Accuracy of self-assessment in a ninth grade earth science classroom

Alyssa Jacobson
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Abstract
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The purpose of this study is to determine how accurately high school aged students can self-assess and how students make decisions when they self-assess. To determine accuracy, student self-assessment scores were compared to their actual scores. Students also provided an explanation of their score which was used to determine the basis students use to self-assess. Self-assessment is found to vary in accuracy based on student ability and therefore is not an effective technique for helping all students grow.

This study will help teachers evaluate the degree of usefulness self-assessment practices have in the classroom and it can help teachers make decisions about how they design self-assessment procedures in the classroom. This study will also provide insight into the different ways high school aged student think about the learning process.

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Accuracy of Self-assessment in a Ninth Grade Earth Science Classroom

Non-thesis Curriculum Development Project for the
Masters of Arts in Science Education
University of Northern Iowa

Presented by
Alyssa Jacobson
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This Paper by: Alyssa Jacobson

Entitled: Accuracy of Self-assessment in a Ninth Grade Earth Science Classroom

has been approved as meeting the non-thesis requirement for the Degree of Master of Arts

Date: 04/14/2021     Dr. Jody Stone, Advisor

Date: 04/14/2021     Dr. Dawn Del Carlo, Outside Reader
Abstract

Student engagement is a constant struggle teachers and schools work to address. Students who are not engaged are more likely to drop out of school and participate in risky behaviors that negatively impact themselves and society as a whole. As a means to combat student disengagement, school districts have begun to implement *The New Art and Science of Teaching*, a framework meant to engage students by involving them in the learning process through self-assessment.

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# Table of Contents

Acknowledgements .................................................................................................9  

Chapter 1. Introduction .........................................................................................10  

Chapter 2. Literature Review ................................................................................14  
  Importance of Student Engagement .................................................................14  
  Factors Influencing Student Engagement .........................................................15  
  Self-assessment as a Form of Student Engagement .........................................17  
  Positive Aspects of Self-assessment ................................................................19  
    Improving Learning ..........................................................................................19  
    Active Learning ...............................................................................................20  
    Performance Satisfaction ...............................................................................21  
    Transferrable Skill ...........................................................................................22  
  Self-assessment Shortcomings .........................................................................22  
    Expectation Discrepancies .............................................................................23  
    Personal Bias ..................................................................................................23  
    Ability Based ..................................................................................................24  
  Research Purpose ...............................................................................................25  
  Theoretical Framework .......................................................................................25  

Chapter 3. Methodology .......................................................................................27
Site and Participation .................................................................27
Data Collection Procedures ..........................................................27
Classroom Routine .................................................................29
Developing the Learning Targets ......................................................30
Planning the Unit .................................................................33
Chapter 4. Results .................................................................38
Quantitative Data Results ..........................................................38
Qualitative Data Results ..........................................................41
Discussion .................................................................45
  Accuracy of Self-assessment ......................................................45
  Improvements in Self-assessment ................................................46
  Basis of Self-assessment ......................................................46
  Basis of Self-assessment by Accuracy ...........................................47
  Additional Steps for Self-assessment ............................................47
  Limitations .................................................................48
  Further Research .............................................................49
References .................................................................50
Appendix A: IRB Letter of Exemption .............................................56
Appendix B: Assessments .................................................................57

Practice Quiz #1.1 .................................................................57

Practice Quiz #1.2 .................................................................57

Practice Quiz #1.3 .................................................................58

Practice Quiz #1.4 .................................................................59

Practice Quiz #1.5 .................................................................59

Rock and Mineral Quiz .........................................................60

Rock Cycle, Mining and Natural Resources Quiz .........................64

Unit 1 Exam ...........................................................................68
## List of Tables

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Table of Self-assessment Scale and Descriptors</td>
<td>28</td>
</tr>
<tr>
<td>2 Table of Unit 1 Learning Targets</td>
<td>31</td>
</tr>
<tr>
<td>3 Table of Participants in Self-assessment Opportunities</td>
<td>38</td>
</tr>
<tr>
<td>4 Table of Comparison of Self-assessment and Actual Scores</td>
<td>39</td>
</tr>
<tr>
<td>5 Table of Categories of Student Self-assessment Explanations</td>
<td>42</td>
</tr>
<tr>
<td>6 Table of Self-assessment Explanations by Accuracy</td>
<td>44</td>
</tr>
</tbody>
</table>
## List of Figures

<table>
<thead>
<tr>
<th>FIGURES</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Purpose of Assessments</td>
<td>28</td>
</tr>
<tr>
<td>2 Unit 1 Plan for Instruction</td>
<td>34</td>
</tr>
</tbody>
</table>
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Chapter 1

Introduction

Engagement in school is crucial in learning. Teachers struggle daily keeping students active in their learning. It is clear that students who do not participate are more likely to drop out of high school and are not prepared to meet the demands of the twenty-first century society (Appleton et al., 2008; Archambault et al., 2009). High school students are especially difficult to engage as they are going through social and sexual changes that take a great deal of their attention. Students that disengage may use alternative routes to achieve some form of success in school including, but not limited to, completing the bare minimum amount of work or cheating off their peers. As a result, student engagement remains at the forefront of school reforms across the nation (Willey & Gardner, 2010).

In recent years, local school districts and districts across the world have begun adopting the instructional framework developed by Marzano (Marzano, 2017). In his book, Marzano addresses quality instruction as a means to develop student engagement to increase student success. Marzano (2017) also provides a definition of engagement that fits into the goals of the framework. Engagement is when students are paying attention, energized, intrigued, and inspired. Marzano’s instructional framework is built upon the foundation that effective teaching strategies for classroom management, engagement, and assessment will provide students the opportunity to flourish within the classroom context. The framework explains that effective application of instructional strategies will generate mental states and processes in students that will lead to enhanced learning. To engage students in these mental states, teachers must provide support in three main categories: feedback, content, and context.

Feedback is critical to student growth. It is the continuous exchange of information between student and teacher. The student provides information to the teacher about what they
have learned and the teacher provides the students with information on how they have progressed in their learning. This increased level of discussion will give the student an idea of the significance and importance of what they are attempting to learn (Marzano, 2017). Continuous interactions involving feedback will allow students to tap into the cognitive dimension of engagement as identified by Fredricks, Blumenfeld, & Paris (2004). The cognitive dimension of engagement refers to how invested a student is participating in meaningful learning and using self-regulation strategies to reach success. By maintaining the cycle of feedback between teacher and student, the student will have a clear idea of how they are progressing in learning the content as well as have a clear idea of what success looks like in that classroom. The teacher will also be able to use this feedback to make decisions about how to better support that student in their learning and may choose from the many teaching strategies at their disposal to better help individual students. As part of an effective feedback system teachers must carefully craft assessments to support the flow of information between teacher and student.

Although teachers regularly provide students with valid and reliable feedback, student improvement and motivation do not necessarily follow. While teacher feedback is a critical component to student success, an instructional system that incorporates student self-assessment will more likely lead to overall student growth (Marzano, 2017; Moore et al., 2015). Teaching students to self-assess will help them to build a skill that is transferrable to other academic and professional pursuits. McMillan and Hearn (2008) developed the Student Self-assessment Cycle which summarizes the basic steps students must be able to do in order to successfully self-assess as they are working. First, the student must understand the requirements of the learning target, meaning students should have a clear idea of what goal they are working toward and how they will reach that goal. They must also be able to compare their current level of understanding against that expected of the learning target. Finally, they must take appropriate action to close the
gap in their understanding which they have identified (McMillan & Hearn, 2008; Sadler, 1989).

In Marzano’s instructional framework, self-assessment allows students to increase the amount of feedback they receive and limits the time spent waiting for feedback from the teacher (Marzano, 2010).

Marzano’s second area of support is content. Content refers to how teachers organize topics to assure students’ progress from their initial knowledge to meeting the learning targets. Understanding of students’ current knowledge and abilities and how to connect new information and skills to that foundation guides lesson planning. Carefully constructed content allows students to build new knowledge onto the existing foundation built in previous units and courses. The structure of a course should allow students to gradually build on their initial understanding and experiences to deepen understandings and applications of information (Marzano, 2017).

Lastly, teachers must support students by addressing context. Context support addresses the students’ psychological needs. Students must feel engaged in their learning process, that there is order in the classroom, that they belong with the group of learners, and that they are working toward meeting high expectations. This addresses the affective dimension of engagement (Fredricks et al., 2004). The affective dimension of engagement is specific to each student as it takes into account each individual’s feelings, attitudes, and interests toward school. This may vary between courses or activity for each individual; however, the teacher can influence affective engagement by remaining aware of the social-emotional responses of students in the classroom and reacting appropriately to those changes.

