Motivation Factors that Contribute to Student Engagement in an Electronic Learning System

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Abstract: This study reports on motivation factors for student engagement with an electronic learning system designed for general organic chemistry courses. Engagement is proposed as a simple and broadly applicable parameter against which student motivations can be evaluated. Self-efficacy correlates most strongly with course performance, but self-determination correlates most strongly with engagement. General extrinsic and intrinsic motivation factors exhibit very weak correlations with both performance and engagement, suggesting that future work should focus identifying system-specific motivation factors.

Introduction

Student motivation has long been identified as a factor that can contribute to success in electronic learning (e-learning) systems (e.g., Del Soldato & du Boulay, 1995; Garcia, Falkner & Vivian, 2018). Most studies of motivation in e-learning have focused on understanding how student motivation is influenced by a specific e-learning environment, and how these interactions influence performance within that environment (e.g., de Vicente & Pain, 1998; Duffy & Azevedo, 2018). Considering e-learning in a wider range of delivery models, in online distance learning for example, a broader understanding of how students interact and are motivated to engage with e-learning systems would be desirable (Hartnett, St. George, & Dron, 2011). This is of particular interest if online learning can truly develop to better meet the education needs of a greater diversity of students (Stewart, 2004).

Studies of motivation factors are often approached from social-cognitive perspectives, in particular, self-regulated learning (SRL) (Black & Deci, 2000; Zimmerman, 2001). SRL theory recognizes that learning is hard work, and that students must be motivated to apply effort to learn. Student effort is regulated by beliefs that influence, and that are influenced by, different motivation factors (Schunk & Pajares, 2001). Students who are more motivated are more likely to expend effort towards learning, are less likely to exhibit task avoidance, and are more likely to persist. Self-regulated learners are motivated to build cognitive skills, use metacognition to develop and adjust learning strategies, and are in control of their learning environment (Zimmerman, 2001). Ways to facilitate student self-regulation have been widely discussed (Nilson, 2013), examples include:

- Helping students set goals
- Providing students with choices
- Providing multiple opportunities to practice new concepts in multiple contexts
- Modelling desired skills and strategies
- Helping students' metacognition by providing rich feedback
- Explaining that making mistakes is part of learning
- Delivering high quality information to students about their progress.

We have built a web-based e-learning system, the Organic Chemistry Practice Environment (OPE). General organic chemistry is considered challenging for undergraduate students, and has been reported to have attrition rates as high as 50% (Grove, Hershberger, & Bretz, 2008). OPE is currently used in the two-semester general organic chemistry at a large university in the Southwestern U.S., in both on campus and online distance courses. Course material is delivered in standard lecture-style; OPE is the companion active course component.

OPE provides categorized problems that cover all of the standard organic chemistry course material. When students log into the site, they see a simple interface that provides access to the problems, categorized according to the course structure. Students also see a summary of their progress at the overall course level and at category levels. The site has additional features that align with suggestions from SLR theory:

- There are no regular deadlines or quotas for completing problems. Each student decides how many problems to attempt as they progress through the course, with one exception, see below.

- Students earn the same credit for getting a problem incorrect as correct since making mistakes is recognized as an important part of learning. The system is non-punitive.
- Students receive extensive positive and negative feedback in response to an input for each problem.
- Many problems have video explanations that model strategies and problem-solving processes.
- There are over 1200 problems per course, allowing students to practice new concepts in multiple contexts.
- Some problem types require complex responses that cannot be entered into the system or graded. In these cases, students self-report their ability to solve the problem, in support of autonomy.
- Students can attempt a problem as many times as they like.

