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Self-Assessment in the Middle School Science Classroom

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Action Research Report
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Self-Assessment in the Middle School Science Classroom
A Solomon Four-Group Design

by Stephanie Tanis

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In a hard time of my life, I had to come to Dordt for a week to take a class and that class impacted my life immeasurable. Thanks to the amazing group of people in that class, I don't even remember their names, but our conversations within the walls of that classroom changed how I view God and myself.

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Abstract

Teachers using self-assessment in classrooms understand its vital role in a student's ability to understand their own learning. The diversity of the student learners requires a diversity of assessment strategies. Specifically, in an inquiry-based science classroom, students must be able to identify their current skills and their areas of growth. The implementation of self-assessment strategies helps students to set goals and achieve them. The goal of the researcher in this study was to determine if self-assessment strategies are effective in the middle school science classroom and to determine if such strategies provide evidence supporting the growth of student achievement. Through a Solomon Four research design, the researcher found that self-assessment strategies when specifically taught and practiced in the classroom did impact student achievement scores.

Assessment is not a new word in the world of education. Dedicated teachers in one-room schoolhouses long ago found a variety of strategies and tools to support student learning and assessment (Rutledge, 2003). Assessment drives instruction in the classroom. It is imperative that teachers have the most effective assessment strategies available to them. The research done on best assessments is key to helping teachers choose impactful strategies that will benefit in the growth of their students.

Assessment strategies lead to important decisions that teachers make before, during, and after teaching to impact and to benefit students in multiple ways (Morrison, 2010). When assessment practices are done with a specific purpose, teachers are able to diagnose what the learner's current ideas are and to prepare for where to guide the learner next (Harlen, 1999). Assessment is also important because it gives the teacher an understanding of what each learner 's prior knowledge is and where there are misconceptions, so the teacher can work to build new frameworks of understanding (Garbett, 2011).

One particular form of assessment, self-assessment, plays a key role in the development of students as learners. Vital understanding and realization can come to students who understand and are open to using self-assessment strategies. Within the content area of science, self-assessment holds an important role as well. Through experiments and investigations, students are asked to reflect on their role as scientists. They must consider evaluative questions such as, "How confident am I in my results?" or "Where were my places of error in this investigation?" For young scientists, self-assessment is key to understanding and improving their scientific ability.

Problem Statement

Schools are rapidly changing due to the increasing diversity of learners. Student populations range from students who require support services to students who qualify for the gifted and talented programs. All these students are enrolled in the general science program. Effective assessment is important to meet the diverse needs of all students. Student use of self-assessment tools and strategies may be helpful in meeting these learning needs. This study examined the best practices for assessment, specifically the use of self-assessment strategies in the middle school general science classroom.

Research Questions

To examine the best practices in assessment, the following research questions were addressed in this study.

1. What are the most effective ways to assess students' learning needs in a middle school science classroom?
2. Does the use of self-assessment strategies have a significant effect on the achievement scores of middle school science students?

Definitions

For the purpose of this study, the following definitions were used. The definitions are those of the author, unless otherwise noted.

Assessment – the process of gathering information from multiple and diverse sources to develop an understanding of what students know and understand.

Differentiation – personalized instruction to meet the needs of individual students.

Inclusion – educating students with special educational needs.

Inquiry-based – a type of learning where the student seeks information and knowledge by questioning.

Self-assessment – students judging the quality of their work based on evidence and criteria for the purpose of improvement in the future.

Summary

Teachers using self-assessment in classrooms understand its vital role in a student's ability to understand their own learning. The diversity of the student learners requires a diversity of assessment strategies to impact a differentiate classroom. Specifically, in an inquiry-based science classroom, students must be able to identify their current skills and to identify areas of growth. The implementation of self-assessment strategies helps students to set goals and achieve them. The goal of the researcher in this study was to determine if self-assessment strategies are effective in the middle school science classroom and to determine if such strategies provide evidence supporting the growth of student achievement.