Addressing feedback, content, and context in the classroom allows a widespread shift in student engagement. Although self-assessment is a complicated process as it melds ideas from Marzano’s instructional framework support areas of feedback, content and context, it is critical to successful student learning. There is a significant body of work surrounding the accuracy of self-
assessment, but most focus on post-secondary students with several years of rigorous educational experience. There is little research evaluating the abilities of younger students to self-monitor their abilities and about the accuracy of their self-assessment. The purpose of this study is to determine how accurately students self-assess and the rationale they use when assigning themselves a grade.
Chapter 2

Literature Review

Importance of Student Engagement

While the definition of student engagement is broad and multifaceted, the consequences to disengagement are clear. In a sampling of high school aged students, it was found that student engagement within the institution played a critical role preventing students from dropping out. In a multifaceted approach study, students answered questions that related to various aspects of engagement including social and academic factors (Archambault et al., 2009). The results showed that in looking past the familial and social economic influences, student disengagement can lead to eventual dropout. There was also a general trend shown in that students tend to disengage from the cognitive domain first, which can go unnoticed by staff members and teachers. Following cognitive disengagement, a student’s behaviors will begin to change, which could draw negative attention to that student from school staff, furthering the student’s disengagement. Eventually, the decrease in interest in school and the ramifications of their behavior could lead to alienation and dropout of the institution. In general, students must feel they belong, in some way, to the institution and are of some worth to it. When students feel they belong, they will be more likely to participate within the institution. In turn, as students participate more within their school, they will begin to feel more connected to it thereby keeping them in a cycle of engagement (Archambault et al., 2009).

Henry, Knight, and Thornberry (2012) utilized the School Disengagement Warning Index (SDWI) as an indicator of potential problem behaviors and eventual dropout among 911 eighth and ninth grade boys using the Rochester Youth Development Study, which provided longitudinal data. The SDWI indicated the following five risk factors of disengagement: not
proficient standardized test scores, missing 20% or more school days, failing one or more subjects, one or more suspensions from school, and grade retention. The study found that the more risk factors a student had, the more likely they were to drop out of school. There was a correlation between the SDWI with dropout and arrest, as individuals that dropped out of school had an increased likelihood to participate in violent crimes, property crimes, and drug use. This study suggests that disengagement in school negatively impacts both the individual and society.

Engaging in school prevents the development of problem behaviors. In a survey of sixth, seventh, and eighth grade students in suburban Maryland, students who felt bonded to their school, perceived the school climate as positive, and felt they were able to adjust to the school environment were less likely to participate in problem behaviors, such as substance abuse or bullying. The study also found that older students were less likely to enjoy school thus making them more likely to demonstrate problem behaviors (Simons-Morton et al., 1999). School climate and engagement can prevent students from participating in risky behaviors.

Schools that are focused on community are more likely to engage students. A survey of teachers and students in 254 non-alternative high schools across the United States found that schools that fostered a sense of community experienced less disorder. Disorder was defined by reports of crimes against teachers, crimes against students, or crimes committed by students. Community oriented schools had fewer instances of crimes committed by students. The study also indicated that supportive and collaborative relationships in the school made it more likely for students to internalize school norms and goals (Payne et al., 2003). Building relationships with students is a crucial step in engaging students in learning.

**Factors Influencing Student Engagement**

It is important to remember that engagement changes over time. Newman (1989) writes comprehensive studies “…from psychology and sociology suggest the importance of five factors
[of engagement]: student’s need for competence, extrinsic rewards, intrinsic interest, social support, and sense of ownership” (p. 34). The amount of influence each of these factors might have on student engagement will vary from student to student. While intrinsic motivation and student’s need for competence are not easy for a teacher to influence, others are simple for educators to promote. Consider the role a teacher may have in providing social support for a student. Learning involves taking risks and some students are not willing to take risks if they feel unsupported by the teacher or their peers. However, if a teacher takes the time to foster an environment that encourages students to take chances and learn from their mistakes, rather than be punished for them, students will be more likely to actively participate in the coursework. Educators can also promote the student’s sense of ownership by offering students flexibility and choice when completing projects or tasks in the classroom. Implementing self-regulated learning strategies may increase the sense of ownership a student feels in their work and allow students a voice in the classroom (Newmann, 1989).

Appleton, Christenson, Kim, and Reschly (2006) developed the Student Engagement Instrument (SEI) to further determine factors that lead to student participation in learning. The SEI is a Likert-style survey that determines the degree to which aspects of cognitive and psychological engagement influence student participation. The SEI was administered to 1,931 ninth grade students in the midwestern United States. The results of the survey indicated the following factors have positive correlations with academic success: Student-Teacher Relationships, Peer Support in Learning, Future Aspirations and Goals, Family Support, and Extrinsic Motivation. Burrows (2010) administered the SEI to 371 ninth grade students and found that Future Aspirations and Goals had the highest correlation with credit completion and grade point average, while Peer Support in Learning correlated the least. This study indicates that
teaching students goal setting and tracking progress toward those goals is one way to increase student engagement.

**Self-assessment as a Form of Student Engagement**

Self-assessment is a process through which students make judgements about their own learning achievements (Boud & Falchikov, 1989). Self-assessment presents an opportunity to engage learners as making these judgements allows students to initiate a process of determining their level of performance and making decisions about how they will proceed in their learning to reach the desired outcome (Adachi et al., 2018; Mahayukti et al., 2017; Willey & Gardner, 2009c). Participating in self-assessment requires a standard, norm, or criterion students can reference as the desired outcome of learning (Boud & Falchikov, 1989; Kitsantas et al., 2004). Self-assessment is formative and meant to assist student learning by identifying gaps in the learning and making intentional steps to close those gaps. It is also an ongoing process a student must revisit often to identify areas of growth and additional gaps that may form before taking the summative assessment. When properly implemented, self-assessment can increase student motivation and effort and increase the amount of meaningful learning taking place (McMillan & Hearn, 2008).

Self-assessment gives learners valuable information useful for success on the summative assessments they complete to demonstrate learning. There are three general steps to engaging learners in self-assessment: (1) articulate expectations, (2) self-assessment, and (3) revision (Andrade & Valtcheva, 2009; McMillan & Hearn, 2008). Expectations are presented in many forms, such as learning targets, rubrics, or sample work, but should acquaint students with the task they are to complete and what constitutes quality work. Interacting with expectations will help students gain a better understanding of what they are to complete. Students then complete practice work and compare their achievement to that laid out in the expectation. Finally, students
must look back at their work and use their own feedback to move forward. For effective self-assessment, the opportunity to correct misunderstanding is critical. Through that process the gaps in understanding close (Andrade & Valtcheva, 2009; McMillan & Hearn, 2008; Sadler, 1989). Having students self-assess their work is an effective way to assist students in revising their understanding of content prior to receiving summative feedback from the teacher. When a student adopts this cycle of self-assessment and revision, they take control over their own learning.

Building an instructional system around self-assessment requires the teacher to take strategic steps in teaching students the skills needed to accurately evaluate themselves as well as how to remediate the gaps in their understanding. To support the content and context, teachers must be willing to model the actions and provide students opportunities to reflect on their learning. Well defined learning targets are the basis for content focused on student learning. Having clear learning targets helps students understand the clear evaluative criteria that defines their success in meeting the learning target. Learning targets may be accompanied by scales or rubrics that define each level of understanding as students’ progress in their learning (Sadler, 1989). A student should be able to identify, using criteria provided by the teacher, what level of achievement they have obtained. In addition to rubrics and scales, teachers may choose to show sample work at each level so students can compare their current work with where their goals say they should be (Moore et al., 2015). Having a well-established self-assessment routine and clear expectations will foster an environment that welcomes students to engage in their learning.

Teachers must also support context, or the psychological needs of the student, by providing assessment tools and opportunities that are aligned with the evaluative criteria defined. Learners must be allowed time for reflection on their work and behavior that contributed to their progress. During time for reflection, teachers should promote the idea that mastery of the learning target can be achieved by all students and the ultimate goal is to progress in knowledge, not to
simply complete tasks. When properly implemented, self-assessment can increase student motivation and effort and increase the amount of meaningful learning taking place (Marzano, 2010, 2017; McMillan & Hearn, 2008).

**Positive Aspects of Self-assessment**

Self-assessment was shown to improve student learning. From increases in course grades to attitudes and perceptions about course delivery, an expanding body of research reports the benefits to learners of implementing self-assessment. Through the meta-analysis of several articles, Boud and Falchikov (1989) assert that self-assessment is a skill used by all good students and all students must learn to do it to achieve success. The ability to self-assess is a transferrable skill that is useful beyond the classroom, extending into the workforce. McDonald and Boud (2003) performed a study in which 256 students in their final year of high school were trained and participated in self-assessment practices across high school subjects. They found that students who underwent self-assessment training were more likely to adopt the skill and use it in real life than their peers in the control group that did not receive self-assessment instruction. Learning, refining, and practicing self-assessment sets the stage to develop life-long learners.

