Students' motivational attitudes in introductory STEM courses: the relationship between assessment and externalization

Sarah Walters, Cesar Santana, Yevgeniya V. Zastavker, Alexander Dillon, and Jonathan D. Stolk
Franklin W. Olin College of Engineering
Needham, MA, USA

Michael D. Gross
Wake Forest University
Winston-Salem, NC, USA

***Abstract*—Work-in-Progress. Students' *contextual* motivation in introductory STEM (Science, Technology, Engineering, and Mathematics) courses has been a focus of many recent studies; this work provides a new lens to this work by investigating students' *situational* motivations. Grounded theory is used to analyze survey responses from ten students in an introductory STEM course at a small private technical school that features project-based learning environments. Analysis resulted in an emerging relationship between assessment and a behavior we call externalization. We observe a co-occurrence between externalization and problem-set-related assessment; the co-occurrence indicates that some students may not feel as though they have control over their progress and performance on problem sets and it is this lack of control that the students report to be frustrating and amotivating. Additionally, we observe that blame is presented either as externalization or non-externalization while credit is almost always non-externalized. The two presentations of blame suggest that students might externalize to cope with negative affective experiences. The results of this study may have implication for design of STEM courses with motivations as both means and ends in students' learning processes.**

Keywords— motivation; internalization; emotion; autonomy; empowerment; relevance; project-based learning

I. INTRODUCTION

Nearly all pedagogical approaches, from the most traditional to the most novel, feature some form of assessment. While traditional assessments are often summative and are used as an evaluative tool of student cognitive learning outcomes, more student-centered assessments may incorporate both formative and summative feedback, integrate aspects of students' motivational and behavioral engagement, consider the emotional and social conditions of the classroom and testing environment, and emphasize process skills or mastery learning. Progressive models for assessment seem to imply that the learner impacts the assessment results, but also that the assessment experience and context may have important effects on the learner.

Research into motivation - the psychological drive to take action - suggests that this learner-context dynamic is not only possible, but is a key factor in educational outcomes. Researchers using the Self-Determination Theory (SDT) framework [1] have demonstrated that students driven by externalized forms of motivation are less likely than students driven by internalized forms of motivation to show positive outcomes such as enhanced learning engagement, improved self-regulation, higher persistence and better performance [1-12].

SDT posits that the extent to which a student internalizes a motivation is influenced by their perception of their environment's support of three fundamental needs: autonomy, relatedness, and competence [1]. In combination, these needs could be interpreted as a snapshot of student motivation and a predictor of likely motivational outcome. This insight could be valuable in the classroom because the internalization process is ongoing: even long-held beliefs can be altered by more recent experiences [13].

This work presents a new lens to the theoretical and empirical research on students' classroom motivation, most of which is done at a contextual level. Specifically, to understand students' situational motivational attitudes in STEM courses, we use grounded theory approach, which allows for emergence of new theoretical frameworks while using existing theory as data sources [14]. In isolation of the aforementioned theories, we propose an emergent framework that includes the themes of internalized and externalized perceptions of assessment and offers links between emotion, motivation, and performance, both positive and negative. In addition to further validating existing theoretical frameworks, this analysis may also suggest to practitioners how sometimes abstract theoretical concepts, such as externalized motivations and outcome attributions, could be identified within, and perhaps driven by, concrete classroom situations. Instructors and students may gain important insights from a consideration of how routine course activities such as problem sets, projects, and exams contribute to learners' adoption of motivations, emotions, and attributional strategies that could either support or undermine healthy and productive learning engagement.

II. METHODS

The dataset consists of 735 open-ended survey responses about situational motivation from 132 students enrolled in introductory STEM courses at 4 study sites. This paper

considers ten students from a single class at one of the sites of study. Eight of the students are women and two are men; three are sophomores, four are juniors, and three are seniors. The study site is a small private technical school featuring project-based learning throughout its curriculum, and all but one of the students are taking the course as a mechanical engineering major requirement.

We use grounded theory as an analytical approach for understanding emergent thematic trends [14]. Open, axial, and selective coding methods are used to identify emergent categories [15]. Analytical memos are used for identifying emergent themes, which are then compiled into matrices that are used to explore intra- and inter-theme correlations [16].

III. Results and Discussion

Our analysis of students' experiences in STEM course activities highlights emergent relationships among students' perceptions of *assessment*, their sense of *control* or outcome *attributions* (crediting or blaming), and their *motivational* and *emotional* responses. Our emergent definition of assessment is shaped by students' descriptions of progress or performance in the course; these descriptions comprised both student self-assessment and traditional forms of instructor assessment, though we observe mostly self-assessment at the site under consideration.