Literature Review

In 1 Corinthians 9:19 it says, "Even though I am free of the demands and expectations of everyone, I have voluntarily become a servant to any and all in order to reach a wide range of people." Like the servant Paul, Christian teachers have been given this choice. Christian teachers, holding firm to the beliefs that each person has been created in the image of God and is beautifully unique, have striven to meet the demands placed on them by a diverse group of students in their classrooms. Christian teachers recognize the importance of powerful assessment strategies that will ensure that the learning needs of diverse learners are met in their classrooms.

Teachers need to have a strong understanding of the content that they are teaching, so that they are able to recognize and correct misconceptions (Garbett, 2011). They must have the ability to combine content knowledge with best practices, to present and assess in differentiated ways, as well as the ability to utilize a variety of strategies for assessment (Garbett, 2011).

Assessment practices have a variety of important features that can be specific to differentiated science teaching and learning (Hodgson, Pyle, & Shamsan, 2009, p. 2). In a study done by Hodgson, Pyle, and Shamsan (2009), researchers found that the key features to a thriving assessment-based classroom were classroom climate, talk, feedback, and questioning, and peer- and self-assessment. The researchers randomly surveyed science coordinators in 94 primary schools in England. Study results indicated that these five components of assessment-based classrooms were found to be the most impactful and beneficial to students' learning.

Classroom climate is very important so that students feel comfortable expressing their ideas. The classroom should be a non-threatening place, where teachers can establish student ideas and misconceptions, while pushing students to develop their understandings (Hodgson, et al., 2009, p. 2). This component is especially relevant in inquiry-based science classrooms (Hodgson, et al., 2009).

Assessment through talk in the classroom is another key component that aids understanding the differentiated science classroom. Through talk, ideas are shared and group members are able to assess each other, give feedback, and create new understanding (Hargreaves, 2007). Talking with peers allows students to share ideas and check with one another (Black & Harrison, 2004).

Talk is also very important in science due to the technicality of scientific language. Learning to talk about science with scientific terms is an important skill (Asoko & Scott, 2006). Also as

students get older, the advancement of oral skills becomes even more important. A central part of the science classroom is the ability to talk through ideas and misconceptions of concepts (Asoko & Scott, 2006). For effective talk to happen in the classroom, there should be a variety of discourse that happens, ranging from interactive teacher to student discussion to initiation discourse, where talk is teacher started and student responded (Asoko & Scott 2006). Talk leads to another key component of assessment-based classrooms, feedback.

Feedback can be done in a variety of ways, including oral, written, and through peer- or self-assessed work (Department of Children, Schools, & Families, 2009). Feedback provides learners a time to celebrate learning, to highlight their next learning goals, and to continue to develop themselves into independent learners (Department of Children, Schools, & Families, 2009). For feedback to be clear for students, teachers need to have a solid understanding for what the learning objectives and outcomes should be. Feedback allows students a better understanding of where they are and where they can head to next (Harlen, 1999). Feedback is especially important in science because it allows for teacher and students to have an ongoing dialogue about scientific process skills. Assessment can be done in every activity and can be gathered through observations, questioning, task setting, and asking students to communicate their thinking in a variety of ways (Harlen, 1999).

In the study by Sawyer, Graham, and Harris (1992), students who received feedback through self-assessment performed better than those who did not experience such feedback. This study compared forty-three learning-disabled fifth and sixth grade students. Those utilizing self-assessment performed better than those with feedback only from the teacher (McCurdy & Shapiro, 1992). This research study showed that there is an important relationship between using self-assessment and feedback.

There are a variety of strategies that teachers can use to give feedback. Teachers can interview students about their science. The use of this strategy demonstrates to students that the work they have done in science class is important (Harlen, 1999). Students could also look at previous tests they have taken and highlight key words, then have fellow peers explain alternative approaches to answering the questions and talk through responses (Daws & Singh, 1999). Another strategy is for students to write answers about a topic and have students develop what their questions might be (Black & Harrison, 2001b).

