

WIP: For the Love of the Game: Exploring Student Motivation in Game-Based Learning Environments

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Abstract—This Work-in-Progress Research Paper centers on game-based learning and its impact on student motivation as a function of their self-defined demographic factors. Specifically, this work investigates the game-based learning experience of civil engineering undergraduates engaged with the Cone Penetration Testing module of *GeoExplorer*, a virtual learning environment that simulates in-field learning about the structural properties of soil, providing students with the opportunity to practice competencies and mindsets associated with real-world data collection and analyses. In this paper, we explore the impacts of *GeoExplorer* on student motivation by addressing the following research questions: (1) How, if at all, do students experience identifiable motivational shifts over the course of their engagement with *GeoExplorer*? (2) What is the interplay between engagement with *GeoExplorer*, demographic factors, including students’ racial, ethnic, and gender identities, and student motivation? and (3) How can game-based learning environments best address the needs of students with different motivational attitudes? Preliminary analyses of 60 response pairs to the pre- and the post-*GeoExplorer* engagement surveys from 2021 were analyzed. Deductive analytical practices using ‘a priori’ qualitative coding, based on Self-Determination Theory (SDT) of motivation, were used to examine the following survey item: *What factors contributed to your motivation over the past week in the course? Please give specific examples of activities, interactions, emotions, thoughts, etc. that may have contributed to your motivation.* While our early findings indicate distinct differences in students’ motivational outcomes between the pre- and post-survey, no clear patterns in motivational shifts are identified across the board, suggesting that the *GeoExplorer* experience may have impacted each student’s motivation uniquely. However, patterns emerged between students’ pre-survey motivation types, based on demographic factors. Additionally, unique shifts in motivational attitudes between the pre- and post-surveys were found to occur within each demographic grouping. These findings and challenges in performing this study are further discussed with a proposal for possible future directions.

Index Terms—Game-Based Learning, Motivation, Self-Determination Theory, Race, Gender, Demographic factors

I. INTRODUCTION AND LITERATURE REVIEW

This Work-in-Progress Research Paper centers on the impact of game-based learning on student motivation, and, more specifically, the role of self-defined demographic factors on students’ motivational outcomes in game-based learning environments.

Game-Based Learning (GBL) environments, those in which student learning takes place in a virtual game-based space,

have been shown to be effective for content retention and other positive cognitive outcomes, such as conceptual understanding and analytical tools as they pertain to communicating students’ understanding [1][2]. Krouska and Troussas (2021) found that engagement with GBL results in “a significant and positive impact on student engagement and academic performance” [3]. Positive cognitive outcomes may be of particular importance for low-achieving students. For example, Chen et al. (2020) found that, for students at the K-12 level, GBL “effectively gave low-achieving students a new opportunity to learn better than with traditional instruction both in terms of conceptual understanding and argumentation skills” [2]. In their meta-analysis, Wouters et al. (2013) also reported that “serious games were found to be more effective in terms of learning and retention” than traditional teaching methods. Importantly, this meta-analysis also undertook an investigation of serious games’ effect on students’ motivation and found no difference in motivational outcomes in these environments compared to traditional instruction [4]. Studies of GBL’s impact on non-cognitive learning outcomes demonstrated its supportive role in the development of both interpersonal skills, i.e., “intellectual openness, work ethic and conscientiousness, and positive core self-evaluation,” and intrapersonal skills, i.e., “teamwork, collaboration, and leadership” [5].

While a general understanding of how GBL impacts students provides useful context and justification for its further integration into curricula across many disciplines, it is important to take a closer look at GBL’s impact on STEM curricula specifically. Wang et al. (2022), in their investigation of students’ learning achievement in STEM, found that “digital games are a promising pedagogical method in STEM education that effectively improves learning gains” across “different STEM subjects” [6]. However, other authors have found less positive results. For instance, Neimeyer (2006) found that computer-assisted educational games negatively impacted “achievement levels” in seventh-grade mathematics classes [7].

Overall, literature indicates that GBL can be a powerful tool if implemented well. However, upon examining its impacts on various demographic groups, a different story seems to emerge. Joiner and colleagues (2011) found that, while there

was “no gender difference in the beneficial effect” of GBL among undergraduate Mechanical Engineering majors in terms of content learned, there was “some evidence that female students found [GBL] more motivating than male students” [8]. However, another study engaging a multi-year ethnography approach determined that women in GBL environments “perform more poorly” due to a “digital identity divide” among men and women [9].

To date, we found a paucity of literature on the influence of race and ethnic identity on students’ outcomes in GBL environments [10]. Acosta and Denham (2018) argue that “digital games that intend to recreate histories of racial oppression can be harmful to African American children if they reproduce popular and problematic notions of indigenous lives and experiences” [11]. Everett and Watkins (2008) further explore how video games can teach children “dominant ideas about race in America” whether intentionally or tacitly, simply by portraying race at all [12].

