DIAGNOSING STUDENT MOTIVATION TO LEARN MATHEMATICS: A FORM OF TEACHER KNOWLEDGE

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This paper reports research that investigated how a teacher motivated his students in a mathematics class. It addresses the work in the field of affect in mathematics education using various frameworks borrowed from educational psychology including Attribution Theory and Self-Determination Theory. The analysis of student motivation levels based on the intrinsic and extrinsic continuum of the Self-Determination Theory in this study will provide some frameworks that teacher could implement to influence student motivation.

Keywords: Mathematics, Extrinsic Motivation, Intrinsic Motivation, Self-Determination

INTRODUCTION

Mathematics educators and teachers face challenges in engaging students in mathematics classes. It is an ultimate goal to have students intrinsically motivated to learn mathematics. This indeed was not the case because most academic tasks were not designed to intrinsically motivate (Ryan & Deci, 2000). Even though intrinsic motivation is important, a teacher could find ways to extrinsically motivate students to engage in mathematical tasks hopefully leading to intrinsic motivation and improve student learning. This paper presents part of a larger study investigated how a teacher extrinsically motivated his students to learn mathematics in a College Algebra Course.

THEORETICAL FRAMEWORK

Mathematics education has been examined from different theoretical perspectives borrowed from other disciplines to inform its research and practice. Several frameworks of motivation from educational psychology were used to guide the study: (1) Attribution Theory (Graham & Weiner, 1996) and Self-Determination Theory (Ryan & Deci, 2000).

Attribution Theory

Attribution theory explains how people perceive the cause of their actions and those of others (Weiner, 1985). According to Graham and Weiner (1996), attribution theory is rooted in the work of Fried Heider (1958), Harnold Kelley (1971), and Bernard Weiner (1985). Attribution theorists strive to understand the causal conclusions of their environment; attribution theory falls under the expectancy-value approach asserts that behavior is a function of how one values the outcome of a certain behavior based on his or her expectation on the result of performing that behaviour. According to Middleton and Spanias (1999), this theoretical orientation is widely held in mathematics education; because attributions are cognitive, they provide a middle ground among other motivations. Specifically, attribution theory was
applied in studying learner helplessness; here, individuals view success as unattainable so they tend to show little motivation for challenging tasks. Previous studies indicated that there is a significant difference in how passing and failing students attributed their performance in a mathematics course (Cortes-Suarez & Sandiford, 2008). Motivation is not a “unitary phenomenon” because people have different levels of motivation and different types of motivation (Ryan & Deci, 2000).

**Self-Determination Theory**

Self-Determination Theory (Deci & Ryan, 1985) distinguishes types of motivation based on different goals (intrinsic and extrinsic motivation). Whereas intrinsic motivation refers to doing something because it is inherently interesting or enjoyable, extrinsic motivation refers to doing something because it leads to some tangible outcome. The quality of experience and performance of an individual can be different depending on whether one is behaving for intrinsic versus extrinsic reasons. Even though intrinsic motivation results in a high quality of learning and creativity, extrinsic motivation is equally as important. Specifically, as a reinforcement bridge until the task becomes intrinsically motivating.

According to Ryan and Deci (2000), understanding different types of extrinsic motivation and what is specifically reinforcing to students especially those students that are not intrinsically motivated. Therefore, intrinsic and extrinsic motivation can be thought of as two ends of the continuum. Between the two extreme continuums is behaviors that originally were extrinsically motivated but have become internalized and now are self-determined. For example, even though students do not want to work on academic activities, they may choose to do so to obtain rewards. As students develop skills and believe that they are more competent, they perceive a sense of control (or self-determination) over learning, and then activities become more intrinsically motivating (See Ryan & Deci, 2000) for detail explanation). Also, choices affect intrinsic motivation, therefore when people believe they have control over their environments, they perform higher and tolerate aversive stimulation better (Ryan, 1993).

Extrinsically motivated behaviors are not inherently interesting and must initially be prompted externally (Ryan & Deci, 2000). People are willing to engage in behaviors that are valued by significant others to whom they feel connected. Self-Determination Theory called this a sense of relatedness. In a classroom, this relatedness means that students feel respected and cared for by the teacher. This is essential for their willingness to accept the classroom values. Furthermore, Self-Determination Theory concerns about an individual’s competence issue. Students are more likely to adopt and internalize a goal if they understand it and have the relevant skills to succeed at it. Hence, meeting an individual psychological need of relatedness, competence, and autonomy will foster self-determination. Ryan and Deci (2000) theorized that supports for competence such as offering optimal challenge and relevant feedback could facilitate internalization of extrinsic motivation.