Hodgson, Pyle, and Shamsan (2009) surveyed science teachers at ninety-four schools in England. They found questioning to be a valuable assessment skill for teachers. Questioning offered an important element for assessment in the science classroom. It was an important feature in teaching science and engaging in science activities. The study found that three-fourths of the teachers surveyed used questioning as an assessment for learning (Hodgson, Pyle, 2010, p. 13). The study found that questions can be used to identify student ideas and misconceptions (Hodgson, Pyle, & Shamsan, 2009). Through questioning, teachers had the ability to find out what students knew. Overall, teachers reported positive results when using these types of assessments (Black & Harrison, 2004).

Self-assessment was a key strategy for further growth in learning as well. Harrison and Harlen (2006) stated that, "it is important for learners to become more autonomous and identify their own learning needs." Ross, Rolheiser, and Hogaboam-Gray (1998a) also defined self-assessment as "students judging the quality of their work based on evidence and criteria for the purpose of doing better in the future" (p. 4).

There are many benefits that come from using self-assessment in the classroom. Many self-assessments have the potential to positively impact student self-efficacy and internal

motivation (Rolheiser, n.d.). Children become more responsible and gain the skills to be self-monitors by checking their own progress and recognizing where they have learning needs (Hodgson, et al., 2009, p. 5). Students eventually are able to judge their own work to improve performance as they identify places that need it (McMillan & Hearn, 2008). This process encourages students to set higher goals and to be willing to commit more of their own resources like time (Rolheiser, n.d.).

McMillan and Hearn (2008) discussed three important aspects of student thinking that were impacted by the self-assessment process: self-monitoring, self-judgment, and identifying and internalizing what they needed do for success. Self-monitoring allows students to pay attention to what they are doing by being more aware of their thinking and progress. In self-judgment, students learn to better identify the process they need to move towards a targeted performance. This leads students to identify and internalize the criteria they need for success. Stow (1997) found that self-assessment strategies could be used to focus children on their own learning in science. He found that children showed improved motivation. These studies have shown that clear self-assessment processes and proven strategies can build student motivation and knowledge of self.

There were a variety of self-assessment tools in science for teachers to use. Stow's study (1997) using concept maps offered students a way to demonstrate their thinking on a topic by including words or pictures and creating links between ideas. For example, students would be given the topic of osmosis and asked to demonstrate their understanding through pictures. Students identified their way of mapping their thinking and found areas of thinking where there still needed to be development. Concept mapping was a way for students to monitor their thinking as well as to see progress.

Another self-assessment strategy used in science classrooms is traffic lighting -- a way for students to self-assess was by using color squares to indicate their level of thinking. Students chose colors based on their understanding: green, yellow or red. Another self or peer-assessment strategy is done through a concept cartoon. A concept cartoon contains a picture that relays a key science concept. Students must understand the cartoon and explain it. Using concept cartoons is an effective way to identify students' misconceptions and leads to an experience where students can see firsthand if they are correct in their understanding (Keogh & Naylor, 1998). There are a variety of other types of self- and peer-assessment, which include the use of graphic organizers, journals, drawings, and interviews that lead to helpful discussion and processing in the science classroom.

There are other popularly used self-assessment strategies used in the classroom. One is the use of a rubric. When using rubrics, students should be given exemplary models and should be given help in understanding what the outcomes and expectations are (McMillan & Hearn, 2008). Student can then react to feedback from rubrics and adjust strategies where needed. Reflection is also an important strategy. Students benefit from explaining their work's quality. (McMillan & Hearn, 2008). They can do this in many of the ways already described, as well as through written conferences, checklists, rating scales, questionnaires, and student-generated questions (Haugen, 1999).

A solid and working system of self-assessment in the classroom is marked by a variety of important conditions or characteristics. First in a self-assessment structure, teachers need to be familiar with students' ideas of what self-assessment is, their misconceptions about self-assessment, and their understanding of why it is beneficial (Rolheiser, n.d.). Next, the teacher needs to select a performance or outcome for students to work toward. Clear learning targets

must be articulated so that students understand exactly what the desired outcome is (McMillan & Hearn, 2008). Within a self-assessment structure, teachers must also be willing to pass on some of the responsibility of assessment on to the students (McMillan & Hearn, 2008.) Teachers within this structure, help students develop learning goals, provide good examples of work, and model goal-setting. The teacher also works with students to help determine where they had strengths and gaps in their learning. And finally, together, teacher and students create learning plans and goals (Capacity Building, 2006).