To support the work that bridges the gaps in equitable access to GBL and contributes to the GBL scholarship, this research analyzes students’ responses to pre- and post-*GeoExplorer* engagement, which is a GBL platform that simulates prohibitively expensive civil engineering equipment, and rare and/or dangerous natural events. This work engages the Cone Penetration Testing (CPT) module of *GeoExplorer*, which enables students to gain knowledge, skills, and mindsets relevant to CPT, including driving a CPT truck, performing field tests, and analyzing resulting data. This module provides a real-world experience to civil engineering students otherwise unavailable for most engineering undergraduates [10][13]-[26].

In this paper, we explore the impacts of *GeoExplorer* on student motivation by addressing the following research questions: (1) How, if at all, do students experience identifiable motivational shifts over the course of their engagement with *GeoExplorer*? (2) What is the interplay between engagement with *GeoExplorer*, demographic factors, including students’ racial, ethnic, and gender identities, and student motivation? and (3) How can GBL environments best address the needs of students with different motivational attitudes?

II. METHODS

As part of a larger mixed-methods study, this paper considers 60 pre- and post-*GeoExplorer* engagement survey response pairs from 60 undergraduate students attending 12 U.S. institutions in 2021. Participant demographics included all levels of undergraduate study, diversity of self-reported racial and ethnic backgrounds, and self-identifications as women and men, with two participants who preferred not to say.

In the week between completing the pre- and post-engagement survey, participants interacted with the Cone Penetration Testing (CPT) module of *GeoExplorer*. This engagement occurred within the context of their academic coursework, usually in a geotechnical engineering course that served as a civil engineering major requirement. This study investigates student responses to the following pre- and post-survey item: **“What factors contributed to your motivation**

over the past week in the course? Please give specific examples of activities, interactions, emotions, thoughts, etc. that may have contributed to your motivation.”

Deductive analytical practices with ‘a priori’ qualitative coding were used, based on Self-Determination Theory (SDT), which specifies six motivational types: (i) Intrinsic (e.g., “*the task is interesting/I find passion in it*”); (ii) Integrated Regulation (e.g., “*the task is part of my identity*”); (iii) Identified Regulation (e.g., “*the task represents one or more of my core values*”); (iv) Introjected Regulation (e.g., “*the task is tied to my self-esteem*”); (v) External Regulation (e.g., “*the task is tied to a reward and/or against punishment*”); and (vi) Amotivation (e.g., “*I am not motivated*”). Student responses that could not be coded as one of these motivational types – whether because an emotional, factual, or nonsensical response was provided – were coded as non-evaluated or non-answer. Often, double- and triple-coding was used to capture the complexity of student responses.

Five scholars initially coded each of the 60 response pairs individually, followed by a discussion and group coding of 10 pre-/post-survey response pairs. This process was followed by individual coding of the same 60 pairs, yielding an intercoder reliability of 81% and 82% for the pre- and post-surveys, respectively. The intricacies of coding for integrated, identified, and introjected regulations presented significant challenges in achieving high intercoder reliability among five coders, due to the varied interpretive positionalities of scholars involved and quick survey response nature. Nevertheless, our coding process resulted in the achievement of an acceptable reliability standard of 80% agreement on 95% of codes, a high accomplishment given an unusually high number of coders [27].

III. RESULTS AND DISCUSSION

Below we describe three emergent themes: (1) the impact of *GeoExplorer* on students’ motivational shifts between the pre- and post-survey; (2) the relationship between race/ethnic identity, gender, and GBL, and how that interplay might inform our understanding of students’ motivational shifts; and (3) the role of GBL in addressing the needs of students with different motivational attitudes.

A. *GeoExplorer* and Students’ Motivational Shifts

Of the 60 student responses analyzed, 39 demonstrated motivational shifts from the pre- to post-survey. For example, one student modified their response from “I don’t want to fail the course” in the pre-survey to “I want to make the most out of this course” in the post-survey. We coded the pre-survey response as external regulation (fear of punishment) and introjected regulation (an internalization of failure possibly due to low self-efficacy). In contrast, the post-survey response was coded for identified regulation (internalized meaning-making process about the student’s value in engaging with the course). Of note in the post-survey, the student’s acknowledgment of an alignment between working towards course success and their core value of “making the most” of their opportunities.

The identified variability in students’ motivational shifts raise additional emergent questions: What factors influence

these differences? Which of these factors are attributable to *GeoExplorer* explicitly rather than other situationally relevant elements of students' learning milieu?

