rope tow to pull your siblings up a 20-m slope that is tilted at 25 ° relative to the horizontal. You must choose a motor that can pull your 50-kg sister up the hill.

Part A

Determine the force that the rope should exert on your sister to pull her up the hill at constant velocity.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$F_{\text{R on Sister}} = m\sin(\theta)\cdot 9.8 = 210\,\mathrm{N}$

Also accepted: $m\sin(\theta)\cdot 9.8 = 207\,\mathrm{N}$

Problem 3.20

Description: A string with one 10-g washer on the end is attached to the rearview mirror of a car. When the car leaves an intersection, the string makes an angle of theta with the vertical. (a) What is the acceleration of the car? [Hint: Choose the washer...

A string with one 10-g washer on the end is attached to the rearview mirror of a car. When the car leaves an intersection, the string makes an angle of 6 ° with the vertical.

Part A

What is the acceleration of the car? [*Hint:* Choose the washer as the system object for your force diagram. Use the vertical component equation of Newton's second law to find the magnitude of the force that the string exerts on the washer. Then continue with the horizontal component equation.]

Express your answer to one significant figure and include the appropriate units.

ANSWER:

$a = 9.8\tan(\theta) = 1\,\frac{\mathrm{m}}{\mathrm{s}^2}$

Also accepted: $9.8\tan(\theta) = 1.0\,\frac{\mathrm{m}}{\mathrm{s}^2}$, $9.8\tan(\theta) = 1.03\,\frac{\mathrm{m}}{\mathrm{s}^2}$

Assignment 6

Problem 3.22

Description: A m-kg skier starts at rest and slides L down a hill inclined at 12 degree(s) relative to the horizontal. Consider the force of friction on the skier to be negligible. (a) Determine the the acceleration of the skier. (b) Determine the...

A 52-kg skier starts at rest and slides 30 m down a hill inclined at 12° relative to the horizontal. Consider the force of friction on the skier to be negligible.

Part A

Determine the the acceleration of the skier.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$a = 2.0\,\frac{\mathrm{m}}{\mathrm{s}^2}$

Also accepted: 2.04 m/s^

Part B

Determine the normal force exerted on the skier by the surface.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$N = m\cdot 9.8\cos(12) = 500\,\mathrm{N}$

Also accepted: $m\cdot 9.8\cos(12) = 498\,\mathrm{N}$

Part C

Determine the speed of the skier after sliding 30 m downhill.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$v = \sqrt{2\cdot 9.8\sin(12)\,L} = 11\,\frac{\mathrm{m}}{\mathrm{s}}$

Also accepted: $\sqrt{2\cdot 9.8\sin(12)\,L} = 11.1\,\frac{\mathrm{m}}{\mathrm{s}}$

Part D

Determine the time for the skier to slide down 30 m.

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$\Delta t = \sqrt{\frac{2L}{9.8\sin(12)}} = 5.4\,\mathrm{s}$

Also accepted: $\sqrt{\frac{2L}{9.8\sin(12)}} = 5.43\,\mathrm{s}$

Problem 3.38

Description: A m-kg refrigerator sits on the floor. The coefficient of static friction between the refrigerator and the floor is mu. (a) What is the minimum force that one needs to exert on the refrigerator to start the refrigerator sliding?

A 87.0-kg refrigerator sits on the floor. The coefficient of static friction between the refrigerator and the floor is 0.70.

Part A

What is the minimum force that one needs to exert on the refrigerator to start the refrigerator sliding?

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$F = \mu m \cdot 9.8 = 600\,\mathrm{N}$

Also accepted: $\mu m \cdot 9.81 = 597\,\mathrm{N}$

Problem 3.39

Description: A m-kg student sitting on a hardwood floor does not slide until pulled by a F-N horizontal force. (a) Determine the coefficient of static friction between the student and floor.

A 63-kg student sitting on a hardwood floor does not slide until pulled by a 260-N horizontal force.

Part A

Determine the coefficient of static friction between the student and floor.

Express your answer using two significant figures.

ANSWER:

$\mu = \frac{\frac{F}{m}}{9.8} = 0.42$

Problem 3.41

Description: A certain car traveling at 97 (km)/h can stop in s on a level road. Assume that the wheels of the car roll to a stop without skidding. (a) Determine the coefficient of friction between the tires and the road. (b) Is this kinetic or static...

A certain car traveling at 97 $\mathrm{km/h}$ can stop in 52 m on a level road. Assume that the wheels of the car roll to a stop without skidding.

Part A

Determine the coefficient of friction between the tires and the road.

Express your answer using two significant figures.