**Organismic Integration Theory**

Organismic Integration Theory is one of five mini theories of Self-Determination Theory. It provides detail of the different forms of extrinsic motivation and the contextual factors that
either promote or hinder internalization and integration of the regulation for these behaviors (Deci & Ryan, 1985). Organismic Integration Taxonomy illustrates different types of motivation, arranged from left to right in terms of the extent to which the motivation for one’s behavior emanates from oneself (see Ryan & Deci, 2000, for review). The basic assumption in studies of intrinsic motivation is that people are “active organisms working to master their internal and external environment;” this assumption led to the importance of self-determination (Deci & Ryan, 1985, p. 35). In this taxonomy, integrated regulation is the most autonomous form of extrinsic motivation; this occurs when identified regulations have been fully assimilated to the self-examination. Integrated forms of motivation share many qualities of intrinsic motivation. The process of internalization is developmental as social values and regulations are being internalized over the lifespan. However, one does not have to progress through each state of internalization with respect to a particular regulation. A person can move forward or backward through the taxonomy depend upon both internal and external factors. Differences in attitudes and adjustment were also associated with the different types of extrinsic motivation (Ryan & Deci, 2000).

In Self-Determination Theory, a regulation that has been internalized may only be interjected and could leave people feeling satisfaction of their needs for competence and relatedness (Ryan & Deci, 2000). However, this is not enough for people to feel self-determined. Ryan and Deci argued that controlling contexts may yield interjected regulation if tasks support competence and relatedness. However, only an autonomy supportive context will yield integrated self-regulation. Therefore, they stated that to fully internalize a regulation, people must inwardly grasp its meaning and value. The meanings that become internalized and integrated in the environment provide supports for the needs for competence, relatedness, and autonomy. Also, they concluded that intrinsically motivated behaviors are performed based on interest and satisfy the innate psychological needs or competence and autonomy, forming the prototype of self-determined behaviors. Even though extrinsically motivated behaviors are executed because they are instruments to some separable outcome, internalization and integration are the processes through which extrinsically motivated behaviors become more self-determined. The authors concluded that the facilitation of more self-determined learning requires classroom conditions that allow satisfaction of the three basic human needs for one to feel connected (relatedness), effective (competence) and agentic (autonomous) as one exposes to new ideas and skills (Ryan & Deci, 2000).

METHOD

The study was contextualized at a local community college in the Southeastern United States. From the group of 11 teachers, three teachers were identified as potential participating teachers. Using the snowball sampling method (Patton, 2002), one intrinsic teacher, Mr. Algebra, was chosen as the intrinsic case (see Nguyen, 2011 for review on the selection criteria). Data collected from the study include multiple classroom observations, in-depth interviews with the teacher and his students, surveys, artifacts, and the input of a critical friend. Student interviews were comprised of questions related to students’ experiences in learning mathematics, how their teachers motivated them to learn mathematics, and their understanding of function concepts. Teacher interviews included questions about his views of
mathematics teaching and mathematics learning. Fourteen students were interviewed but this paper only reports the analysis on five students based on their performance.

**Student Participants**

*Tyrone* is 21-years old. He is an “A” student in the class and intends to double majors in Biology and Chemistry. Mathematics is his strongest subject and he likes to solve mathematics problems without using a calculator. Also, he shared that his best experience in mathematics is with Mr. Algebra and he looks forward to coming to class. Even though he likes the course and expected to get an “A” in the course, he does not like to do homework/quizzes so he completed the course with a “D”.

*Daisy* is 19 years old. She enrolled in this course to fulfill the requirement for the nursing program. She recalled her worst experience with a mathematics teacher was in 4th grade and that “horrible experience” almost “took her off mathematics,” until she enrolled in Mr. Algebra’s course. Daisy looks forward to going to class to “fight” for the first seat in the class. She plans to take Pre-Calculus and other mathematics courses. She expects to get an “A” but she completes the course with a “D”.

*Nicole* is between 18-22 years old. Nicole said, “Mathematics is not her thing.” Nicole did not have a good experience in high school because her teacher was “mean and rude.” Nicole enrolled in College Algebra for the first time. She also enjoyed the course but she does not like the online homework. She is expected to get a “B” in the course and plans to take Trigonometry when she completed the course. Nicole did not report what she earned in this course, but she reported that she failed the first two exams in the course.

*Brittany* is 19 years old. She wants to become an architect. She withdrew from College Algebra previously and enrolled for the second time. She plans to enroll in Trigonometry after she completes the course. Her worst experience with a mathematics teacher was her previous semester’s College Algebra teacher. She felt that he rushed through the material. Brittany is very satisfied with the course she is taking: “I love math as long as I have a teacher who can teach it right like Mr. Algebra”. She shared that when Mr. Algebra shared his experiences; she realized that if she failed one exam it does not mean she is bad at mathematics. She completed the course with a “C” and currently is taking Trigonometry.

