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An Exploratory Qualitative Study of the Proximal Goal Setting of Two Introductory Modeling Instruction Physics Students

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Abstract. Proximal goal setting has been strongly linked to self-efficacy and often occurs in successful problem solving. A qualitative study, using both observations and interviews, investigated the problem-solving processes and the self-efficacy of two students enrolled in an introductory physics course that implemented Modeling Instruction at Florida International University. We found that the problem solving process could be divided into two main phases: the goal setting process and the self-efficacy feedback loop. Further, from the qualitative data, the goal setting process could not be isolated from its impact on the self-efficacy of the students. This relationship between the goal setting strategies within the problem-solving process and self-efficacy may be linked to the retention of students in physics. We present results of the study and its possible link to student retention.

Keywords: Self-efficacy, Modeling Instruction

PACS: 01.40.Fk, 01.40.gb

INTRODUCTION

Although several attributes contribute to the success of a student, many students perceive success in a physics class as unattainable [1]. Introductory physics focuses heavily on problem solving, but few classes explicitly develop these skills. Over the recent decades, bachelor's degrees in physics have lagged behind other STEM degrees, accounting for only 2% of the undergraduate degrees awarded in these fields [3]. This leads to investigating what may help students continue in physics.

Fencl and Scheel discussed the possibility of self-efficacy impacting the retention of students in the physics classroom [3]. In 1977, Bandura defined self-efficacy to be the beliefs in one's ability to perform a *specific* task, particularly stressing the specificity of the task, in an effort to supply a theoretical explanation for human behavior change [4]. Thus though self-efficacy might be well understood in other fields, it needs to be investigated separately in physics.

Betz and Hackett showed that in mathematics, self-efficacy expectations are strong predictors of mathematics-related educational and career choices [5]. Furthermore, studies of self-efficacy in career and educational psychology have strongly linked self-efficacy to both persistence in technical fields and success in those same fields [6], [7], [8]. These works suggest that it would be beneficial to the science

education community to explore the relationship between self-efficacy and physics in general, as well as the role of self-efficacy in reformed instructional approaches such as Modeling Instruction.

As physics is intimately tied to problem solving, it is necessary to investigate the relationship between the physics problem-solving structure and self-efficacy. This leads to understanding goal setting as a primary component of problem solving. Schunk's research on self-efficacy examines the relationship between self-efficacy and goal setting [9], [10]. Bandura and Cervone [11] (as cited in [10]) showed that providing students with feedback on goal progress increases self-efficacy. Furthermore, Schunk showed that setting goals enhances self-efficacy [9]. Additionally, Schunk makes it clear that these goals must be proximal in nature (*i.e.* closely related to the students' task) [10]. Thus, to better understand self-efficacy in physics, and its impact on the retention of students in the field, one must also understand the goal setting habits of students in physics classes. Our study uses the definition of goals provided by Wentzel, "a cognitive representation of *what* it is that an individual is trying to achieve in a given situation [12]." With these ideas in mind, this study will address our research question: How do two Modeling Physics students, one man and one woman, construct and use proximal goals?

METHODS AND PARTICIPANTS

The two-semester introductory physics sequence is required for most STEM majors. At Florida International University (FIU), students may enroll in large lecture sections or sections that implement Modeling Instruction. These modeling sections are interactive engagement studio format, where students work together on lab and guided inquiry activities in small groups (3 to 4) and also engage in large class discussions, where they present their ideas and results to their peers. The instructor spends a minimal amount of time lecturing, encourages group work, and engages students through Socratic questioning. In the Modeling classroom, multiple opportunities exist for students to set their own goals as they learn the material. We investigated a Modeling class as it provided a rich environment in which to collect data, prerequisite for an effective qualitative study [13].

The timing of the study was the first semester of a two-semester sequence, where students focused mainly on Newtonian Mechanics. Three sources for the case study were used: observation, interviews, and a researcher reflection notebook kept throughout the data collection process [13]. Data collection began with observing all 30 students in one Modeling class for approximately two hours. The observation took place during an in-class activity where the goal was to find the mass of a turkey suspended asymmetrically on two ropes, as seen shown in Figure 1. Interaction between the researcher and student participants was minimal, with observing time divided among all 9 groups. Observations were recorded as field notes during the 2-hour time frame. Due to the variety of career paths in introductory physics, students ranged from entering freshmen to seniors. Also, the class was approximately 40% female and mostly Hispanic. There were 9 mixed-gender groups of 3 students each, arranged in the classroom as seen in Figure 1.