ANSWER:

$\mu = \frac{\left(\frac{97}{3.6}\right)^2}{2 \cdot 9.8 s} = 0.71$

Part B

Is this kinetic or static friction?

ANSWER:

- (selected) static friction
- kinetic friction

Problem 3.42

Description: A m-kg box rests on the floor. The coefficients of static and kinetic friction between the bottom of the box and the floor are 0.70 and 0.50, respectively. (a) What is the minimum force a person needs to exert on the box to start it sliding? (b)...

A 46-kg box rests on the floor. The coefficients of static and kinetic friction between the bottom of the box and the floor are 0.70 and 0.50, respectively.

Part A

What is the minimum force a person needs to exert on the box to start it sliding?

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$F_{\min} = 0.70m \cdot 9.8 = 320\,\mathrm{N}$

Also accepted: $\mathrm{ceil}\left(\frac{0.70m\cdot 9.8}{10}\right)\cdot 10 = 320\,\mathrm{N}$, $0.70m\cdot 9.8 = 316\,\mathrm{N}$

Part B

After the box starts sliding, the person continues to push it, exerting the same force. What is the acceleration of the box?

Express your answer to two significant figures and include the appropriate units.

ANSWER:

$a = \frac{(0.7-0.5)\,m\cdot 9.8}{m} = 2.0\,\frac{\mathrm{m}}{\mathrm{s}^2}$

Also accepted: $\frac{(0.7-0.5)\,m\cdot 9.8}{m} = 1.96\,\frac{\mathrm{m}}{\mathrm{s}^2}$, $\frac{sigdig\,(0.70m\cdot 9.8, 2) - 0.5m\cdot 9.8}{m} = 2.1\,\frac{\mathrm{m}}{\mathrm{s}^2}$, $\frac{sigdig\,(0.70m\cdot 9.8, 2) - 0.5m\cdot 9.8}{m} = 2.06\,\frac{\mathrm{m}}{\mathrm{s}^2}$, $\frac{\mathrm{ceil}\left(\frac{0.70m\cdot 9.8}{10}\right)\cdot 10 - 0.5m\cdot 9.8}{m} = 2.1\,\frac{\mathrm{m}}{\mathrm{s}^2}$, $\frac{\mathrm{ceil}\left(\frac{0.70m\cdot 9.8}{10}\right)\cdot 10 - 0.5m\cdot 9.8}{m} = 2.06\,\frac{\mathrm{m}}{\mathrm{s}^2}$

APPENDIX D

ONLINE SELF-REGULATED LEARNING QUESTIONNAIRE

Table C.1 *OSLQ Modified Items by Subscale*

Subscale	Original Item	Modified Item
Goal Setting	1. I set standards for my assignments in online courses.	1. I set standards for my online assignments.
	2. I set short-term (daily or weekly) goals as well as long-term goals (monthly or for the semester).	No-change
	3. I keep a high standard for my learning in my online courses.	3. I keep a high standard for my learning in my courses.
	4. I set goals to help me manage studying time for my online courses.	4. I set goals to help me manage studying time for my courses.
	5. I don't compromise the quality of my work because it is online.	5. I don't compromise the quality of my work *when* it is online.
Environment Structuring	6. I choose the location where I study to avoid too much distraction.	6. I choose the location where I *do homework* to avoid too much distraction.
	7. I find a comfortable place to study.	7. I find a comfortable place to *do homework*.
	8. I know where I can study most efficiently for online courses.	8. I know where I can *do homework* most efficiently for my courses.
	9. I choose a time with few distractions for studying for my online courses.	9. I choose a time with few distractions for *doing homework.*
Task Strategies	10. I try to take more thorough notes for my online courses because notes	10. I try to take more thorough notes for my courses *with online homework* because notes

	are even more important for learning online than in a regular classroom.	are even more important for learning online than in a regular classroom.
	11. I read aloud instructional materials posted online to fight against distractions.	11. I read aloud instructional materials posted online to fight against distractions.
	12. I prepare my questions before joining in the chat room and discussion.	Question not used
	13. I work extra problems in my online courses in addition to the assigned ones to master the course content.	13. I work extra problems *for physics class* in addition to the assigned ones to master the course content.
Time Management	14. I allocate extra studying time for my online courses because I know it is time-demanding.	14. I allocate extra *homework* time for my *physics homework* because I know it is time-demanding.
	15. I try to schedule the same time every day or every week to study for my online courses, and I observe the schedule.	15. I try to schedule the same time every day or every week to *complete homework for my physics course*, and I observe the schedule.
	16. Although we don't have to attend daily classes, I still try to distribute my studying time evenly across days.	Question not used.
Help Seeking	17. I find someone who is knowledgeable in course content so that I can consult with him or her when I need help.	17. I find someone who is knowledgeable in course content so that I can consult with him or her when I need help.
	18. I share my problems with my classmates online so we know what we are struggling with and how to solve our problems.	18. I share my problems with my classmates online so we know what we are struggling with and how to solve our problems.
	19. If needed, I try to meet my classmates face-to-face.	19. If needed, I try to meet my classmates face-to-face.
	20. I am persistent in getting help from the instructor through e-mail.	20. I am persistent in getting help from the instructor through e-mail.