In an extensive study by Ross, Rolheiser, and Hogaboam-Gray (1998a), researchers worked with teachers to evaluate the best practices in student-evaluation in cooperative learning. The result of the study led to a clarification of four stages of implementing successful self-assessment strategies in the classroom. The first stage involved including students in defining the criteria that will judge their performance. Teachers had students create solid goals that required negotiations between teacher and student. This provided students an opportunity to influence and to feel responsibility over their learning. In the second stage, teachers taught students how to apply the evaluative criteria to their own work. At this point students saw examples along with teacher modeling. Stage three involved the teacher giving feedback to students on their self-evaluations. Lastly, in stage four, students were helped in creating productive goals and action plans. Teachers also helped students to understand their self-evaluation data and set new goals.

Assessment continues to be a driving force in determining student learning. There are many strategies that teachers use in the classroom that have important and impactful results in student achievement growth. Self-assessment is one of those. Through the use of effective self-assessment strategies, students take more responsibility of their learning and become more

intrinsically motivated. Overall, the research evidence suggests that self-assessment contributes to higher student achievement and improved behavior (Ross, et al., 1998a).

Self-assessment in science is extremely important. It allows students to become more scientific in their thinking and questioning. It also pushes students to involved in the scientific process (Lindsay & Clarke, 2001). There are strong relationships between a student's ability to self-assess and reflect with their ability to create and adapt their scientific investigations. Scientists are constantly evaluating their work. Because of this, self-assessment carries multiple benefits when used in the science classroom.

Methods

Participants

The participants in this study were 7th grade students at a large Christian school in southwest Michigan. The school was located in an urban setting. The students were 12-13 years old. The majority of the students were of Caucasian background, while others were a variety of ethnic backgrounds including African American, Asian, and Hispanic. Students were generally of middle to upper class socio-economic background, with some exceptions. The school is an inclusion school. Within this model, students with special needs spend most or all of their time with general education students, but these special needs students did not participate in the research project. For the 2013-2014 school year, there were 106 students involved in this study. Control and treatment groups were chosen randomly. Each group contained between 19-26 students.

Research Design

This was a correlational study. It studied the relationship between achievement in science and the role of self-assessment in that process. The study is set up as a Solomon Four design, where each of the four groups will follow different expectations. Students participated in a pre-test on their current knowledge of the science content. In the unit there was one mini lesson of 10-15 minutes that was taught to students on the need for self-assessment followed by three lessons that focused on strategies for self-assessment. Students were asked to self-assess on five areas related specifically to the subject of science, such as science concepts, reasoning, and science tools. The researcher demonstrated and modeled how to self-assess in these areas. Throughout the rest of the unit, students participated in self-assessment strategies as they engaged in the science content. Artifacts were collect and used by the researcher. These artifacts were written copies made by students as a result of activities throughout the unit. Groups that were not given the treatment went through the unit without receiving any of the self-assessment lesson or activities. Results were collected and analyzed by researcher. All classes in the study participated in a post-test.

Materials

The researcher changed the unit to contain lessons and activities that specifically targeted the strategies of self-assessment. The researcher created mini-lesson plans focused on specific self-assessment strategies and its importance in science. For the mini lessons the researcher created documents that would be used for self-assessment. The pre-test and post-test were the same assessment tool, created by the researcher. The researcher used the state standards as well as a science textbook to inform what questions were included on the assessments.

Procedure

The researcher began a new science unit, incorporating self-assessment activities for the classes receiving the treatment. It studied the relationship between achievement in science and the role of self-assessment in that process. The study results looked to support the use of self-assessment in the science classroom and its impact in differentiating classroom-learning activities. In this study, the independent variable was the use of self-assessment strategies and the dependent variable was the level of student achievement in science based on the researcher-created assessment. A Solomon Four design was chosen to collect a variety of data. The Solomon Four design controls for several variables that tend to confound research studies such as: 1) participants working hard to improve because they were in a research study (Symmons, 2013); 2) This design also eliminated some problems that can happen with pre- and post-tests, such as the pre-test impacting results in the post-test. The design contained two control groups. This served to diminish the influence confounding variables. The researcher was allowed to test whether the pretest itself had an effect on the study participants. The Solomon Four design also opposed many of the possible internal validity issues. This gave the researcher the power to control variables. It also allowed the researcher to understand if the pre-test impacted the results (Shuttleworth, 2009).