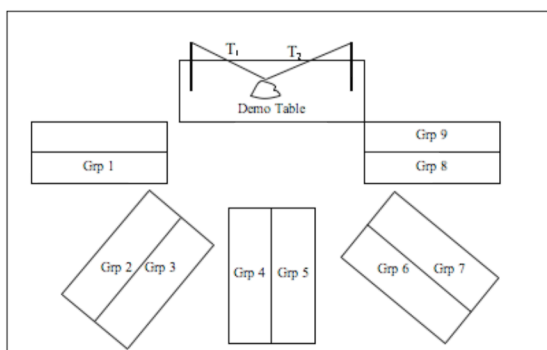


FIGURE 1. The classroom layout for the in class observation.

To obtain information rich data, we choose interview participants, in the middle of the fall semester, with a great deal of familiarity with the course and its requirements [15]. Two students were chosen: Giselle and John (gender-specific pseudonyms). Both John (Group 7) and Giselle (Group 4) are sophomore biology majors in the pre-medical school track. Giselle never had any physics before this class and had participated in studies before with the researchers. John had one physics class in high school in Brazil, and had never participated in a study with the researchers. The interviews took place in the middle of the semester and were conducted individually for approximately 45 minutes each. See Table 1 for the major interview guide.

TABLE 1. Major questions used as an interview guide for both John and Giselle.

Major Interview Guide:

- A) I'm interested in understanding what a student does to succeed in [Insert Professor]'s physics class. What would you tell a friend is necessary?
- B) Let's use an example of problem solving. Walk me through the activity you did when you tried to find the mass of the turkey.
- C) How was this an example of a typical physics problem?
- D) Are there any examples in this "find the mass of the turkey activity" of general things that you do when solving physics problems?
- E) Generally, how would you say you attempt to solve a physics problem?

At Florida International University, the Physics Department has incorporated Modeling Physics classes that are, in part, designed to build learning communities that include majors and introductory students. The FIU physics community is very tight-knit, where students spend much of their time working together and become most collegial. As a graduate student in this environment, the researcher is necessarily a part of this community. However, the introductory students have minimal connection with the physics community. Introductory students interact almost exclusively through the classes and undergraduate-led tutoring sessions. Thus, introductory students will have had little to no outside contact with the researcher during the study. Throughout the research, a reflection notebook was used to monitor subjectivity, and member checking was used to ensure validity of the interviews.

RESULTS AND ANALYSIS

The analysis on the three types of data yielded five final codes derived from the transcripts: the self-efficacy feedback loop, introduction and representation, coordination of representation, applications, and checking for consistency. The self-efficacy feedback loop provides information on how the goal setting process impacts the self-efficacy of the students in a fashion parallel to the problem solving process, while the other four themes—introduction and representation, coordination of representation, applications, and checking for consistency—exemplify the goal-setting process. To better understand self-efficacy in physics, and for this paper, our focus is primarily on the interaction between the feedback to self-efficacy loop and the goal-setting process.

In identifying the self-efficacy feedback loop, we looked for statements of self-efficacy. Using the definition provided by Bandura [4], we clearly identify statements of “I can” or “I am able” to be statements of self-efficacy. However, at times it is necessary to infer statements of self-efficacy. These inferences occur most often in places where students are making “I need” statements. To link these statements to self-efficacy, we require that the “I need” statement to be explicitly and directly linked to a statement of purpose. See Table 2 for examples.

TABLE 2. Examples of inferred self-efficacy statements.

	Quote	Purpose Analysis
Self-efficacy statement (Giselle)	“To find the angle we needed to get all the measurements... the hypotenuse, the adjacent, and the opposite.”	Purpose: to find the angle Need: measurements
Non self-efficacy statement (Observation)	“We need to combine components”	Purpose: NA Need: combine components

The self-efficacy feedback loop, while related to the goal-setting process, does not actually characterize the process itself. When students solved a problem in class, and later spoke of their experiences in interviews, a specific, non-sequential process was commonly observed throughout the data set; this process had distinct codes: (a) introduction and representation, (b) coordination of representation, (c) applications, and (d) checking for consistency. A student might be in any one of these stages while solving a problem. This process does not have a specific order, and the students seemed to go through multiple cycles of the process before solving the problem. Notably, this process found from the data is

strikingly similar to the Modeling process Brewé outlines as part of the instructional cycle these students participate in [16].