Self Evaluation	21. I summarize my learning in online courses to examine my understanding of what I have learned.	21. I summarize my learning in *physics class* to examine my understanding of what I have learned.
	22. I ask myself a lot of questions about the course material when studying for an online course.	22. I ask myself a lot of questions about the course material when *completing physics homework.*
	23. I communicate with my classmates to find out how I am doing in my online classes.	23. I communicate with my classmates to find out how I am doing in my p*hysics class.*
	24. I communicate with my classmates to find out what I am learning that is different from what they are learning.	24. I communicate with my classmates to find out what I am learning that is different from what they are learning.

APPENDIX E

FEEDBACK ENVIRONMENT SCALE

Table D.1 *FES Item Modification*

Original FES Item	**Modified FES Item**
My supervisor gives me useful feedback about my job performance.	*Mastering Physics* gives me useful feedback about my *homework* performance.
The performance feedback I receive from my supervisor is helpful.	The performance feedback I receive from *Mastering Physics* is helpful.
I value the feedback I receive from my supervisor.	I value the feedback I receive from *Mastering Physics*
The feedback I receive from my supervisor helps me do my job.	The feedback I receive from Mastering Physics helps me do *better on my assignments*.
The performance information I receive from my supervisor is generally not very meaningful.	The performance *feedback* I receive from *MP* is generally not very meaningful.

APPENDIX F

INTERVIEW PROTOCOL AND ALIGNMENT

The following interview protocol will be used to conduct the student interviews:

Date / Time: ____________________

Location: ____________________

Interview Number: ____________________

Welcome, thanks for participating in this study and this interview. The purpose of this interview is to collect data on how the online homework platform, Mastering Physics, has impacted your learning. The interview will take approximately 45 minutes. No one other than me will have access to any identifying information about this interview. Your answers are confidential and will not in any way affect your grade in this class. Please answers the questions honestly and to the best of your ability. To aid in my data collection, would you be ok if I took an audio recording of this interview? (Yes or No) Ok, are you ready to begin?

R1. How and to what extent does the implementation of individualized online homework and feedback impact self-regulated learning among Honors Physics high school students?

1. What is Mastering Physics (MP)?

    a. Can you walk me through what a typical experience with MP looks and feels like for you?

    b. Can you tell me about any technical challenges that you have experienced while using MP (such as problems with the website or internet)?

2. Can you give me one or two examples of how using MP has affected your preparation for doing homework?
    a. Is it easier to begin an MP assignment because you know that you will be given feedback from MP about your progress?
    b. How do you prepare for a homework assignment?
        i. Do you go to a certain location?
        ii. Do you get out certain tools (pen / paper / calculator)?
3. Tell me how you go about completing the MP homework assignments?
    a. Can you give me examples of what happens when you get the answers right?
    b. Can you give me examples of what happens when you get the answers wrong?
        i. When you get an answer wrong, do you read the feedback text generated by MP? Why or why not?
        ii. Does using MP make you more careful in crafting your answers? Why or why not?
    c. Can you describe your thought process while completing a problem in MP?
4. Can you give me examples of times you have thought about MP homework after you have completed it?

a. Can you give me an examples of a time you have thought about a past MP problem?

b. Can you tell me about a time that you have thought about a MP problem while not doing MP homework?

c. Can you give any examples of a time when you have thought about past MP problems when encountering a new problem?

5. How do you use the record of your progress in MP? (Scores, Time Spent)

    a. How do you think this record aligns with your actual progress in the course?

R2. How does the implementation of individualized online homework impact students' perception of the feedback quality provided by an individualized online homework platform?

1. Tell me about the ways in which MP delivers feedback about your performance on homework assignments.

2. How would you describe the feedback that MP gives you while completing an assignment?

    a. Is the textual feedback clear?

    b. Is the textual feedback helpful?

3. Can you describe a time when you have ignored the feedback that MP is giving to you?

    a. If so, why?

b. Have there been times when you did not understand the feedback that MP was giving to you?

i. Can you give me examples of the kind of feedback you did not understand?