**Improving Learning.** When properly implemented, self-assessment practices can lead to an increase in student learning as evidenced by students’ grades. Kitsantas et al. (2004) found that when students set goals, self-assessment helps students achieve those goals and increases their learning. In this study, ninth and tenth grade students set goals rooted in learning to use a computer animation software. The researchers found students who set goals and self-assessed their progress toward meeting those goals outperformed students in the control group. This reported success was attributed to the fact that students were able to evaluate their work and catch errors more often when they self-assessed, allowing them to fine tune their knowledge and skills. Students who performed self-assessment also reported they were more satisfied with their
performance than students who did not self-assess. Students who self-assessed also viewed the instruction they received to be of higher quality than did students in the control group. In another study a survey of university students enrolled in an engineering course which employed self-assessment techniques found that 61.5% of students agreed that the feedback provided by self-assessment allowed them to better identify their strengths and weaknesses (Willey & Gardner, 2008). Mahayukti et al. (2017) studied self-assessment as a way to engage grade eight students in mathematics. They found that students engaged in a self-assessment process in which they were trained to monitor, reflect, and adjust their practices obtained a deeper understanding of mathematical concepts. Self-assessment not only increases student learning, it increases student participation in the learning process.

**Active Learning.** Through self-assessment, students have more opportunities to participate in their learning. In a survey of university students, 69% of students believed the self-assessment process improved their ability to meet learning outcomes (Willey & Gardner, 2009b). In a qualitative survey of college educators, the development of independent learners was identified as a key benefit of implementing self-assessment. In a learning environment without self-assessment, students come to rely on their instructors for feedback. These students are unable to move ahead in their learning or analyze their own work without assistance from the instructor, therefore the students become passive learners, dependent on others for improvement (Adachi et al., 2018).

Self-assessment allows students to take learning into their own hands in a variety of ways. By providing their own feedback, students take more responsibility for their learning. The quality of feedback students give themselves directly impacts the actions they take to improve their learning. As learners generate and apply their feedback to their work, it allows them practice in improving their judgement, evaluation skills, and assessment abilities. Self-assessment
provides students the opportunity to push boundaries and take risks in their learning without fear of criticism or failure. Self-assessment is a learning opportunity, not a punishment. Providing regular self-assessment leading up to summative assessment allows students to practice free of pressure and judgement while still working to improve their learning (Willey & Gardner, 2010).

Performance Satisfaction. When self-assessment implementation is effective, students are more satisfied in their learning. Kearney (2013) similarly surveyed first year university students about their experiences with self-assessment and found 61.5% of students believed participating in self-assessment was beneficial in helping them engage their interest in course assessments. When asked about self-assessment in general, 71% found the process beneficial to their learning.

Andrade and Du (2005) report on several benefits students find when they engage in self-assessment practices. Fourteen undergraduate education students enrolled in a psychology course that provided instruction and practice in self-assessment were asked about their experience in small focus groups. These students reported the more often they self-assessed, the better they felt about the process and the more helpful they perceived it. As a result, students would engage in self-assessment more regularly as they experienced the benefits. Learners in this study also noted that self-assessment allowed them to focus on the key elements of the course, as they could better understand the expectations for assessments. Furthermore, students reported they had increased levels of motivation in the courses employing self-assessment and were more mindful in their approaches and strategies for learning. Finally, participants described decreased levels of anxiety about the coursework when self-assessment support was present. The satisfaction and benefits students experienced in these courses is not limited to the classroom, but can transition into the real world (Andrade & Du, 2005; Andrade & Valtcheva, 2009).
**Transferrable Skill.** Willey and Gardner (2009c) found self-assessment to be effective in developing the skills of reflection, evaluation, and ability to provide feedback among students. In their survey of university students enrolled in an engineering program, 74% agreed their ability to assess their work improved as the course progressed and 76% agreed their ability to give and receive feedback improved. Having acquired and practiced these skills will allow students to effectively implement reflection, evaluation, and communicating feedback in the workforce. In a survey of thirteen college professors about their opinions on self-assessment, Adachi et al. (2018) found participants spoke to the opportunity provided by self-assessment to develop cognitive and behavioral skills that will benefit the student in the future, such as effective communication, critical thinking, and self-awareness. The act of making evaluative judgements will sharpen these skills as students progress.

**Self-assessment Shortcomings**

While the benefits of self-assessment are clear, there are also associated difficulties and inconsistencies. The process of creating a self-assessment routine, implementing the routine with students, and teaching students how to use their self-assessment feedback is time consuming and does not guarantee student improvement. Some teachers express concern that taking assessment out of their hands might upend the power balance between teachers and students (Adachi et al., 2018). Individuals’ self-assessment scores often have weak correlations to their actual performance (Dunning et al., 2004; Lew et al., 2010). Another drawback is self-assessment is a process not easily mastered by all learners. The differences in knowledge and skill level between teachers, students, and biases students have about themselves interfere with accurate and effective self-assessment. Self-assessment research highlights some of the problem areas in effectively using self-assessment to enhance student learning.
**Expectation Discrepancies.** Self-assessment requires students to deeply understand the assessment expectations. Andrade and Valtcheva (2009) noted that often there was a dissonance between the expectations of the teacher and those held by the students, which would lead to differences between how the student assessed their work and how the teacher assessed their work. The different expectations between subjects and educators also prevents students from using learned self-assessment skills in other classrooms. For example, undergraduate education students reported that in some cases, they believed themselves to be prepared for the assessment task, but then would receive a grade or feedback from the teacher indicating the student was not at the level they had previously thought. Other subjects in the study expressed that they did not feel as though they were self-assessing, but were trying to change their work to fit into the expectations provided by the teacher (Andrade & Du, 2005).

The vast difference in knowledge level between teachers and students also contributes to a gap in their expectations of how success is demonstrated. Students are novice learners, but self-assessment asks them to make expert level judgements about their progress. Students simply do not possess the background knowledge they require to fully and effectively evaluate their own work. Because students are not experts in the subject area, they may superficially engage in self-assessment and do very little to help advance in their learning. The inexperienced or insincere feedback will prevent the feedback loop from being complete as the learner will be unable to make appropriate adjustments to improve their learning (Adachi et al., 2018; Dunning et al., 2004).

**Personal Bias.** Individuals’ self-assessment scores often have weak correlations to their actual performance (Dunning et al., 2004; Lew et al., 2010). Dunning et al. (2004) completed a meta-analysis demonstrating that inaccurate self-assessment often arises from the desire to have others perceive them well. These researchers found when placed in a position to self-assess,
inexperienced learners do not have the tools they need to accurately assess and often ignore information that might make them give themselves a lower assessment. Instead, these learners focus on the tasks and information they did well on and give themselves a higher ranking. People are also optimistic about how they will perform. Individuals are more likely to see themselves as above average, likely to take action to become better, and underestimate the time it will take to complete tasks. Self-assessment becomes less effective as learners have a lack of necessary knowledge and a tendency to ignore unflattering information that would allow them to improve their learning (Dunning et al., 2004). Self-assessment scores are often skewed because of their desire to appear capable and inaccurate perceptions of knowledge. Dunning et al.’s (2004) findings of student tendencies to over-rate their self-assessments is further supported by several other studies (Maki, Jonas, and Kallod, 1994; Hacker, Bol, Horgan, and Rakow, 2000).

**Ability Based.** Self-assessment is not effective for all students. Boud, Lawson, and Thompson (2013) observed two major trends when implementing self-assessment among 1400 undergraduate students enrolled in a four-year Design Program administered online. First, students initially struggle with self-assessment and do not accurately assess their abilities. As they continue to practice self-assessment, students tend to get better at accurately assessing their work. However, this refinement in judgement is not universal for all learners and tends to be related to academic ability. High achieving students consistently underestimate their performance and continue to do so even after practicing self-assessment. Low achieving students consistently overestimate their performance and their judgement does not improve with self-assessment practices. Middle achieving students tend to overestimate their performance early on in self-assessment, but improve as they practice and eventually assess themselves more accurately (Boud et al., 2013, 2015; Lew et al., 2010). A study of the same undergraduate design students over a five-year period by Boud et al (2015) found students are able to refine their judgement faster
when the mode of self-assessment is consistent. If students are learning how to present their learning in a new form, this pulls their attention from the content they are representing. Learners will self-assess more accurately with an established self-assessment routine designed by the teacher to meet the needs of the course and enrolled students (Boud et al., 2015).