To explore these questions, all 60 paired responses were filtered to the 8 that explicitly mentioned the "experience" or "*GeoExplorer*," "VE" or "virtual environment," "game" or "videogame," "CPT" or "Cone Penetration Testing." Narrowing the analytical scope in this way allowed for a more clear understanding of the impacts of *GeoExplorer* on these motivational shifts and establishment of a benchmark for students' motivation prior to their GBL engagement.

While no clear pattern of students' motivational shifts has emerged in this process, our preliminary findings suggest that, at least for some students, the *GeoExplorer* experience has a direct impact on their motivation. For example, one student's pre-survey response to the motivational question stated, "The first thing I would say is [the professor's] approach to both us and the course. He makes us love the course and topics. I am happy to take the course from him." In comparison, in their post-survey, this same student reported, "Playing and experiencing the open world of *GeoExplorer* motivated me a lot over the past week since I was looking forward to playing it because it seemed fun." Whereas before the *GeoExplorer* activity, the student identified the satisfaction of their psychological need for relatedness as their source of motivation, this identified regulation shifted to intrinsic motivation as a direct result of the enjoyment of the *GeoExplorer* activity itself. Another student's response changed from "Trying to bring my grade up" to "I was excited to play the game." Here, the pre-survey response was coded for external regulation, as the student shared their perception of grading as either a punishment or reward. In comparison, the intrinsically motivated nature of this same student's post-survey response was unambiguous – the student was motivated by their interest in the game.

Another group of students described their engagement with *GeoExplorer* in a different way. Rather than the game influencing their motivation, these students' motivation appeared to influence how they experienced *GeoExplorer*. In their pre-survey, one student shared their "desire to learn about soil properties," indicating an interest in the subject before engaging with *GeoExplorer*. As well, the post-survey response, "My desire to learn more about geotechnical engineering as a whole motivated me to keep going with the simulation," described how intrinsic motivation drove engagement with the *GeoExplorer*, rather than the activity motivating interest in the subject.

In summary, while no single or typical motivational shift was identified pre- to post-*GeoExplorer* engagement, over half of the responses analyzed did indicate changes in students' motivations, with students reporting both how *GeoExplorer* might be influencing their motivation and vice versa. Of importance to this discussion is that in many cases, coding for motivations was challenging or impossible due to incongruence between the motivation prompt and students' responses (e.g., students responding with "Too many exams," and "NA").

B. GeoExplorer, Race/Ethnicity, and Gender Identity

To explore the relationship between students' self-reported demographic factors and their motivational outcomes, we considered the entire set of 60 pre- and post-response pairs.

1) Preliminary Findings on Racial/Ethnic Identity

We identified a shift in motivations from the pre- to post-*GeoExplorer* engagement across all demographic groups with several noteworthy trends. Firstly, while no patterns in motivational shift emerged when all students were considered as one group, when separated into racial/ethnic groups, comparison of the pre- to the post-survey results indicate an increase in external regulation and a decrease in identified regulation among White students and students of Hispanic, Latino, or Spanish origin. Of importance is that many student responses were tagged with multiple codes, rendering challenging the determination of whether the decrease in identified regulation is connected to the increase in external regulation. Yet, 3 of the 4 students whose responses did shift from solely identified regulation to solely external regulation self-identified as White.

Secondly, while none of these 3 White students explicitly mentioned *GeoExplorer*, this group demonstrates some of the most distinct pre- to post-survey motivational shifts. For example, the same student who reported in the pre-survey, "The motivation I have had throughout this course is thanks to my group because we contribute and work together in order to obtain a good grade for the course" followed up in the post-survey with "The motivations ... for this course [is] to pass it, it is because I want to pass this class with an A. I am trying to get good grades because I am trying to graduate this semester." Unfortunately, it is difficult to draw conclusions from our limited data regarding such shift's relation to *GeoExplorer* due to other independent variables (e.g., time of the semester, assessment practices within the course, personal situation, etc.) often not cited by the students explicitly.

Finally, in both the pre- and post-survey, compared to White and South Asian students, other ethnic groups demonstrated higher levels of external regulation, being more likely to cite grades, passing their class, or graduation as their motivation. This is especially true for students of self-reported Hispanic, Latino, or Spanish origin. White students, on the other hand, exhibited a greater tendency towards identified regulation, suggesting a stronger conceptual alignment between their basic psychological needs and their academic tasks.

2) Preliminary Findings on Gender

Our findings indicate that gender is also correlated with students' motivational responses post-GBL engagement. While women exhibited a notable increase in external regulation in the post-survey compared to the pre-survey, intrinsic motivation appeared to be significantly less prevalent among female respondents in both the pre- and post-survey compared to their male counterparts.