4. What does the feedback from mastering physics mean to you as a physics student?

a. Does it help you to think more critically about your answers?

b. Does it help you catch errors that you would have otherwise missed?

5. Can you tell me about a time when working with MP that frustrated you?

a. What part frustrated you the most?

b. Did the frustration with MP diminish over time?

6. Has using MP helped you understand physics?

a. What about MP has helped your understand physics?

b. What about MP has made it easier or harder for you to understand physics?

7. Can you explain whether using MP made it easier or harder to complete homework?

a. What about MP has made you more or less likely to complete homework?

b. How does having randomized variables impact, if at all, your completion of homework assignments?

Table E.1 aligns each interview questions with the research questions of this study.

Table E.1 *Research Question and Interview Questions Alignment*

Research Question	**Interview Questions**
R1. How and to what extent does the implementation of individualized online homework and feedback impact self-regulated learning among Honors Physics high school students?	1. What is Mastering Physics (MP)? a. Can you walk me through what a typical experience with MP looks and feels like for you? b. Can you tell me about any technical challenges that you have experienced while using MP (such as problems with the website or internet)? 2. Can you give me one or two examples of how using MP has affected your preparation for doing homework? a. Is it easier to begin an MP assignment because you know that you will be given feedback from MP about your progress? b. How do you prepare for a homework assignment? i. Do you go to a certain location? ii. Do you get out certain tools (pen / paper / calculator)? 3. Tell me how you go about completing the MP homework assignments? a. Can you give me examples of what happens when you get the answers right or wrong? i. When you get an answer wrong, do you read the feedback text generated by MP? Why or why not? ii. Does using MP make you more careful in crafting your answers? Why or why not?

Research Question	Interview Questions
	b. While completing MP homework, can you describe your thought process while completing a problem? 4. Can you give me examples of times you have thought about MP homework after you have completed it? a. Can you give me an examples of a time you have thought about a past MP problem? b. Can you tell me about a time that you have thought about a MP problem while not doing MP homework? c. Can you give any examples of a time when you have thought about past MP problems when encountering a new problem? 5. How do you use the record of your progress in MP? (Scores, Time Spent) a. How do you think this record aligns with your actual progress in the course?
R2. How does the implementation of individualized online homework impact students' perception of the feedback quality provided by an individualized online homework platform?	8. Tell me about the ways in which MP delivers feedback about your performance on homework assignments. 9. How would you describe the feedback that MP gives you while completing an assignment? a. Is the textual feedback clear? b. Is the textual feedback helpful? 10. Can you describe a time when you have ignored the feedback that MP is giving to you? a. If so, why? b. Have there been times when you did not understand the feedback that MP was giving to you? i. Can you give me examples of the kind of feedback you did not understand? 11. What does the feedback from mastering physics mean to you as a physics student? a. Does it help you to think more critically about your answers? b. Does it help you catch errors that you would have otherwise missed? 12. Can you tell me about a time when working with MP that frustrated you?

Research Question	Interview Questions
	a. What part frustrated you the most? b. Did the frustration with MP diminish over time? 13. Has using MP helped you understand physics? a. What about MP has helped your understand physics? b. What about MP has made it easier or harder for you to understand physics? 14. Can you explain whether using MP made it easier or harder to complete homework? a. What about MP has made you more or less likely to complete homework? How does having randomized variables impact, if at all, your completion of homework assignments?