**Research Purpose**

While it is clear that self-assessment is an area of interest in educational research and beyond, the ability of young students to accurately judge their learning is lacking in research. Many self-assessment related studies focus on students in post-secondary education. This population of students have shown the initiative required in education to continue learning at higher level institutions and have chosen degree paths matching their personal desires. This built-in level of motivation and interest is in many cases lacking in middle and high school students. What remains unclear is whether these younger students are capable of using self-assessment to accurately assess their skills and learning progress. In an effort to address this lack of self-assessment knowledge among younger students, this study will engage high school students in a process of self-assessment through formative assessment quizzes in order to evaluate their self-assessment accuracy. This research aims to answer the questions: (1) How accurately do ninth grade students in an Earth Science course self-assess their learning? (2) How will students’ skills in self-assessment change as they practice and become more familiar with the process of self-assessment? (3) What basis do students use to assess their learning? (4) How do the explanations provided by students that accurately self-assess compare to students that do not accurately self-assess?

**Theoretical Framework**

Self-assessment plays a role in the Social Cognitive Theory of Learning (SCT). SCT describes that learning takes place through interactions between the learner’s self, environment,
and behavior. The self refers to the knowledge held by the student and their motivation. The environment refers to the space in which students are learning and working. Behavior is the actions taken by the student to influence their learning. These variables fluctuate in their degree of influence and will each play a role in prompting the learner (Zimmerman, 1989). High quality self-assessment provides an opportunity and environment where students can practice and improve their skills without fear of punishment or failure, which in turn gives them the opportunity to try new behaviors and acquire new skills they can call upon for future learning opportunities. In building self-assessment learning experiences, students will become self-regulated learners, which are individuals who are active learners through awareness of both what they know and of the knowledge they lack. Self-regulated learners can find information when they need it and proactively take steps to learn new material. These learners view taking in new information as an achievable process that provides results (Zimmerman, 1990). Self-assessment is one tool that will allow students to transition from being dependent on others in their learning into self-regulated learners who can control themselves, their actions, and their environment to create academic success.
Chapter 3
Methodology

Site and Participation

This research took place at a suburban high school in Iowa in the Earth Science classrooms as part of the district transition to Standards Based Grading. The high school serves a total of 1,800 students in grades 9-12. The school is predominantly white with only 21.83% of students identified as a non-white minority. Regarding special programs, 31.89% of students qualify for free and reduced lunch, 3.56% receive support as English language learners, and 8.67% of students receive additional support through Individual Education Plans (National Center for Educational Statistics, 2018). Students who participated in this study were in the required freshmen level Earth Science course. However, students identified by middle school teachers or standardized tests scores as advanced in math or science have the opportunity of completing this course a year early before coming to high school. Students who move to the district without an Earth Science credit must take the course for graduation. As a result, most participants in this study are freshmen, but there are a few sophomores, juniors, and seniors included.

Data Collection Procedures

The purpose of this study was to evaluate the degree of accuracy high school students have when they self-assess. The first unit covered five learning targets and students participated in opportunities to self-assess over those learning targets. Each learning target had three opportunities for self-assessment throughout the unit. Students first self-assessed on a practice quiz, then on a graded quiz three to five days later, and finally on the unit exam when instruction had finished. The practice quiz, quiz, and exam were scaffolded to assist students in growing their understanding. Figure 1 provides the purpose of each type of assessment.
Figure 1. The purpose behind each assessment and the different roles they played in collecting data from students.

Per district directive, students ranked their completion of the learning target on a scale of one to four. A level one ranking indicates room to improve while a level four denotes mastery of the topic. Student’s work was then evaluated by the teacher using the same four-point scale to determine their actual score. Table 1 shows additional descriptors added to the numerical scale to assist students in ranking their understanding. The Earth Science teachers generated these descriptors to guide students in selecting a more accurate self-assessment level.

Table 1

Self-assessment Scale and Descriptors

<table>
<thead>
<tr>
<th>Self-assessment Level</th>
<th>Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I am practicing this! I was lost and had to guess a lot.</td>
</tr>
<tr>
<td>2</td>
<td>I’m working on this! I got a few of them but had to do a little guessing.</td>
</tr>
<tr>
<td>3</td>
<td>I understand this! I got most of them right without guessing!</td>
</tr>
<tr>
<td>4</td>
<td>I could teach this! I got them all right without guessing!</td>
</tr>
</tbody>
</table>
The first attempt at self-assessing a new learning target was on a formative practice quiz. Students were asked to assess their progress over specific learning targets through formative assessment quizzes prepared on Google Forms and assessed their understanding on a four-point scale. It was found that students who engage with formative assessment quizzes achieve higher grades than students who do not attempt practice exercises (Aravinthan & Aravinthan, 2010; Kibble, 2007). Each practice quiz was designed to assess a key aspect of one learning target. Following the structure as identified by Andrade and Valtcheva (2009), the expectation for student success was identified in the learning target, the formative assessment quiz was completed by the student and they assessed their progress according to the four-point scale before learning of their actual quiz score. Finally, through discussion of the formative assessment quiz with their teacher and peers, students were able to correct mistakes as necessary to progress their learning.

On each practice quiz, quiz, and the final exam, the last questions were self-assessment questions asking students to assess their own work and explain why they selected that score for themselves. This self-assessment was completed before students received their actual score. Student self-assessment scores and their reason for choosing that score provided data which was analyzed. The numerical data provided was used to determine if students were self-assessing accurately and if they improved their accuracy of self-assessment as the unit progressed. The basis for how students chose their self-assessment score and how that varied between accurate and not accurate assessors was determined using student explanations of their score selection. The methods used in this study were approved by the University of Northern Iowa Institutional Review Board. (Appendix A)

Classroom Routine
Because goal setting has been shown to play a definitive role in student engagement, on the first day of classes, students were encouraged to set an academic goal they would like to work toward throughout the year (Burrows, 2010). Students were provided examples of goals they might set, including turning in work on time, achieving certain grades, or setting aside a certain amount of time to study during the week. To establish early on the importance of self-assessment and the frequency in which the class would participate in the practice, the process that would be used for self-assessment was introduced on the second day of class. First, students’ attention was drawn to the learning target being addressed by the practice quiz so students explicitly knew on which skills and knowledge they were reflecting. Prior to completing the first practice quiz, the teacher specifically addressed that the practice quiz was formative practice and that results would not impact their grade. Students were encouraged to think about their progress on the topic and to reflect on what had led them to that point (Marzano, 2010, 2017; Sadler, 1989). The process was then modeled for the students by the teacher, including making mistakes in the questions and then providing a low self-assessment score citing the uncertainties made while modeling. The modeling process demonstrated that it was alright not to know all the answers and to admit that more work needed to be done before competency was achieved (Newmann, 1989). After the demonstration, students were provided time to work on the practice quiz questions and self-assessment questions that followed. Student computer screens were monitored so that all students were provided enough time to complete their self-reflection.

**Developing the Learning Targets**

The implementation of the Next Generation Science Standards (NGSS) expanded the scope and rigor of Earth Science education. The NGSS is structured to improve geoscience literacy and correct misconceptions that students may have from previous experiences. With higher quality Earth Science education, the public will be more informed decisionmakers when
considering geologic issues, such as resource development and consumption, climate change, and impacts of natural disasters (LaDue & Manning, 2015). Because Earth Science is a newly required course, there is a small body of work addressing misconceptions in earth science, few of those articles address the geosciences (Guffey & Slater, 2020; Kusnick, 2002). The first unit of Earth Science focuses on geoscience topics including minerals, rocks, and natural resources. The Earth Science teachers developed the learning targets for this unit using NGSS priority standards HS-ESS3-1 and HS-ESS2-1 as well as supporting standards HS-ESS3-2 and HS-ESS3-3 (NGSS Lead States., 2013). The Earth Science teachers also decided to write the learning largest as “I can…” statements to make them more accessible to students and to clearly establish what students will know at the end of the unit. Table 2 summarizes the learning targets that are addressed throughout the unit.

Table 2
Unit 1 Learning Targets

<table>
<thead>
<tr>
<th>Numerical Identifier</th>
<th>Learning Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Target 1-1: Minerals</td>
<td>I can list the requirements for a substance to be classified as a mineral.</td>
</tr>
<tr>
<td>Learning Target 1-2: Rock Characteristics</td>
<td>I can describe the properties of the three main types of rocks.</td>
</tr>
<tr>
<td>Learning Target 1-3: Rock Cycle</td>
<td>I can diagram how each rock type is created in the rock cycle.</td>
</tr>
<tr>
<td>Learning Target 1-4: Mining Costs</td>
<td>I can explain the cost/benefits of mining operations and describe the impacts of mining.</td>
</tr>
<tr>
<td>Learning Target 1-5: Renewable and Nonrenewable Resources</td>
<td>I can describe the difference between renewable and nonrenewable resources and identify examples of each.</td>
</tr>
</tbody>
</table>

Learning Target 1-1: Minerals aims to address common misconceptions students hold about minerals by providing a list of requirements that all minerals meet. Students do not
typically recognize a difference between rocks and minerals due to their similar physical features. Students also hold misconceptions about minerals due to their association with vitamins in nutrients (Guffey & Slater, 2020; Happs, 1982; King, 2008). Addressing this learning target will provide a foundational definition of mineral that will allow students to understand how they are different from rocks despite their similar physical appearance.