Exemplary is feedback from one of the women, whose pre-survey response was double-coded for intrinsic motivation and introjected regulation and whose post-survey response lacks any indication of intrinsic motivation. Explicitly, in the pre-survey, she expressed, "I am interested in this subject, so I

want to do well to ensure my foundation is there. I also do not want to fail a class.” In contrast, in the post-survey, she stated, “My biggest motivation is making it through this semester without failing.” While her responses to both the pre- and post-survey were coded for introjected regulation, her fear of failure persisted becoming a primary motivating factor – she no longer expressed an interest in the subject. This example is emblematic of the intrinsic motivation dearth in the women’s post-survey responses. However, due to a limited number of references to *GeoExplorer*, further investigation is needed to determine the cause of lacking intrinsic motivation. As is the case with the race/ethnic identity, other independent variables may play a role in women students’ motivational responses that are beyond GBL’s impact.

Although responses from men were more frequently coded for intrinsic motivation, compared to women, we found a noticeable decrease in the intrinsic motivation reported by men between their pre- and post-surveys, with many shifting from intrinsic motivation to identified regulation. One potential explanation for such change for men might be that their ties to professional core values become more salient as academic challenges intensify. For instance, one man’s pre-survey response reads, “The material is interesting to learn,” an example of intrinsic motivation. In his post-survey, however, the same student shared, “It is important to understand how soil acts as a civil engineer,” demonstrating a possible identification with professional core values relevant to civil engineering, and recognition that understanding content knowledge is a stepping stone to achieving that goal. Within the week between pre- and post-*GeoExplorer* engagement, this student’s responses demonstrate a decrease in the subject matter’s interest in favor of a deeper understanding of the material to achieve success in the field of civil engineering.

C. GBL and the Needs of Students with Different Motivations

Of all the student responses analyzed, the most common motivation type was external regulation: 24 and 26 student responses were coded for external regulation in the pre- and post-survey, respectively, with many of these students citing the importance of good grades, graduation, and meeting deadlines. One student wrote, “A big piece of motivation not only to learn a lot and do well in this class but for all my classes stems from one idea: GRADUATE ON TIME.”

The second most frequent motivation was identified regulation, with 15 pre- and 8 post-survey responses. These students emphasized the importance of learning, upholding the connections they built within the classroom with their classmates and professor, and continuing to work towards a career in geotechnical engineering. One student reported that “[the professor] is presenting materials to me clearly and makes me feel like I can do the task. Hence, I want to do something I am good at because the feeling is rewarding”.

As discussed in Section A, our findings indicate that a student’s experience with GBL did not merely influence motivation, nor did motivation merely influence a student’s experience with GBL; the two informed each other. Since together, external and identified regulation comprised the majority of the

coded motivations, incorporating connections between these motivational types and the content being delivered through GBL could increase the impact of this learning environment.

Students in this study were able to identify the connection between GBL and their more externally motivated goals, such as good grades and graduation. Therefore, we suggest that future GBL designs aim to not only meet the educational metrics that they are designed for but also work to target students’ core values. Whether implicit or explicit ties to common student values within the course content would be more impactful is a subject for our future research.

IV. STUDY LIMITATIONS

One significant challenge in this study is the complexity of interpreting students’ self-reported motivations through the SDT. As the analysis reveals, students often provide ambiguous or even nonsensical responses. This could stem from students’ unfamiliarity with motivational language or the challenges relevant to introspection necessary for engaging with motivational prompts, leading to interpretive decisions that may not capture the intended complexity of their motivations.

The necessity for making such interpretive decisions underscores the importance of acknowledging the limitations inherent in analyzing student motivations through self-reported survey instruments. While efforts were made to apply SDT categories systematically, the diverse and sometimes contradictory nature of students’ responses highlights the inherent subjectivity involved in analyzing qualitative data. Thus, our next steps will include data triangulation for a more holistic assessment of student motivations, including data sources from student and faculty interviews, to provide a more comprehensive understanding of the motivational dynamics at play.

V. CONCLUSIONS

As GBL becomes increasingly common in classrooms, more research is necessary to understand how to maximize its potential benefits on student learning. Whether considered through the lens of SDT or other theories of motivation, student motivations are impacted by a diversity of internal and external factors. Taking demographic factors into consideration not only reveals racialized and gendered patterns in how different groups are differently motivated, but also further contextualizes the nuanced nature of the relationship between motivation and course engagement. Given the preliminary nature of our work and limitations of analyses reported, we expect to learn a great deal more in our future work about the efficacy of GBL environments in supporting students’ positive motivational outcomes. As well, we invite engineering education audiences to join us in establishing a robust scholarship to understand the effect of GBL’s deployment at large scale, particularly post-pandemic and with the exponentially rising development and use of AI technology.

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