*Wendy* is 21 years old. She enrolled in this course to complete her requirements to be admitted to an Elementary Education program. This is the second time she enrolled in College Algebra. She had a bad experience with her previous College Algebra teacher. Wendy recalled when she did not do well on her first exam, she sought help from the teacher and he suggested that she should change her major so that she would not pass her fear of mathematics to her students. Wendy witnessed this same teacher slams the chalk against the board when a student asked a question and the teacher did not want to respond. She also shared that her third teacher was mean and not very encouraging. She thinks that having teachers like that would “set” students to not like mathematics. She completed the course with a “B”.

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**Data Analysis**

Qualitative were compared constantly (Miles & Huberman, 1994.) with *in vivo* and open coding (Strauss & Corbin, 1998). Qualitative data were analyzed in light of the motivational lenses on how students perceived the ways in which the teacher motivated them. The five students presented in this paper were motivationally challenged; they were at different stages on the extrinsic and intrinsic continuum. As a result, how one student perceived that the teacher motivated him or her is different than of the others. Therefore, data were triangulated with multiple interviews and sources. For example, when a student described that the teacher was encouraging, a researcher would create a category for “encouraging,” if the category had not been identified. Furthermore, additional observations about a particular category were validated with field notes, classroom observations, student interview, and course materials. Interpretations of data were confirmed with the help of a critical friend and a doctoral student with background in educational psychology to draw conclusions.

**RESULTS AND DISCUSSION**

Student interviews were comprised of questions related to students’ experiences in learning mathematics, how their teachers motivated them to learn mathematics, and their understanding of function concepts. Data obtained from interviews were analyzed through motivational lenses with respect to how students perceived the ways in which the teacher motivated them.

According to these students, an ideal mathematics classroom has four essential components: the physical set up (Nguyen, 2011), comfortable setting, the teacher, and the students. A comfortable environment means the teacher must capture their attention, allow students time to work on tasks, and let students talk, which was found in Mr. Algebra’s classroom. He let students talk and interact with each other. He cared for students so they showed interest in learning. Brittany shared, “everybody just gradually became friends. It’s a very comfortable setting.” Next, Mr. Algebra set up his classroom with a structure that when it is time for a person to talk, others will listen. Students shared that he motivated them to learn because he was an energetic, funny, and real in the ways he presented the materials. He was consistent and direct because he informed students that the material is not easy but if they work hard they will earn a decent grade. Tyrone shared, “He doesn’t change.... He is always himself.” Therefore, students viewed such consistency very positively in how Mr. Algebra he motivated them.

Also, Mr. Algebra was helpful to students because he provided accessible online class notes, supplementary material, videos, office hours, and his personal cellular phone number. He provided autonomous opportunity for students. Since all the homework and quizzes were online, he was flexible in having an end of unit deadline instead of daily deadline. This allowed students that have jobs more time to complete the assignments. By allowing student to be responsible for their work, Mr. Algebra demonstrated knowledge of his students and amended his homework policy accordingly. Furthermore, Mr. Algebra concerned about students’ safety. Daisy thought that it was nice that he is genuinely concerned for his students’
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safety; this is one important aspect in an individual’s psychological need, a sense of relatedness (Deci & Ryan, 1985).

Moreover, he was specific but encouraging. He was articulated to students that they needed to attend classes, complete assignments, ask questions, and seek help. Students described him as “...a good teacher. One in a million.” Wendy shared, “He is very positive. I wish every teacher was like him...I’ll base my teaching skills off him” (Interview, June 2010).

Additionally, Mr. Algebra promoted student self-determination by sharing his experiences with them. Usually, he provided background information when introducing new concepts. Also, he demonstrated the relevance of the material and built student confidence in learning mathematics and stimulated students’ interest. Mr. Algebra’s teaching practice had engaged students to see the relevance of the materials. For instance, Brittany stated:

The way he taught that you are going to need this type of material. We are going to need to know such and such. It helps me know that’s how math is really going to be. This is the level I am in and this will be [what I will get into]. It may get hard as it goes on, but if I just put in the work and just put in the practice or whatever, I should be able to do fine. (Brittany, Interview, June 2010).

An analysis of students’ motivation levels based on the Self-Determination Sub-Theory, Organismic Integration Theory show that students are at different level on the extrinsic and intrinsic continuum motivation base on this sub-theory (Table 1).