Learning Target 1-2: Rock Characteristics builds upon the work done in Learning Target 1-1: Minerals by introducing rocks and how they are different from minerals. Learning to classify rocks into igneous, metamorphic, and sedimentary is typically a challenge for students. When making observations of rocks, students focus on features that do not indicate the formation of the rock, such as color or weight of the rock (Guffey & Slater, 2020; King, 2008; Remmen & Frøyland, 2020). This learning target allows students to engage with rocks and make observations about them while learning about the specific textures, crystallizations, or characteristics that indicated the way the rock formed.

Once students are familiar with the tree types of rocks and their characteristics, Learning Target 1-3: Rock Cycle introduces how rocks cycle through various processes in the geosphere. The rock cycle is often difficult for students to fully grasp because of the timescale in which it takes place. Students often see the rock cycle as the cause for rock formation and not as a model of rock formation that demonstrates relationships. Instead of understanding the complete system, they simplify it into a repeating cycle (Ford, 2005; King, 2008). Kusnick (2002) found that even while learning about the rock cycle, students frequently describe it as taking place in a short amount of time, insert the actions of humans as contributions to weathering and eroding sediments, and have difficulty believing that the earth is changing because they believe it is stable based on their own observations.
After discussing rocks and minerals, Learning Target 1-4: Mining Costs begins to address how humans use rocks and minerals to build their society. This section begins with students exploring how rocks and minerals can be utilized and then expands into the mining and usage of fossil fuels. A majority of students believe that fossil fuels are only found deep underground and do not give much thought to where these resources come from or how they are maintained (DeWaters & Powers, 2011; Guffey & Slater, 2020). Students explore various mining processes, including fracking and oil derricks, and the impact they have on their environment. They also look into the economic aspect of mining to understand how mining corporations spend money, make money, and pay for reclamation when the site closes.

Finally, the unit closes by looking into natural resources used to generate energy by exploring Learning Target 1-5: Renewable and Nonrenewable Resources. DeWaters and Powers (2011) indicate that to have an energy literate population, it is critical that students learn where their energy comes from and think about their energy usage. In a survey of middle and high school students, it was found they lacked knowledge on energy conservation, did not think about their energy consumption on a daily basis, could not identify what natural resources powered their home, and supported the use renewable resources as long as their usage did not increase costs. Energy education is a critical step in educating consumers about the benefits to renewable energy technology and its availability (DeWaters & Powers, 2011). This learning target allows students to explore the positive and negative aspects of various natural resources that are used as energy sources. Students have the chance to analyze the resources energy output and its longevity as an energy source.

**Planning the Unit**
Using the learning targets as a guide, the Earth Science teachers established 10 days were needed to adequately address all the content. This required a total of 20 calendar days due to the use of block scheduling. All classes were held virtually due to damage done to the school building during a severe storm, so all hands-on labs and activities required virtual substitutes.

The units included direct instruction over each topic and a blend of virtual interactives and review activities including supplemental videos, online flashcards, and teacher designed review sheets.

Two research projects were included as additional opportunities for students to demonstrate their learning and achieve a deeper understanding of the content. Figure 2 shows the instructional plan for unit 1.

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Day 2</td>
<td>Practice Quiz #1.1</td>
<td>Virtual Rock Identification Lab</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 3</td>
<td>Practice Quiz #1.2</td>
<td>Rock Cycle Notes</td>
<td>Rock Cycle Interactive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 4</td>
<td>Rock and Mineral Quiz</td>
<td>Mining and Natural Resources Notes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 5</td>
<td>All About Rocks/Minerals Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 6</td>
<td>Practice Quiz #1.4</td>
<td>Practice Quiz #1.5</td>
<td>Aim to Reclaim Interactive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 7</td>
<td>Rock Cycle, Mining, and Natural Resources Quiz</td>
<td></td>
<td>Natural Resources Project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 8</td>
<td></td>
<td></td>
<td>Natural Resources Project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 9</td>
<td>Unit 1 Review Sheet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 10</td>
<td>Unit 1 Exam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. Plan for instruction for Unit 1, Rocks, Minerals, and Natural Resources. This outline provides placement of each assignment and learning opportunity provided to the students during the first ten days of learning.
The unit began by covering Learning Target 1-1: Minerals and Learning Target 1-2: Rock Characteristics through direct instruction. Immediately following direct instruction, students were provided a teacher designed review sheet over the main ideas in the notes which is called a Big Ideas Sheet. The purpose of the Big Ideas Sheet is to draw student’s attention to the most important information needed to attain the learning target. The second day of instruction introduced the first practice quiz about mineral requirements. Following the discussion of the practice quiz, students completed an online rock identification simulator that required students to apply the information they had learned in the class period prior. In the following class period, students had their second chance to self-assess on the second practice quiz about Rock Characteristics. This discussion transitioned into direct instruction about the rock cycle, which was followed by an interactive rock cycle where students experienced the processes rocks undergo to create new types of rocks.

On the fourth day of instruction, students completed their first graded quiz and then received direct instruction over Learning Targets 1-4: Mining Costs and Learning Targets 1-5: Renewable and Nonrenewable Resources. This direct instruction was followed by a Big Ideas Sheet over Learning Target 1-3: Rock Cycle, Learning Target 1-4: Mining Costs, Learning Target 1-5: Renewable and Nonrenewable Resources. At the halfway point of instruction, students were provided a research project that would allow them to explore the usage of rocks and minerals. For this project, students selected a rock or mineral that had been discussed or identified in class and they researched how it is used, mined, and how that mining impacts the environment. This project helped students make a connection between the learning targets at the beginning of the unit and the learning targets at the end of the unit. On day 6 of instruction, students completed practice quizzes over Learning Target 1-4: Mining Costs and Practice Quiz #1.5: Renewable and Nonrenewable Resources. After discussion about those learning targets, students completed an
online simulation about the reclamation of a former mining site. In this simulation, students learned about the careers involved, the process of refurbishing a mine into a wildlife refuge, and the expenses the mining company is responsible for.

The following day, students took their second graded quiz of the unit covering Learning Target 1-3: Rock Cycle, Learning Target 1-4: Mining Costs, and Learning Target 1-5: Renewable and Nonrenewable Resources. After completing the quiz, students began researching information for the Natural Resources Project which would span into day 8 of instruction. In the Natural Resources Project, students selected a natural resource that is used to provide energy, such as coal, oil, hydropower, solar power, or nuclear power. Once students selected a natural resource to research, they created an informational pamphlet that described how energy is derived from the source, where the resources can be found, places in the United States that use that type of energy, and positive and negative aspects to using this resource. Students ended the project by identifying the natural resource as renewable or nonrenewable. If the resource was renewable, students described technological advancements made to improve accessibility to the resource. If the natural resource was nonrenewable, students describe ways to conserve the energy source.

Day 9 of instruction focused on review of the entire unit. Students completed a teacher designed review sheet that contained practice questions covering each of the learning targets for the unit. Additional digital practices were provided for students as optional activities including digital flashcards, supplemental videos, and practice exams. On the last day of instruction students completed the unit exam that covered all learning targets. The exam was composed of short answer questions over Learning Target 1-1, Minerals, Learning Target 1-2: Rock Characteristics, Learning Target 1-4: Mining Costs, and Learning Target 1-5: Renewable and Nonrenewable Resources. To assess Learning Target 1-3: Rock Cycle, students labelled a diagram with matching and fill in the blank questions. Students were also asked to identify
renewable and nonrenewable resources off a list to address Learning Target 1-5: Renewable and Nonrenewable Resources (Appendix B).

The Earth Science teachers decided to use Practice Quizzes as the first opportunity for self-assessment. Because Practice Quizzes are formative assessments, it was low stakes for the students and allowed themselves to be honest about their level of understanding. The practice quizzes could also be completed quickly at the beginning or end of a class period to gauge understanding and guide further instruction and review. An Earth Science teacher volunteered to draft the practice quizzes and brought them to the Earth Science Planned Learning Community (PLC) to discuss and edit the drafts as a group. The Earth Science PLC edited the questions to ensure the practice quiz addressed the learning target content, were an appropriate level of difficulty based on where it would be assigned in the unit, and contained both self-assessment questions (Appendix B).