Our analysis of students' survey responses identifies an emergent construct of externalization, a phenomenon which occurs when a student describes an assessment, or a reaction to an assessment, as if it is out of their control. Generally, in our dataset when students externalize they perceive that an external agent or force is in control of the assessment (e.g., a grade on an exam) or their reaction to the assessment (e.g., an emotional response to a grade). When they do not externalize, students perceive that they are in control. Both externalization and the lack thereof can be divided into two categories: "crediting" and "blaming." For example, Mark uses crediting externalization when he says

> *I think the last problem set was very good for my learning.* (Mark, 2/17)

Discursively, Mark gives the problem set credit for a positive self-assessment. By contrast, Francesca credits but does not externalize when she says

> *When I feel like it's beyond my abilities (and I'm too busy to sink lots of time into it), I just don't feel motivated to work on it because I don't see what I'm getting out of it.* (Francesca, 3/10)

Francesca's self-assessment results in an internal motivational response: she is not motivated to work on activities which she feels are too difficult for her or which are disconnected from her own goals, values, or sense of progress. A number of factors could trigger this response, but the feeling that the task is "beyond her ability" would indicate low task self-efficacy or expectancy of failure [17], and her inability to see what she's gaining from the work would indicate low task value [12,18]. Francesca's low motivation is the expected outcome in this situation, given the well-documented importance of self-efficacy and task value self-motivation and self-regulation [3,12,17].

Students' attributional strategies in response to course assignments provide insights into their cognitive and affective processes in specific assessment-related learning situations. For example, we find crediting and blaming externalization in students' descriptions of problem sets. As shown in the "Externalized" column of Figure 1, students are inclined to use crediting externalization when describing doing well on

	Externalized	Not externalized
Crediting	**Student describes**: ● doing well on problem set ● doing well in course "I think the problems that we work on inside and outside of class are scaled very appropriately to my level of understanding. Just easy enough that I'm confident I can work on it and just hard enough that I know I will learn something if I can solve it." - Margaret Amethyst, 2/17	**Student describes**: ● positive emotion ● positive motivation ● doing well on project "I feel that I did very well because I caught up on all of the course work that I had fallen behind on." - Kenneth Amethyst, 4/14
Blaming	**Student describes**: ● negative emotion ● amotivation ● doing poorly on problem set "The math lecture was slightly frustrating at first because of how fast our professor was going..." - Kenneth Amethyst, 2/24	**Student describes**: ● negative emotion ● amotivation ● doing poorly on project "When I feel like it's beyond my abilities (and I'm too busy to sink lots of time into it), I just don't feel motivated to work on it because I don't see what I'm getting out of it." Francesca Amethyst, 3/10

Fig. 1. This table describes students' perceptions of assessment, their motivations, and their emotions, which co-occur with externalization/non-externalization and crediting/blaming. In addition to our findings, each quadrant of the table includes a representative quote from a student. Non-externalization includes cases in which a student describes an assessment or a reaction to an assessment as if it is within their control as well as cases in which a student describes an assessment or a reaction to an assessment without discussing control.

problem sets; in contrast, they are likely to use blaming externalization when describing doing poorly on problem sets. Margaret uses crediting language when she says

> *I think the problems that we work on inside and outside of class are scaled very appropriately to my level of understanding. Just easy enough that I'm confident I can work on it and just hard enough that I know I will learn something if I can solve it.* (Margaret, 2/17)

Margaret externalizes her high performance on the course's problem sets by giving credit to the instructor's design of the problems. Conversely, Kenneth uses blaming language when he says

> *Given the way the homework problems were initially worded, it would have been impossible to do the problem.* (Kenneth, 2/17)

Kenneth externalizes his initial negative performance on a problem set, blaming the wording of the problems for his struggle to complete them.

These two quotes exemplify the co-occurrence of externalization and discussion of problem sets. In contrast, we find few cases of externalization – either crediting or blaming – in students' descriptions of projects or deadlines, which tend to evoke non-externalized responses. Since crediting and blaming behaviors represent attributional strategies that may provide insight into learners' expectancy and control beliefs [12,18], and since crediting and blaming may help predict learning engagement and outcomes [19,20], the influences of both personal and social-contextual factors on these responses are important for instructors and students to understand.