Introduction and representation. The first stage of introduction and representation is the depiction of the problem to be solved, and can take the form of equations, diagrams, or graphs. Almost all the students start the goal-setting process by creating a diagram that is an accurate introduction and representation of the situation at hand. This is evidenced early in the observation: “[Giselle’s group members] say they need to check some angles. They are drawing diagrams and trying to relate the angles in them.” Also, Giselle discusses drawing graphs in the interview: “No, [graphs] are helpful because you can see it more, and you kind of understand what’s going on a little bit more.” While Giselle is clearly in the introduction and representation stage of the goal-setting process, we can also notice how she talks about graphs improving her understanding. This representation has impacted her self-efficacy to understand the problem. We see a direct link to the self-efficacy feedback loop by her mention of better understanding. Further, diagrams, equations, and graphs are all parts of the introduction and representation stage, and students return to creating these representations throughout the problem solving process, thus impacting their self-efficacy along the way.

Coordination of representation. The second theme, coordination of representation, occurs when the student relates the representations to one another, which may involve interpretation in words, or simply finding the relationship between the diagrams and equations. John most clearly explained this part of the goal-setting process, “We had to utilize trigonometry to find the tension [the lines] would have going in the x-axis, and the tension it would have going in the y-axis, in order to solve for the weight of the turkey.” In this segment, John discusses the relationship between the physical setting of the experiment (turkey), the physics concept (tension), and the mathematical tools (trigonometry and axes). He coordinates all of the representations to create a coherent and complete design of the task at hand. At the same time, we can infer a statement of self-efficacy when he relates his ability to find the tensions in each component to the task of finding the weight of the turkey.

Similarly, students were observed trying to create a coherent relationship between the representations, “[John’s group] says they need to measure the angles because they want to split the forces into components...” They’re trying to coordinate their diagrammatical representation with the physical experimental setup (see Figure 1) and the necessary physics knowledge. Again, we infer the statement of

self-efficacy as they require the angles to find the components of the forces.

Applications. The third theme, applications, occurs when a student makes use of the coordinated representations to move forward in the problem-solving process, including putting the correct measurements or numbers into the equations or graphs. This theme arises out of the students making sense of all the information they've been working with so far. This is easily understandable when John says:

Well there are different forces that act in each axis that affect the gravity and the normal force that oppose each other. So I can find the normal. And the tension, it was already provided. And since it was in equilibrium, the two forces in the x-axis would have to be in equilibrium or it would be moving. So I think we found that; I think we did solve for the mass. But we had to get a lot of measurements in order to find the forces.

John uses his the coordinated representation of the equilibrium physics, as things not moving, to his diagrammatical representation with reference to the forces acting in the different axes. He also applies his coordinated representations when he references the measurements needed in order to find these forces. In addition, a direct connection to self-efficacy is evident in John's statement, "I can find the normal." Given his accurate coordination of representations, John's self-efficacy to complete the application step increases.

Checking for consistency. The applications stage does not end the goal-setting process; rather, a checking for consistency theme also emerges from the data. Checking for consistency is verifying the reliability of a result, consisting mainly of checking units or making sense of a number. This happened repeatedly in the observation: "One student, looking at his answer [for the mass of the turkey] says, 'I'm satisfied because it weighs about 4/5 of a pound,' and I hear, 'Our units do go!' as well as, 'Wow, that's really too low, let me see what you did.'" In the last quoted statement from this example, we see the student checking over the answer appears confident in his/her ability to look over the problem-solving process of his/her peer. We can infer this as a statement of self-efficacy by noticing that the purpose of checking over the process is to check the answer.

During the entire goal-setting process, information is transferred back to the self-efficacy feedback loop each time the students complete a stage and move to the next during the goal-setting process. In the final stages of the process, when the students find out the answer, regardless of whether they were correct, a variety of information influencing their self-efficacy has passed between them as a result of the problem-solving process.

CONCLUSION

The observations and interviews of the two Modeling Physics students indicate the problem solving process can be divided into two main themes: goal-setting process and self-efficacy feedback loop. The goal-setting process consists of four primary codes that transfer information to the self-efficacy feedback loop. It is evident that each stage of the goal-setting process independently impacts the self-efficacy, supporting Schunk's conclusion that proximal goal setting affects self-efficacy [10]. Considering the link between self-efficacy and the persistence of students in technical fields [8], and the impact of goal setting on self-efficacy in the Modeling classroom, goal setting should be further explored as a way to understand the retention of students in physics.

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