To help familiarize students with the learning targets, the teacher presented the learning targets in a variety of ways. Each day, a brief presentation detailed the tasks for the day and the learning target those tasks addressed. The teacher would read aloud the learning targets and connect them to the assignments for the day. On each activity, the learning targets addressed by the activity appeared at the top of document near the title and directions. The learning target addressed appeared on each practice quiz and was read aloud prior to students completing the quiz. Quizzes and exams displayed the learning targets they addressed in the directions. Students interacted with the learning targets audibly and visually each day to help them become more familiar with their presence and purpose.
Chapter 4
Results

All 148 students enrolled in the course participated in the self-assessment opportunities. Of those students, 146 agreed to participate in the study and 2 declined. Because of absences and student schedule changes, not all students participated in each self-assessment opportunity. Table 3 summarizes participant numbers for each self-assessment opportunity.

Table 3
Number of Participants in Self-assessment Opportunities

<table>
<thead>
<tr>
<th>Learning Target 1-1: Minerals</th>
<th>Practice Quiz</th>
<th>Quiz</th>
<th>Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Target 1-2: Rock Characteristics</td>
<td>133</td>
<td>138</td>
<td>141</td>
</tr>
<tr>
<td>Learning Target 1-3: Rock Cycle</td>
<td>128</td>
<td>126</td>
<td>141</td>
</tr>
<tr>
<td>Learning Target 1-4: Mining Costs</td>
<td>119</td>
<td>126</td>
<td>141</td>
</tr>
<tr>
<td>Learning Target 1-5: Renewable and Nonrenewable Resources</td>
<td>121</td>
<td>126</td>
<td>141</td>
</tr>
</tbody>
</table>

Quantitative Data Results

A paired sample t-test allowed for comparison of scores students assigned themselves and the earned score. A separate t-test was completed for each practice quiz, quiz, and exam on which students provided a self-assessment score. Throughout the unit, students had 15 opportunities to self-assess their progress. Each learning target was self-assessed on 3 occasions. Cohen’s D was calculated to measure the effect size determining the difference between the mean scores of student self-assessments and mean of the actual scores. In 11 of 15 self-assessment opportunities,
there was a significant difference in the self-assessment scores between the students and the earned score. When comparing the self-assessment mean and actual score mean students tended to give themselves a score lower than they actually achieved. In 10 of 15 self-assessment opportunities the self-assessment mean score was lower than the mean of the actual scores. In 4 of 15 self-assessment opportunities, the students assessed themselves accurately. On the exam for Learning Target 1-2: Rock Characteristics, students slightly over estimated their performance.

Table 4 contains a summary of student self-assessment scores and the actual scores they received.

Table 4
Comparison of Self-assessment and Actual Scores

<table>
<thead>
<tr>
<th>Trial</th>
<th>Self-assessment scores</th>
<th>Actual scores</th>
<th>p</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Learning Target 1-1: Minerals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Practice Quiz</td>
<td>2.67</td>
<td>0.78</td>
<td>3.25</td>
<td>0.68</td>
</tr>
<tr>
<td>Quiz</td>
<td>2.65</td>
<td>0.83</td>
<td>3.18</td>
<td>0.99</td>
</tr>
<tr>
<td>Exam</td>
<td>2.89</td>
<td>0.86</td>
<td>3.57</td>
<td>0.81</td>
</tr>
<tr>
<td>Learning Target 1-2: Rock Characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Practice Quiz</td>
<td>2.14</td>
<td>0.69</td>
<td>2.50</td>
<td>0.98</td>
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<tr>
<td>Quiz</td>
<td>2.61</td>
<td>0.82</td>
<td>2.83</td>
<td>1.06</td>
</tr>
<tr>
<td>Exam</td>
<td>2.77</td>
<td>0.82</td>
<td>2.41</td>
<td>1.08</td>
</tr>
<tr>
<td>Learning Target 1-3: Rock Cycle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Practice Quiz</td>
<td>2.81</td>
<td>0.90</td>
<td>3.16</td>
<td>1.12</td>
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<tr>
<td>Quiz</td>
<td>2.96</td>
<td>0.84</td>
<td>3.18</td>
<td>1.02</td>
</tr>
<tr>
<td>Exam</td>
<td>3.04</td>
<td>0.91</td>
<td>3.17</td>
<td>1.09</td>
</tr>
<tr>
<td>Learning Target 1-4: Mining Costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Practice Quiz</td>
<td>2.51</td>
<td>0.71</td>
<td>3.13</td>
<td>1.01</td>
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<tr>
<td>Quiz</td>
<td>2.81</td>
<td>0.68</td>
<td>3.14</td>
<td>0.83</td>
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<tr>
<td>Exam</td>
<td>2.75</td>
<td>0.89</td>
<td>2.75</td>
<td>1.09</td>
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<tr>
<td>Learning Target 1-5: Renewable and Nonrenewable Resources</td>
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<tr>
<td>Practice Quiz</td>
<td>2.44</td>
<td>0.67</td>
<td>2.36</td>
<td>1.06</td>
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<tr>
<td>Quiz</td>
<td>3.06</td>
<td>0.79</td>
<td>3.74</td>
<td>0.74</td>
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<tr>
<td>Exam</td>
<td>3.11</td>
<td>0.86</td>
<td>3.18</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Students assessed themselves accurately on only four occasions, meaning the mean self-assessment score and mean actual score were not statistically different. No clear pattern emerges
as students progressed from practice quiz, to quiz, and exam for the first two learning targets. However, students were more accurate in their self-assessments for the last three learning targets. This indicates the students improved in their accuracy as they practiced self-assessment. In 10 of 15 self-assessment opportunities there was a statistically significant difference between the mean self-assessment score and mean actual score with the mean self-assessment score being lower than the mean actual score. In only 1 self-assessment opportunity was the actual mean score lower than the self-assessment mean score, meaning students overestimated their performance.

For Learning Target 1-1: Minerals, students consistently underestimated their performance. On the practice quiz, students underestimated their skills substantially. On the quiz the gap closed slightly, but the students still assigned themselves lower grades than they actually received. On the exam the gap widened once again with students underestimating their performance. Student’s actual scores decreased on the quiz from the practice quiz, however they raised their scores on the exam.

For Learning Target 1-2: Rock Characteristics, the mean self-assessment scores were less than the actual scores for the practice quiz and quiz, meaning students again underestimated their scores. However, the trend reversed on the unit exam where students scored themselves higher than their actual performance. The effect size for these self-assessment opportunities indicates that the differences between the mean self-assessment scores and mean actual scores is small.

For Learning Target 1-3: Rock Cycle, students once again underestimated their actual performance on the practice quiz and quiz, however they accurately self-assessed on the exam. As evidenced by the decreasing effect size, the difference between the self-assessment mean score and actual mean score decreased as the students moved through the unit, indicating that with each self-assessment, the students were getting more accurate.
For Learning Target 1-4: Mining Costs, students once again followed the expected trends of self-assessments becoming more accurate as learning progressed. A statistically significant difference between self-assessment mean scores and actual mean scores was indicated by the practice quiz. This difference got smaller on the quiz as indicated by the effect size and closed completely on the unit exam where the self-assessment mean score and actual mean score were not statistically different.

For Learning Target 1-5: Renewable and Nonrenewable Resources, students began by accurately assessing on the practice quiz with no statistical difference between self-assessment and actual scores. On the quiz, a gap between self-assessment score mean and actual score mean appeared as students underestimated their abilities. The effect size indicates a large difference between their self-assessment scores and actual scores. On the unit exam, the gap closed once again and there was no significant difference between the self-assessment and actual scores, meaning students were accurately self-assessing their performance on the unit exam.

**Qualitative Data Results**

After providing a numerical self-assessment score on the one to four scale, an additional question provided students the opportunity to explain why they selected that ranking. In addition to the question on the assignment, a verbal prompt reminded students to explain the reason they selected their score with one or two sentences. Analysis by hand for common words and phrases of a random sample of 44 responses provided by the students allowed for representation of six to eight students per section and all grade levels, genders, and student abilities. These 44 responses revealed clear patterns in their thought processes. Some student referred to the descriptors provided by the teacher to explain their score, but most students provided their own explanation for their self-assessment. Three categories emerged in the student provided explanations of their
self-assessment scores, sometimes touching on more than one of those categories. Table 5 summarizes the categories used to classify student explanations.