We find co-occurrences related to externalization (or the lack thereof), crediting, and blaming, and students' motivational and emotional reactions to assessment. As shown in the "Blaming" row of Figure 1, students blame when discussing negative emotion and amotivation; interestingly, that blame can be presented either as externalization or as non-externalization. Consider Christen and Cynthia's descriptions of negative emotion: both use blaming language, but Christen externalizes the blame while Cynthia does not. Christen externalizes when she says

> *I felt a little bit frustrated last week because we started a unit but didn't have much lecture on the topic before doing the homework.* (Christen, 3/19)

She blames the structure of the course for her negative emotion. Conversely, Cynthia does not externalize when she says

> *I was pretty frustrated on the first lecture of the week because I didn't understand the refrigeration cycle at all.* (Cynthia, 3/10)

Unlike Christen, Cynthia blames herself for her own negative emotion. This contrast exemplifies the two presentations of blame which we observe throughout the dataset: negative emotion is sometimes externalized and sometimes not.

Similarly, consider two descriptions of amotivation from Margaret: both use blaming language, but one description externalizes the blame and the other does not. Margaret externalizes when she says

> *Because the project is not working I also don't want to work on other work i have to do for thermo.* (Margaret, 4/28)

In the same survey, she does not externalize when she says

> *Because we feel we've exhausted our resources we aren't motivated to (or feel capable of) continuing work on the project...* (Margaret, 4/28)

Margaret partially attributes her amotivation to an external "agent," the project which isn't working, and partially blames an internal "agent," her team's sense that they've exhausted their resources. Like negative emotion, we observe throughout the dataset that amotivation is sometimes externalized and sometimes not; this represents an interesting finding in light of self-determination theory's description of amotivation as an impersonal disconnect between action and outcome [2]. In contrast with the two ways in which blame is presented when discussing negative emotion and amotivation, credit for positive emotion and motivation is always presented as non-externalization.

The co-occurrence of externalization and negative student reactions with problem set assessments suggests that some students may not feel as though they have control over their progress and performance on problem sets, and that this lack of control may be frustrating and amotivating. This pattern, in which blame related to problem sets is almost always externalized, contrasts with the way students discuss emotion and motivation. Blame related to emotion and motivation can be presented either as externalization or as non-externalization, while credit related to emotion and motivation is almost all non-externalized, as illustrated in the examples in Fig. 1. These two presentations of blame suggest that students might externalize to cope with negative experiences, and that the coping mechanism may not be necessary for positive experiences.

IV. Conclusions

Our analysis suggests that problem sets co-occur with externalization in cases of both crediting and blaming, while projects do not typically co-occur with externalization. It seems that, regardless of performance, project-based work might encourage students to feel that they have control over their assessments and their reactions to assessment, while problem-set-based work might encourage students to perceive that others are in control. Based on existing motivation theory [1-2], we hypothesize that students who have a sense of control are better able to build self-confidence in cases of positive performance and are better able to accept critical feedback in cases of negative performance. Arguably, students who are able to appropriately shift control away from themselves may more readily credit deserving agents in cases of positive performance and more capable of coping with negative affect in cases of negative performance. Ultimately, students who balance externalization and non-externalization (i.e., by externalizing only when an external agent deserves credit or blame) might receive the benefits of both behaviors. We posit

that there may be complex metacognitive processes that enable accurate attribution of learning outcomes, and meta-motivational processes that enable proper sense-making of affective responses. An understanding of how each student uses externalization could help educators improve those students' learning experiences.

Future development of this work could entail the refinement of the non-externalization behavior, which presently includes two behaviors grouped together. Non-externalization includes cases in which a student describes an assessment or a reaction to an assessment as if it is within their control as well as cases in which a student describes an assessment or a reaction to an assessment without discussing control. In future work, the two component behaviors of non-externalization could be examined separately. We expect that significantly different co-occurrences might arise from examining lack of description of control separately from description of being in control.

This case study examines co-occurrences between student externalization and the qualitative context surrounding an assessment; however, it does not consider the relationship between externalization and common quantitative measures of assessment such as letter grade and GPA. In future work, analysis of this possible relationship might allow us to find new ways in which we can understand the complex processes described in this work.

This case study examines ten students at a single site; expanding the analysis to a larger number of students and larger numbers of sites may enable comparison of different classroom environments' influences on student externalization. Additionally, further analysis might allow us to establish these emergent co-occurrences in other contexts, to find further co-occurrences between assessment and externalization, or to identify new co-occurrences between externalization and other themes. In particular, we are interested in studying externalization at a site where traditional assessment is more common than self-assessment.

ACKNOWLEDGMENT

This work was supported in part by grants from the National Science Foundation (DUE #1445950, DUE #1322684, and DUE #1156832).

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