In a Solomon Four design, each group received different procedures throughout the unit. Group one received a pre-test, the self-assessment treatment, and a post-test. The second group would have received a pre-test and a post-test without any treatment. The third section would have received the manipulation and a post-test, while the fourth sections would have received only a post-test. Groups were assigned randomly for the treatment and pre-tests for validity (Symmons, 2013).

At the start of the science unit containing self-assessment strategies, the researcher spent time asking students in groups one and three to reflect on self-assessment and what it is. This provided time to work students through their misconceptions. Then the researcher led students in brainstorming the benefits of self-assessment. Following these activities, the researcher selected what performance outcomes would be used for the self-assessment activity. The first stage involved including students in defining the criteria that judged their performance. The researcher had students create solid goals that required negotiations between teacher and student. This provided students an opportunity to influence and feel responsibility over their learning. Next, the researcher taught students how to apply the criteria to their own work. At this point students saw examples of how to do this skill in practice and see the researcher modeling it. Students were given an opportunity to practice self-assessment. The researcher gave feedback to students on their self-evaluations. Lastly, the researcher met with students to create productive goals and action plans. The researcher helped students to understand their self-evaluation data and set new goals.

In each of the activities within this process students were asked to assess their current understanding and where they saw themselves in the journey to reach the desired learning goals. They were asked to direct where they believed their learning tasks needed to lead to reach their learning goals.

Data was collected in this study by analyzing the pre-tests and post-tests given to the four different groups. The researcher's hypothesis was that the treatment would have a significant impact on student achievement as measured by the assessment.

Results

Results for this study were collected over the span of a two-week unit. The table below shows the data collected. It also provides the number of students, mean, variance, and standard deviation for each group. The mean is represented as a percentage. When figuring the variance and standard deviation, percentages were also used. This can be seen in Table 1.

Table 1

Mean Scores Of The Pre-Test And Post-Test By Group

	Pre-Test				Post-Test			
Group	# of students	Mean	Variance	Standard Deviation	# of students	Mean	Variance	Standard Deviation
1	22	31.8	215.6	14.7	22	79.5	261.7	16.2
2	19	N/A	N/A	N/A	19	63.7	346.8	18.6
3	25	N/A	N/A	N/A	25	71.2	519.3	22.8
4	26	31.8	215.6	14.7	26	77.7	274.5	77.7

Next the researcher compared the post-tests of Groups 1 and 4 (the groups that took the pre-test) to Groups 2 and 3. In this study, both Groups 1 and 4 scored higher than Groups 2 and 3, leading one to state that the pre-test did have an impact on the post-tests for Groups 1 and 4.

Next, the researcher compared Group 2 pretest to Group 4 post-test looking for possible issues of causality. This is important to check for whether the trends and results from an experiment are actually caused by the treatment. When comparing the data in this study, there was no strong factor that seems to have influenced the data. This data can be seen in Table 3.

There was also a comparison made between Groups 1 and 3. This should be done to show whether or not the pre-test had any effect on the treatment. If the posttests of Groups 1 and 3 differ than the pre-test had some effect on the treatment and therefore the experiment was flawed. In this study, there was a difference of ten percent between Groups 1 and 3. This showed that there could have been some impact of the pre-test on the treatment.

Table 2

Mean Scores Of Pretests And Posttests Of Group 1 And 3

	Pre-Test				Post-Test			
Group	# of students	Mean	Variance	Standard Deviation	# of students	Mean	Variance	Standard Deviation
1	22	31.8	215.6	14.7	22	79.5	261.7	16.2
3	25	N/A	N/A	N/A	25	71.2	519.3	22.8

Finally, the Solomon Four design allowed for a comparison of Groups 2 and 4. This was done to compare whether or not the treatment had an effect without the impact of a pre-test. When comparing this data, the researcher found that the treatment did in fact have an impact on the posttest. The group that was given the treatment showed percentage gains of almost eight percent.