Table 5

Categories of Student Self-assessment Explanations

<table>
<thead>
<tr>
<th>Category</th>
<th>Descriptor</th>
<th>Common Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of Confidence</td>
<td>Discusses students’ feelings about their performance.</td>
<td>Confident, feel, know, guess, understand, certain/sure, good</td>
</tr>
<tr>
<td>Level of Self-Efficacy</td>
<td>Discusses previous learning experiences that contributed to their score.</td>
<td>Study, remember, practice, working, reviewed</td>
</tr>
<tr>
<td>Outside Factors</td>
<td>Discusses reasons outside of the student’s control</td>
<td>Confused, tired, hard, unsure</td>
</tr>
</tbody>
</table>

Students often referred to their level of confidence in their responses. These responses refer to the student’s feelings about how they performed. Common themes among these responses included needing to guess on the questions, being confident or lacking confidence in their answers, discussing their comfort with the subject, or providing an evaluation of their academic abilities as a whole. Below are examples of student responses that refer to their level of confidence:

“Because I was struggling and it was hard to figure it out so most of the time I had to guess.”

“im comfortable with my answers.”

“I feel like I know most things about mining and how it is done”

“i feel i did good”
"because im smart"

Students also discussed their level of self-efficacy in their responses. This category of responses referred to a specific action the student took to achieve their level of knowledge. When discussing self-efficacy, students would mention remembering the content, reference a specific assignment or class activity, or discuss the time they spend studying outside of class. The following are examples of student responses that refer to their self-efficacy:

“I hopefully got most of them right, I think I was able to remember from the google slides we did.”

“Because I think that I could use more help with understanding minerals as I have forgotten a lot.”

“I studied the study guide a lot last night.”

“I gave myself that score because I didn’t practice as much as I should have so I don’t understand everything.”

“because i got all my homework done”

Students also discussed outside factors that had an impact on their performance. Outside factors include details about their environment that were distracting, evaluating the assessment tool, or discussing any facet of learning the student feels that they cannot control. The following are examples of student responses that discussed outside factors in their reason for their score:

“i try really hard but i suck at earth science no matter how hard i try”

“I was confused on how the question was asked”

“because im tired”
“my brain is just not working today”

“it wasn’t that hard i don’t think”

Analyzing student explanations for self-assessment by their degree of accuracy reveals interesting trends. Organizing students by their tendency to over assess their abilities, under assess their abilities, or accurately assess their abilities reveals trends in the categories of their responses. Individual student responses were analyzed to determine if the student generally tended to over, under, or accurately assess themselves. If 80% of the students’ self-assessment scores were overestimating their performance, they fell into the over assessor category. The same threshold applied to under and accurate assessors. Table 6 summarizes the percentage of responses in each category used by accurate, over, and under assessors.

Table 6

Self-Assessment Explanations by Level of Accuracy

<table>
<thead>
<tr>
<th>Level of Accuracy</th>
<th>Level of Confidence</th>
<th>Level of Self-efficacy</th>
<th>Outside Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over Assessors</td>
<td>68.7%</td>
<td>7.1%</td>
<td>25%</td>
</tr>
<tr>
<td>Under Assessors</td>
<td>75.9%</td>
<td>20.7%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Accurate Assessors</td>
<td>71.8%</td>
<td>28.2%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

In general, all groups referred to their level of confidence more often than any other category to explain their score. Students who overestimated their performance were much more likely to cite outside factors as the reason for their score and were much less likely to refer to the actions they took to achieve that score. Students who accurately self-assess are more likely to refer to their self-efficacy and the work they did to achieve that level of understanding. Accurate assessors also did not refer to outside factors when explaining why they chose their score.
Students who underestimated their performance were more likely to refer to their level of self-efficacy than students that overestimated their performance and less likely to refer to outside factors.

Discussion

**Accuracy of Self-assessment.** The quantitative results of this study show that students early in their high school career are not able to accurately self-assess without practice. This reflects previous research that indicates students will struggle with self-assessment at first, but will get better as they practice (Boud et al., 2013). Until students started to improve at the end of the unit, the majority of self-assessment scores students submitted were lower than their actual score.

Students do hold personal biases about themselves as Dunning et. al. (2004) suggest, but rather than viewing themselves positively, many students’ scores and comments indicated that they held negative beliefs about themselves. Many students expressed that they were not learning, struggling to learn, or in some extremes, incapable of learning the content while their actual scores were indicating they were demonstrating competency of the content.

To assist students in overcoming their personal bias, it is critical to continue to model goal setting and growth mindset. The studies that indicate that self-assessment practices help improve learning (Willey & Gardner, 2008), engage students in active learning (Willey & Gardner, 2009b, 2010), increase student satisfaction (Andrade & Du, 2005; Kearney, 2013; Willey & Gardner, 2009a) and foster a transferrable skill (Adachi et al., 2018; Willey & Gardner, 2009c) contained data collected from experienced students in post-secondary education. Students who are pursuing post-secondary education have likely internalized the learning strategies they need to advance in their learning.
**Improvements in Self-assessment.** Students did become more accurate self-assessors as they progressed through the unit and became more familiar with the practice. Boud et. al. (2015) suggest that keeping a consistent self-assessment routine will help students calibrate their self-assessment ability faster, and by the end of the unit, students were able to accurately estimate their performance on 3 of 5 learning targets. As a group, the students in this study consistently underestimated their scores throughout the unit, but they still became more accurate self-assessors as the unit progressed.

One possibility for the gap between student perceptions of performance and their actual performance is the expectation discrepancies between teacher and student (Andrade & Valtcheva, 2009). In most cases, students were underestimating their abilities to complete the assignment successfully. This indicates that the students had higher expectations for themselves than did the teacher. This discrepancy could be due to the use of the general four-point scale for each learning target. While the teacher verbally provided expectations for each student on how to rank themselves, the use of a more specific scale for each activity might improve the student’s ability to accurately self-assess (Marzano, 2010, 2017; Moore et al., 2015). For example, for Learning Target 1-2: Rock Characteristics might specify that to achieve a score of 4, a student must be able to describe all the properties of the 3 types of rocks, while to achieve a 3, a student must be able to describe the properties of at least 2 types of rocks. Andrade and Du (2005) suggest that increasing the conversation between students and teachers about the expectations and the differences between them can lead to students having a greater understanding of the expected outcomes for a given assignment.

**Basis of Self-assessment.** The qualitative results of this study offer additional insight on the gap between student and teacher perceptions of progress. Student responses fell into three categories: level of confidence, level of self-efficacy, and outside factors. Students who referred
to their level of confidence discussed their feelings about their performance and would mention how certain or uncertain they felt about their performance. Students who fell into the level of self-efficacy category discussed previous learning experiences that contributed to their score such as discussing specific assignments or study methods. Student responses in the outside factors category explained the performance as being outside of their control. Responses in this category referred to the environment, the students’ physical needs, or evaluated the assessment.

**Basis of Self-assessment by Accuracy.** Boud et. al. (2013) suggested that student ability played a role in a student’s ability to self-assess accurately and that was supported in this study. As a whole, students typically refer to their level of confidence, however students who assess themselves accurately explain their self-assessment rational differently than students who overestimate and underestimate their scores. Students who overestimate their abilities are more likely to discuss outside factors as the reason for their self-assessment than students who overestimate or accurately assess. Students who accurately assess their performance have higher instances of referring to their level of self-efficacy than students who overestimate or underestimate their performance.

As suggested by Boud et al. (2013) the accuracy of self-assessment is rooted in student ability. In general, lower achieving students had a tendency to overestimate their scores while higher achieving students would underestimate their scores more often. Lower achieving students were also less likely to improve their accuracy of self-assessment over time, while higher and middle achieving students were able to become slightly more accurate assessors as they practiced self-assessment.

**Additional Steps for Self-assessment.** While students did not demonstrate the ability to accurately self-assess at this stage, additional steps and changes could be made to this process to
make it more effective for students. Brown and Harris (2014) suggest that simply having students assess themselves, as demonstrated in this study, is the first phase in a much longer process. Having this concrete experience of evaluating work gives students the foundation on which they can build their self-assessment skills. After establishing the routine of self-assessment, teachers can move students to an intermediate stage of assessing, by asking them to compare their work to models, samples, or work completed by their peers. This will allow students to see work at completed at different levels of understanding and allow them the chance to practice placing their own work in this spectrum (Brown & Harris, 2014; Kostons et al., 2012; Ross, 2006).

To transition students to an advanced stage of self-assessment, involving students in determining the criteria on which they will be assessing ensures students have a comprehensive understanding of the requirements (Brown & Harris, 2014). Including students in the development of rubrics, scales, and criterion will also guarantee that they use language that is accessible to students and includes aspects of performance that the students find important (Ross, 2006). This will encourage students to invest in the learning process as they are working toward the goals that they set for themselves. A critical step in working toward goals would be to help students use the self-assessment data they generate. Feedback from the teacher about self-assessment can allow students to align their work expectations with those of the teacher. Teachers can also assist students by pointing out growth in student work and addressing their progress in working toward goals established by the students (Brown & Harris, 2014; Ross, 2006). Students may require some help establishing this trust with the teacher, which may include allowing students to keep some of their self-assessments private or not forcing students to share their work with peers until they are comfortable (Brown & Harris, 2014).