APPENDIX G

ENLARGED CODE MAPS

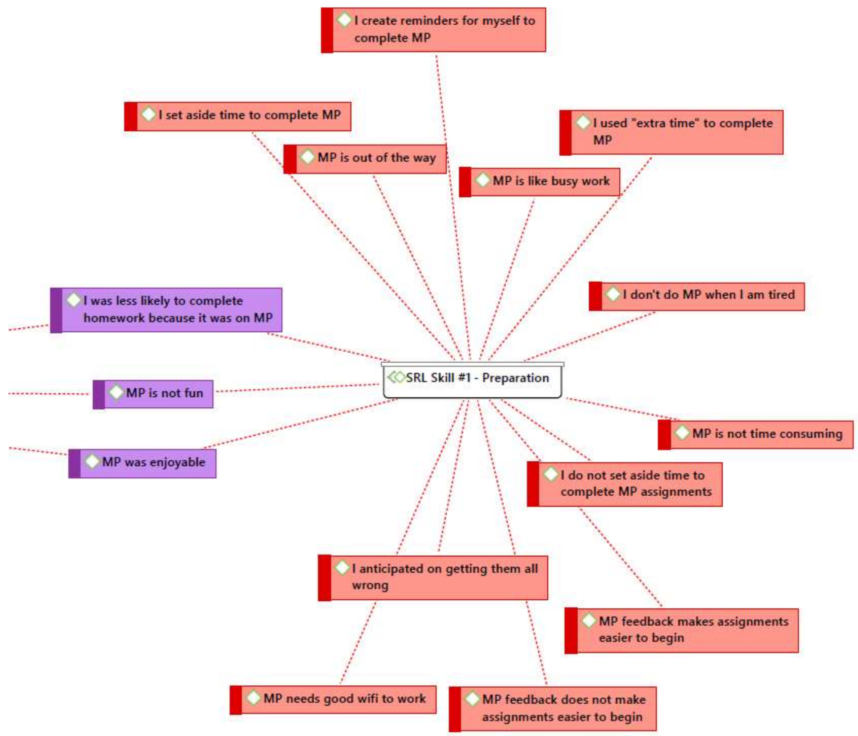


Figure G.1. SRL Skill #1 Code Map.

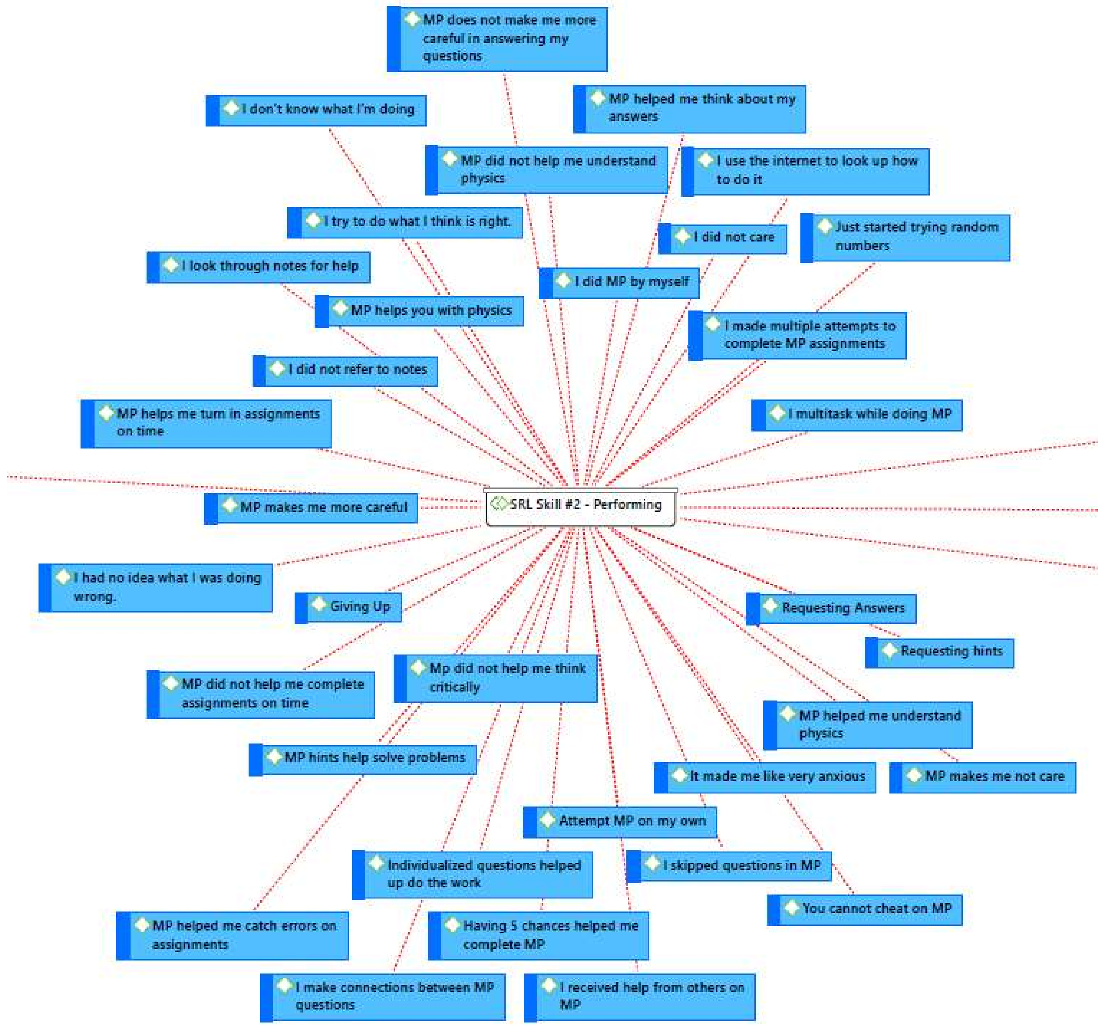


Figure G.2. SRL Skill #2 Code Map.