Table 3

Mean Scores Of Pretests And Posttests Of Group 2 And 4

	Pre-Test				Post-Test			
Group	# of students	Mean	Variance	Standard Deviation	# of students	Mean	Variance	Standard Deviation
2	19	N/A	N/A	N/A	19	63.7	346.8	18.6
4	26	31.8	215.6	14.7	26	77.7	274.5	77.7

Discussion

There were several types of assessment specific to science instruction that are key to successful classrooms. Assessment strategies such as questioning and discussions are essential strategies. Self-assessment is also frequently cited as an important assessment strategy in the science classroom. This strategy allows students to assess their current understandings and grow in a variety of ways.

Through this study, the researcher discovered that self-assessment strategies, when taught directly, do make an impact on student achievement in science. In the study, the treatment given to Groups 1 and 3 showed marked improvement in their scores from the pre-test to post-test. Although the use of the treatment appears to have impacted the achievement in the post-tests scores for those two groups, the overall averages of each group did not vary too widely from each other. Although the growth in achievement was minimal in this study, over time the continual implementation and practices of self-assessment could show continued growth in students. From this study, the researcher concluded that although use of specific self-assessment strategies may have an impact on student achievement, it is not hugely significant.

Limitations

The researcher found that within this study there were limitations. The groupings for the study were not randomly chosen. This caused group size to vary, along with academic ability. Some classes were on average more academically gifted than others. Further research could be done in using different groupings that could be randomized.

There were also limitations to the time frame in which the study was conducted due to the constraints of the school calendar. Another limitation was a lack of prior research in the specific topic of self-assessment in the science classroom. Although the researcher was able to find a

variety of articles and studies on self-assessment strategies, the narrowing of this skill specific to the science classroom was lacking. This showed a need for further research into the topic of self-assessment specifically in the science content area.

Recommendations

The researcher hopes that classroom implementation of self-assessment strategies will influence the students' capacities to grow in their ability to assess their scientific thinking and practice. This study has shown that self-assessment strategies did influence student achievement. But there should be further research done on the best ways to implement these strategies into the science classroom and how to maximize their use for student success. The researcher would like to do a similar study again focusing on the impact of the different types of self-assessment. This would show the level of impact that different types of self-assessment strategies, such as journaling or interviewing have on students as they move through a unit and the result these assessment strategies would have on their overall achievement on final assessments. The researcher would also like to survey student feelings and opinions on self-assessment. Student self-reflection has shown through this study to positively impact achievement, but the researcher is interested to see how the impact of positive or negative student opinion on using self-assessment could impact results and student achievement. Although this study has answered some questions, it has opened the door to more possible studies within this topic of self-assessment.

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Appendix A

Science Inquiry Self-Assessment Rubric

Science Inquiry Rubric	Science Tools	Science Concepts	Reasoning Strategies	Communication
Getting Started (Novice)				
Almost (Apprentice)				
Got It! (Practitioner)				
Wow! (Expert)				

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Education

M.A. Curriculum and Instruction, Dordt College (2014)

B.A. Elementary Education Science and Social Studies, Calvin College (2004)

Academic Employment

Teacher, Grand Rapids Christian Middle School, Grand Rapids, MI (2012-Present)

Teaching 7th grade Homeroom, 7th grade Science, 7th grade Bible
Science Olympiad Head Coach
iXplore week team leader

Teacher, Rockford Christian School, Rockford, MI (2011-2012)

Teaching 7th grade Homeroom, 7th grade Science, 8th grade Science
Paraprofessional with 3rd grade literacy and math in small group setting
Summer Academy Coordinator –Grand Rapids Christian Schools

Teacher, Chicago West Side Christian School, Chicago, IL (2004-2011)

Teaching 6th grade Homeroom, Language Arts, Social Studies, and Bible
Teaching 5th and 7th grade Language Arts, have taught 6th grade Math
Participating in Chapel and Color Club committees
Tutoring in Jump Start program