Limitations
This study took place during the first unit of a freshman earth science class. As students continue to practice self-assessment throughout the remainder of the year, they may improve their accuracy and skills in self-assessment. Because the duration of this study only covered 10 days of instruction, it may not have provided a full scope of the abilities of students to progress. This study was the first unit completed during online learning while students were still adjusting to the new technology and learning conditions necessitated due to construction on the school building. This was many students’ first experience using the district issued laptops, navigating the online learning management system, and utilizing video conferencing to receive instruction. As a result of adjusting to online learning and technology difficulties, students may have missed pieces of instruction including the practice quizzes and discussions about them.

**Further Research**

Additional opportunities for research arise in trying new strategies to teach students to better self-assess their understanding. Further research might address how to engage students in determining grading criteria in an Earth Science class where they are unfamiliar with the subject matter and standards they are trying to meet. In addition, investigating best strategies for holding conferences with students or providing feedback on their self-assessment will allow further clarity in making the self-assessment process more effective. Finally, research might be completed asking for student opinions on how they feel about self-assessment and its usefulness as a learning strategy. Student opinions might offer additional insight into whether students see the value in self-assessment as a learning strategy.
References


https://doi.org/https://doi.org/10.1037/0022-0663.92.1.160


Appendix A: IRB Exemption

Jacobson (Stone): IRB PreK-12 Exempt 1 Determination

Fri, Aug 7, 2020 at 9:23 AM

To: alyssa.jacobson@gmail.com
Cc: Jody Stone <jody.stone@uni.edu>, Sean Parrish <sean.parrish@uni.edu>, Todd Evans <todd.evans@uni.edu>

Dear Investigator[s]:

Your study, Accuracy of Self-Assessment in the High School Science Classroom, has been determined by the UNI IRB to meet the criteria for Exempt status, category 1. You may begin recruitment, data collection, and/or analysis for your project.

You are required to adhere to the study procedures reported in your IRB form, and to monitor the project to ensure that the rights and privacy of the participants in your study are protected.

If you need to make any changes to the study, you must request approval of the changes before continuing with the research. Requests for modifications should be emailed to the IRB Chair Todd Evans at todd.evans@uni.edu.

Your study will not require annual review or closure.

If during the study you observe any problems or events pertaining to participation in your study that are serious and unexpected, you must pause data collection and report this to the IRB immediately (at least within 10 days) to receive guidance on next steps. Examples include unexpected injury or emotional stress, mistakes in the consent documentation, or breaches of confidentiality.

Best wishes for your project success.

Todd Evans
IRB Chair

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Fax number: 273-7023
Appendix B: Assessments

Practice Quiz #1.1

Practice Quiz #1.2
Practice Quiz #1.3 - The Rock Cycle

Identify the type of rock from the options:

- Igneous
- Metamorphic
- Sedimentary

Which processes create igneous rocks?

- Sediment and Weathering
- Melt and Pressurize
- Melt and Pressurize
- Weathering, Melt, and Pressurize

Which processes create metamorphic rocks?

- Weathering, Melt, and Pressurize
- Melt and Pressurize
- Melt and Pressurize
- Weathering, Melt, and Pressurize

How do you think you did on this practice quiz?

- Excellent
- Very Good
- Good
- Average
- Poor

Why did you give yourself that score?

Your answer...
Practice Quiz #1.4

Practice Quiz #1.4 - Impacts of Mining

Q1: What are some of the risks associated with mining? 
Your answer:

Q2: What do mining companies pay for when they mine? 
Your answer:

Q3: What key environmental effects should be included in your cost-benefit analysis? 
Your answer:

Q4: How do you think you will be affected by mining? 
Choose:

Q5: Why did you give yourself that score? 
Your answer:

Practice Quiz #1.5

Practice Quiz #1.5 - Renewable and Nonrenewable Resources

Q1: What are renewable resources? 
Your answer:

Table: Examples of renewable and nonrenewable resources

<table>
<thead>
<tr>
<th>Resource</th>
<th>Renewable</th>
<th>Nonrenewable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td>Coal</td>
<td>☒</td>
<td>☐</td>
</tr>
<tr>
<td>Nuclear</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td>Water</td>
<td>☒</td>
<td>☐</td>
</tr>
<tr>
<td>Wood</td>
<td>☒</td>
<td>☐</td>
</tr>
<tr>
<td>Fossil</td>
<td>☐</td>
<td>☒</td>
</tr>
<tr>
<td>Renewable</td>
<td>☒</td>
<td>☐</td>
</tr>
</tbody>
</table>

Q2: What is the main difference between renewable and nonrenewable resources? 
Your answer:
Rock and Minerals Quiz
Rock and Mineral Quiz - Form A

Form submission will be recorded when you submit this form.
Not [student]@smuds.net: [teacher account]

Rock Characteristics

Choose the number that best describes the SME characteristics that are the most obvious in the space below. You will note the name of each rock. Brief notes will be added in brackets. [Note: 1 - 5]

1. ____________
   - Sedimentary
   - Igneous
   - Metamorphic

2. ____________
   - Interbedded layers
   - Flowing layers
   - Mixed layers

3. ____________
   - Cross-bedding
   - Siltstone layers
   - Coal layers

4. ____________
   - Frozen flow
   - Rapidly solidified
   - Slowly solidified

5. ____________
   - Includes fossils
   - Includes igneous rocks
   - Includes metamorphic rocks

A piece of a penny with holes caused by dissolved gases has a ____________ texture.

I want

If a rock is formed from the particles that have gone through a furnace, it is called a ____________ rock. [Example: granite, basalt, limestone]

I want

If a rock costs quickly outside the earth it is called an

I want

A piece of a penny with holes caused by dissolved gases has a ____________ texture.

I want

If a rock costs quickly inside the earth it is called

I want

Creating a metamorphic rock requires ____________ and [Note: Time needed, heat needed, pressure needed]
Page 5

Page 6
Unit 1 Exam - Virtual

Section 3: Rocks

47. b. There is a chance... to classify igneous rocks. Describe at least two properties that classify igneous rocks. 2 points

Your answer:

48. Sections of geologists use to classify metamorphic rocks. 2 points

Your answer:

49. Sections of geologists use to classify sedimentary rocks. 2 points

Your answer:

Section 3: The Rocks

ID 3.1.3.1: Examine rock type to identify the rock type.

Identify each type of rock in the image:

Igneous: ☐ ☐ ☐
Sedimentary: ☐ ☐ ☐
Metamorphic: ☐ ☐ ☐

Use this image to answer the question below:

Page 4
Unit 1 Exam - Virtual

Your email address will be recorded when you submit the form.

Net apportionment affects? Match account
- Revenue

Section A: Mining

UT #1: List the costs and benefits of mining operations and describe the impacts of mining.

You're considering opening a used mine in Osage County. Your friend that is encouraging you to invest says that it will be a great investment because there are already 24 lead mines in the area. Explain to your friend the costs you'll have to buy and evaluate from you will make a profit.

Your answer:

Back Next

Please submit comments through Google Forms.

You have one more issue of extra credit. Comments cannot be deleted. Next Section

Google Forms

Unit 1 Exam - Virtual

Your email address will be recorded when you submit the form.

Net apportionment affects? Match account
- Revenue

Section B: Valued Resources

UT #1: Identify the difference between renewable and nonrenewable resources and identify derivatives of these.

Select the NONRENEWABLE Resources from the list below.
- Bitumens
- Natural Gas
- Crude Oil
- Coal

Identify the difference between renewable and nonrenewable resources.

Your answer:

Select the NONRENEWABLE Resources from the list below.
- Bitumens
- Natural Gas
- Crude Oil
- Coal

Next Previous
Unit 1 Exam - Virtual

Your email address will be asked when you submit this form.

not apportioned for teachers or testing. Each question has one correct answer.

1. Which of the following is an example of a non-renewable resource?
   - Coal
   - Wind
   - Solar

2. What is the primary function of the rock cycle?
   - Weathering
   - Erosion
   - Transportation

3. How does mining impact the environment?
   - Reduction of biodiversity
   - Contamination of water sources
   - Soil degradation

4. Which of the following minerals is used in the production of batteries?
   - Graphite
   - Copper
   - Silver

5. What is the difference between renewable and non-renewable resources?
   - Renewable resources can be replenished, non-renewable cannot.
   - Renewable resources are found in the ground, non-renewable are not.
   - Renewable resources are free, non-renewable cost money.