Another feature of OPE is that it separately addresses development of the cognitive and metacognitive domains. When students start a problem, they are asked to select one of two buttons, "Studying" and "Testing Performance". Students can select "Studying" when they are learning a concept, developing cognitive skills, and are not yet ready to be tested. Students choose "Testing Performance" when they are ready to assess their learning, i.e. building metacognition. When a student selects "Studying", they can see the answer to the problem with a detailed explanation, and in many cases, a video explanation that models problem-solving. When a student selects "Testing Performance" they must input a solution, which is graded as correct or incorrect, and then the student receives the same feedback as when "Studying". The students are given only one deadline. They receive credit corresponding to 5% of the available course points if they have attempted 800 problems by the date of the final course examination. All OPE problems were written by the course instructor which ensures alignment with the examinations used for assessment of performance.

OPE represents a multi-faceted approach to support self-regulated e-learning. It is not a self-contained tutor since assessment of overall course performance does not take place in OPE. Nevertheless, the extent to which students engage with OPE is vital to their success. The OPE format suggests a different perspective from which examine the influence of motivation on e-learning, i.e, how much they engage with it. To the best of our knowledge, this method of assessing motivation influences has not previously been discussed in the literature. Our research question then was: What motivation factors correlate with students' engagement with the OPE?

Motivation and self-regulation

Motivation factors for learning are commonly divided into *intrinsic*, where students put effort into learning because the subject is interesting or rewarding, and *extrinsic*, where students receive an external reward, such as earning a high grade or advancing towards a career (Glynn & Koballa, 2006). *Self-efficacy* describes students' beliefs that they can succeed in a subject. Self-efficacy also regulates the motivation so that low self-efficacy dampens intrinsic and extrinsic motivation (Schunk & Pajares, 1995). *Self-determination* describes the level of control students believe they have over their learning. Self-determination controls intrinsic motivation (Ryan & Deci, 2000) in that low self-determination results in a lower *perception* of intrinsic motivation. Self-determination is central to self-regulation since it reflects students' self-chosen, voluntary actions to learn.

A common result from studies of motivation in science learning is that self-efficacy is the factor that correlates most strongly with performance (e.g., Zimmerman, 2000; Schunk & Pajares, 2001). In one study of a general organic chemistry courses, self-efficacy was found to account for as much as 50% of the variance in student performance (Austin , Hammond, Barrows, Gould, & Gould, 2018).

Study participants and methods

The participants in this study were enrolled in a 14-week organic chemistry course in Spring 2017 at a research university in the Southwestern United States. To be a participant, students had to complete all course assessments and a motivation survey. 76% of the eligible students participated (n=325). For this exploratory study, motivation factors were assessed using a validated survey instrument, the Science Motivation Questionnaire II (SMQ-II) (Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011). SMQ-II is a 25-item instrument designed to measure intrinsic, extrinsic, and motivation regulation factors, and that was administered in the last week of the course prior to the final examination. SMQ-II measures extrinsic motivation in terms of students' perception of the course's relevance to their anticipated career path (career motivation) and their desired course grade (grade motivation). It also measures intrinsic motivation, self-efficacy, and self-determination as they relate to learning the subject. OPE provides many different kinds of usage data. For this study, the total number of responses ("Total Responses") was chosen as a simple measure of engagement with OPE. "Total Reponses" is the number of times a student attempted any problem using "Testing Performance", which includes all repeat attempts, but not those using "Studying".

Results and discussion

Motivation percentage scores for the five factors of SMQ-II were collected for each student just before the final course examination. The mean values of these percentage scores together with their standard deviations are summarized in Table 1. The average number of individual OPE problems attempted for the participants by the date of the final examination was 856, i.e. larger than the number required for the students to earn course credit. The OPE engagement measure, "Total Responses" was collected for each student on the date of the final course examination. The mean of the "Total Responses", M_{OPE}, was 1269, with a standard deviation, SD_{OPE}, of 574. The percentage course point total, determined from the sum of points for all course assessments including the final examination, was used as a measure of course performance. The mean percentage point total, $M_{perform}$, was 77.0, with a standard deviation, $SD_{perform}$, of 17.7.