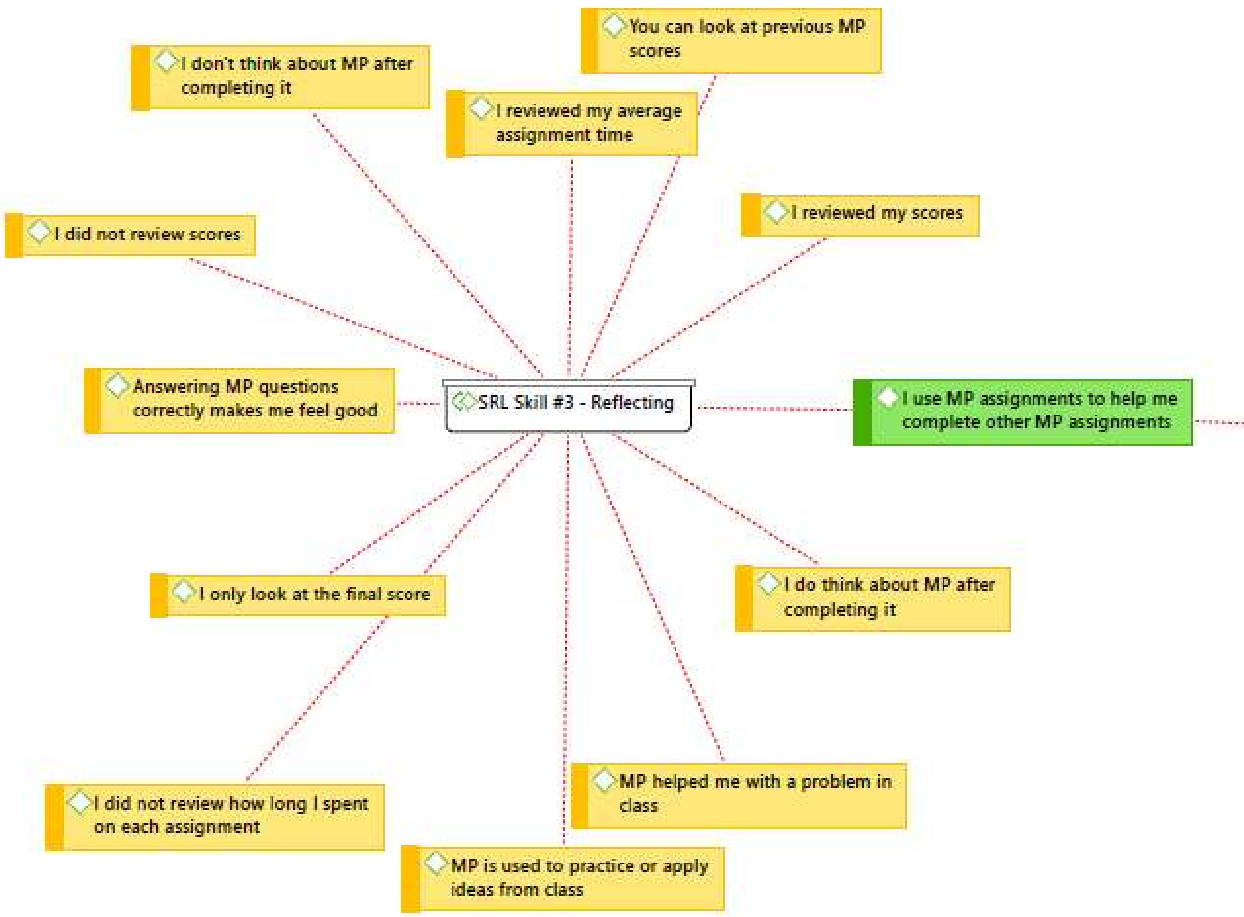


Figure G.3. SRL Skill #3 Code Map.