Tyrone perceived mathematics problems to be something that he could just look at and tell what the answer was. Tyrone wanted teachers to tell him exactly what he should do to make a good grade; he also wanted the teacher to tell him what he was doing and why he was doing it. Tyrone felt confident about his mathematics knowledge and he liked to challenge himself. He thought he had a strong ability and said, “As soon as he [Mr. Algebra] showed the problem, I knew how to do it.” Also, he admitted that he was lazy because he took notes in class, but he “never looked at the notes.” He said, “I could be one of the best students that you ever knew, but I’m lazy.” When asked about why he procrastinated, he said, “I know I will get an “A”.” Tyrone said that he enjoyed doing mathematics and he was good at it. However, evidence showed that he was not intrinsically motivated to do mathematics. He viewed the teacher as a motivator and said that the teacher played a role in his performance. Of the teachers’ role he said, “They keep me in school, keep me motivated.” Tyrone supposed that because of how Mr. Algebra taught, he stayed in school and continued to study Chemistry and Biology. On the continuum of extrinsic and intrinsic motivation of the Organismic Integration Theory, Tyrone was at the introjected level (see Table 1). Tyrone needs to put in some effort to keep up with his goals and, hence, he needs someone to influence his motivation to perform better.

Daisy thought of mathematics as puzzles. She loved to see where everything came from and how one concept related to another. When she had questions in College Algebra, she tried to figure things out on her own using resources such as the Internet, notes, and Mr. Algebra’s YouTube videos, before she sought help from Mr. Algebra. She loved how Mr. Algebra provided background information and discussed how these concepts were interrelated. Daisy’s view of mathematics was different compared to the other four students. Daisy viewed
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mathematics as problem solving (Ernest, 1988) where she would seek out the answer. Even though she failed the course twice, she believed that she still enjoyed mathematics and was willing to learn it again, thus Daisy was *intrinsically* motivated to study mathematics based on Organismic Integration Theory (see Table 1).

Nicole “hated” mathematics because she had bad experiences with a mathematics teacher in high school. Her teacher preferred that the students only used the approach she taught. Nicole thought that she should be able to use her own approach if it made sense to her and that there was more than one way to solve a problem. She did not like mathematics, especially word problems. If she saw them on tests, she would leave the word problems until the end. However, she knew she needed College Algebra for her business major, and she completed all homework assignments and quizzes. When it came to the tests she went blank and did not do well; her confidence went down because her expectations for the tests were different. To Nicole, mathematics problems should be interesting to get her attention, and mathematics problems should be easy enough that she could solve them. She would work on the problem but when she could not get the answer, she skipped it. She said, “Math is not my strongest subject.” She thought of changing her major from business to some other major that does not require mathematics, but she was considering repeating the course because she wanted to get a business degree. She was on the *identified* level on the continuum of the Organismic Integration Theory (see Table 1).

Brittany suggested that mathematics should be fun, should include hands-on experiences, and should go beyond the walls of the classroom. She would do anything to get a good grade, but she wanted to be able to use what she learned in her career. She suggested students “…should experiment outside of the classroom…just like how Ms. Fizzle in the Magic School Bus showed. She taught science outside of the classroom.” Brittany shared that she felt more determined to study mathematics. She was able to relate to Mr. Algebra; it made her realize that failing one test could not make her bad in mathematics. Brittany felt that she controlled her learning; she said, “I can do it now… as far as math is concerned. I believe I can do it.” Brittany liked doing mathematics because it would help her get to where she wanted to be. She enjoyed doing mathematics but the teacher had to make it fun for her. She said, “I love math as long as I have a teacher who can teach it right like [Mr. Algebra].” She passed College Algebra and enrolled in Trigonometry in the fall of 2010. According to Organismic Integration Theory, Brittany was at the *integrated* level (see Table 1).

Wendy claimed that mathematics did not come easy to her, but she tried her best to pass the course and to achieve her goal of becoming an elementary school teacher. Wendy knew that mathematics is challenging. She used examples of how Mr. Algebra related mathematics concepts to make them relevant to her, such as how Mr. Algebra showed the class how to derive the Quadratic Formula. Wendy put effort into this course, communicated with Mr. Algebra and told him she needs help along the way. She shared that she took a mathematics disability test but the results were negative. Wendy claimed the results made her realize that maybe she was “not bad at mathematics”. Hence, she was determined to take the mathematics course again. She put forth much effort in all courses she took. She reported that her experiences were great except her previous mathematics teachers, Mr. Cold, who told her to
Nguyen change her major after she failed an exam. However, she was determined to do well in this course so she could transfer to another school. She claimed that she would model her teaching off Mr. Algebra. She was also in the *identified* level on the Organismic Integration Theory continuum (see Table 1).