Linear regression analysis was performed with both the OPE engagement score and course performance point total as dependent variables with all five motivation factors from SMQ-II as the independent variables. The results are summarized in Table 1. Statistically significant correlations were obtained in all cases ($p<.001$) except career motivation ($p < .05$) with OPE engagement. Linear regression was also performed with course performance point total as the dependent variable and OPE engagement as the independent variable. This analysis showed a moderate correlation, $r = 0.53$, $p<.001$, and $r^2 = 0.28$.

Table 1: Motivation Factors and OPE Engagement Statistics ($n = 325$), and coefficients for correlation with OPE engagement (r_{OPE}) and course performance ($r_{perform}$). Factors with statistically significant correlations ($p<.001$) are indicated with an asterisk

	Intrinsic Motivation	Career Motivation	Grade Motivation	Self-Efficacy	Self-Determination
Mean (*SD*)	60.1% (*20.3*)	59.2% (*23.9*)	81.5% (17.8)	63.4% (*24.4*)	71.0% (*20.2*)
r_{OPE}	.19*	.12	.26*	.38*	.44*
r^2_{OPE}	.04	.01	.07	.14	.19
$r_{perform}$	.35*	.22*	.35*	.68*	.43*
$r^2_{perform}$	.12	.05	.12	.46	.19

The mean student score was highest in grade motivation, lowest in intrinsic and career motivation, and intermediate in self-efficacy and self-determination. The regression analysis of these factors with the course performance measure showed that self-efficacy was by far the strongest correlating factor, Table 1, explaining almost 50% of the variance in course performance on its own ($r^2_{perform} = 0.46$). This is not a surprising result since as mentioned above, self-efficacy is frequently found to correlate strongly with performance in college science courses. The second strongest correlation with performance was self-determination.

The correlations of the various motivation factors with OPE engagement were uniformly weaker than with performance. Interestingly, self-determination was now the factor with the strongest correlation, followed by self-efficacy. This may be understandable since self-determination describes the self-chosen, voluntary acts that contribute to the hard work of learning. Self-determination, however, still only accounts for 19% of the variance in OPE engagement, leaving a large amount of variance unexplained. Self-efficacy had a much smaller shared variance with OPE engagement than with course performance. Self-efficacy describes students' confidence in to be successful in the course, hence a strong correlation with performance. Self-efficacy does not describe confidence in ability to do problems in OPE, hence a much weaker correlation is expected, and observed.

It is interesting that the intrinsic and extrinsic motivation factors correlated only weakly with both performance and OPE engagement. This suggests that a motivation factor that regulates the effort to do the homework problems and succeed in the course is missing from the analysis. SMQ-II is a validated general science motivation instrument, but it cannot measure motivations specific to this course, these students, and this e-learning system. For example, it has been suggested that intrinsic motivation in college-level chemistry courses might arise not as a result of interest in the subject matter, but as a result of a desire to demonstrate accomplishment and achievement as a student (Ferrell, Phillips, & Barbera, 2016). Achievement motivation is not measured in SMQ-II. These observations are consistent with a previous report by Hartnett, St. George, & Dron (2011) that used case studies to study the motivation factors that contributed to SLR in online distance learning environments . These authors also found that learners were not primarily intrinsically motivated and suggested that student motivation was multifaceted and responsive to specific situational conditions.

Conclusion

An e-learning system for general organic chemistry (OPE) was built that incorporated features designed to facilitate selected aspects of self-regulated learning. Student motivation factors measured using SMQ-II showed that self-efficacy correlated most strongly with performance. The concept of engagement with an e-learning system was introduced as a broadly useful context to study student motivation. Engagement was estimated for the purposes of this study as "Total Responses", a simple and useful measure grounded in hundreds of decisions made by the individual student. Self-determination was the factor that correlated most strongly with OPE engagement. General extrinsic and intrinsic motivation factors exhibited weak correlations with both performance and OPE engagement, which suggests that future work should focus on identifying the specific features of OPE that facilitate engagement and overall course performance, in order to further optimize the e-learning environment for students, which could be particularly useful to those more at risk in online distance learning programs.

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