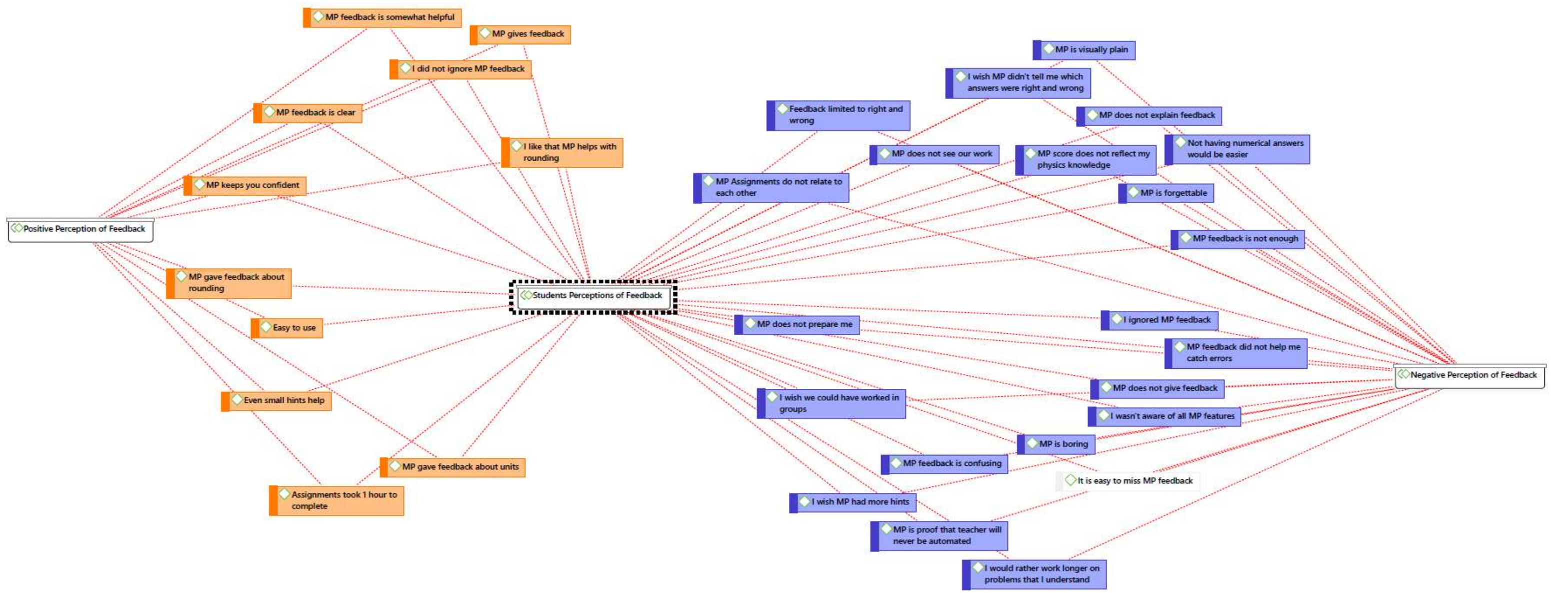


Figure G.4. Student Perceptions of Feedback Code Map.