<table>
<thead>
<tr>
<th>Student</th>
<th>Motivational Level</th>
<th>Behaviors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tyrone</td>
<td>Introjected</td>
<td>Tyrone liked to put effort when there were an audience, ego involvement and need for approval to elicit motivation (by maintaining self-worth).</td>
</tr>
<tr>
<td>Daisy</td>
<td>Intrinsic</td>
<td>Daisy exhibited joy in learning mathematics and hoped to take other mathematics courses for “fun”</td>
</tr>
<tr>
<td>Nicole</td>
<td>Identified</td>
<td>Nicole valued the goals of learning mathematics because it served the purpose of earning a business degree. She worked hard to accomplish the goal.</td>
</tr>
<tr>
<td>Brittany</td>
<td>Integrated</td>
<td>Brittany enjoyed doing mathematics to get some instrumental values toward her future goal of becoming an architect</td>
</tr>
<tr>
<td>Wendy</td>
<td>Identified</td>
<td>Wendy valued the goals of learning mathematics and understood that the course served her purpose of earning a teaching degree.</td>
</tr>
</tbody>
</table>

In summary, analysis of each student’s motivation level based on Self-Determination Theory showed differences in student motivation, which required flexibility in strategies of teaching. The study revealed that:

*Many had unpleasant experiences in grade school or in college, which they attributed to their teachers’ attitudes and actions.* As a result, their experiences in previous mathematics courses influenced their views about mathematics and in particular, their mathematics teachers imparted strong, negative influence, since none of the five students shared that the mathematical content was difficult for them. Hence, students’ motivation levels in learning mathematics were discouraged by their previous mathematics teachers and thus, it was difficult for them to learn mathematics.

In this educational setting, many students had given up with respect to their study of mathematics but Mr. Algebra had the ability to renew their confidence to study mathematics using his knowledge about students. Hence, knowledge of student is essential and it is an important component of teacher knowledge (Ernest, 1989). Therefore, understanding teacher knowledge in this framework would inform mathematics educators and researchers. Even though this model was introduced more than two decades ago, there is room for improvement. Also, it can be used to inform how teachers can support students’ three essential psychological needs of competence, autonomy, and relatedness because meeting these needs helps students to become more self-determined (Ryan & Deci, 2000).
Students were both motivationally challenged and mathematically challenged prior to enrolling in College Algebra. However, the teacher had the ability to review their motivation to learn mathematics. Each of the five students had different views of mathematics, and they were motivationally challenged in different ways. Therefore, teachers need to incorporate their knowledge of students as they design the tasks. I propose that knowledge of student motivation levels will improve the design of tasks that is likely to motivate students which is essential to mathematics teaching and learning.

ASSERTIONS AND FUTURE RESEARCH

The analysis revealed that many students in the course had lost confidence, but the teacher had the power to restore that confidence. This suggested that research linking educational psychology and mathematics education is essential to understand how to motivate student to learn mathematics. Furthermore, motivational theories such as Self-Determination Theory should be applied into mathematics instruction to better understand how to meet student psychological needs. The experience that required Daisy to take more than eight years of mathematics was critical. Mathematics educators and teacher should take measures to help students avoid such experiences. Therefore, to close the gap between students and mathematics, it is time to rebuild the bridges and build new bridges for students to get to mathematics before they could attribute their experiences in mathematics toward teachers of mathematics, instead of the mathematics itself. Additionally, this study took place in an educational setting where many students had given up, but the teacher could motivate them to learn by using his knowledge of students to meet their psychological needs. Even though these students were both motivationally- and mathematically-challenged, the teacher believed that they were willing to perform their best if he could relate to them.

Future Research

I continue to analyze data that were not included in this paper and continue to conduct research to better understand how to motivate students to learn mathematics. My ultimate goal is to create an overall framework to better understand how students were motivated from an organismic point of view. An analysis from a Self-Determination-Theory showed that there is a potential for these students to move forward, even though they had some unpleasant experiences. The analysis also indicated why, what, and how to motivate these students, which will provide some direction to go forward.

Future investigations will include expanding analysis through further research to add to literature on students’ understanding from motivational perspectives. Indeed, there remain large deficits within the literature on mathematics instruction at the K-12 and the post-secondary level (grades13-16). The results from this paper called special attention to diagnosing student motivation to learn mathematics in the course. It is my intention to contribute research that explores the opportunities for motivational strategy implementation within the realm of mathematics education research. Teachers need to provide a strong bridge for students to learn mathematics and maintaining motivation is necessary to do so.
References