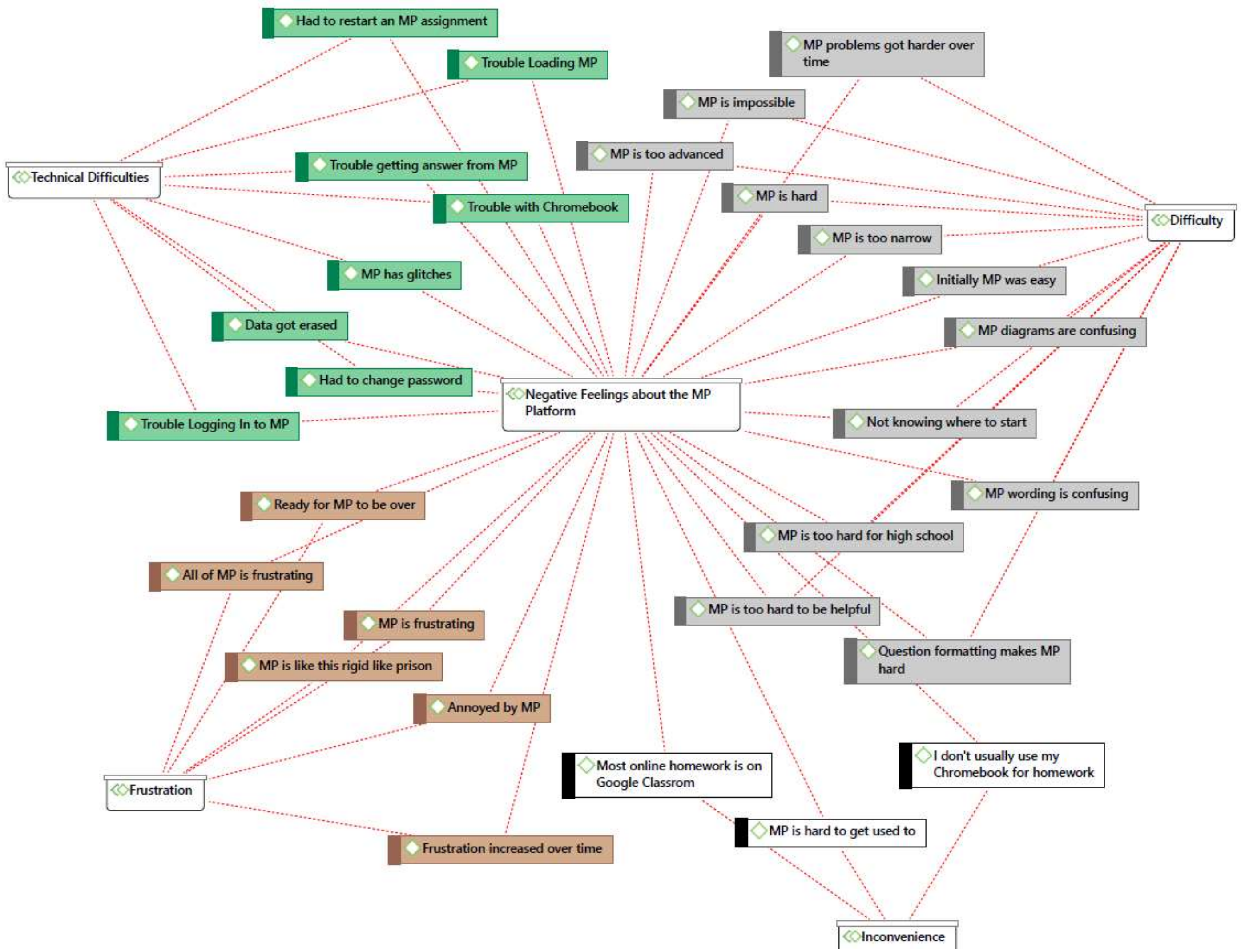


Figure G.5. Negative Feelings Code Map.

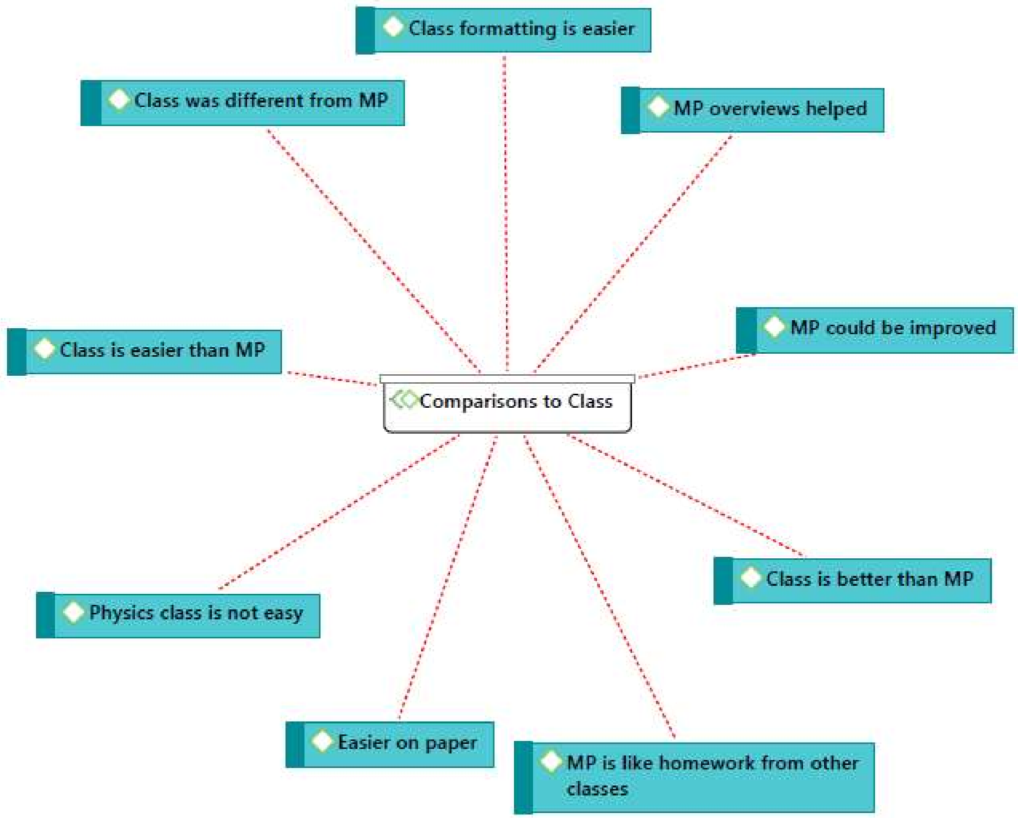


Figure G.6. Comparison to Class Code Map.