Survey Development for Assessing Learning Identity in an ISLE Classroom

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Abstract. Innovative STEM curricula such as the ISLE (Investigative Science Learning Environment) curriculum [1] are centered on active engagement in social learning processes as a means to achieve curricular goals. Classroom practices are highly interactive to facilitate students' development of authentic scientist abilities. To the students, these classroom practices often seem very different from their previous learning experiences in terms of behavioral expectations, attitude, and what it means to learn. Consequently, students must modify their identity as learners in addition to physics conceptual understanding in order to participate productively in this learning environment. Using a survey we developed, we want to assess their 1) expectations of student and teacher roles, 2) self efficacy towards skills supported in ISLE and 3) attitudes towards social learning as well as how these change as a result of their experience in this curriculum. We will discuss the development, validation and preliminary findings of the survey.

Keywords: Active engagement, community of practice, identity, self-efficacy, survey development
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INTRODUCTION

At Oregon State University (OSU), the large enrollment lower division physics courses have been undergoing curricular reform beginning with the calculus based introductory sequence. Peer instruction (PI) and ISLE were adapted to enhance student development of authentic scientist skills in a social learning environment because social interaction is "central and necessary to learning and not merely ancillary" [2]. This is counter to the common student expectation of classroom learning with direct instruction where students are passive observers. Additionally, practitioners have anecdotally reported that students take about nine weeks of exposure to ISLE in order to adjust and productively participate in class [3]. At OSU, we have the challenge of large lecture sections of 200 students and only 10 weeks in a quarter term. Therefore, we are conducting preliminary studies to consider the social process of learning to function in a new learning community and examine the influences that enable or hinder productive participation.

Wenger's concept of a community of practice (CoP) is an apt perspective to consider students learning to participate in our classroom [4]. A CoP is a group of people engaged in a common endeavor through social interactions in meaningful experiences [4]. As learning is the process of gaining competence through participation in social interactions to negotiate meaning, learning is a social act. In order to engage in social learning, students may need to redefine their role as active sense-makers rather than passive knowledge acceptors. Students must come to value learning through social negotiation of what ideas and concepts mean. Lastly, students must feel to some degree that they are able to participate in and learn from these activities.

Through participation in a CoP, members refine their identity that encompasses their perceived role and perception of how others relate and interact with them. Identity also includes the students' past experiences, which affect their roles and interactions in the classroom CoP. Additionally, identity is informed by how students value the practices as a way to achieve learning. Finally, self-efficacy theory indicates that people are most likely to persist and improve at a task if they believe they are capable of succeeding [5].Thus, members of the CoP with a strong learning identity would: (1) actively participate in social interactions with others, (2) believe these interactions are valuable for learning, (3) believe that they can succeed, and (4) perceive that they are being treated as a valued member who can affect change in practices within that community.

We have observed normalized FCI gains of 0.4 in classes taught using an interactive learning environment. On exam problems also given to students in traditional instruction sections of the same course, our students perform comparably. An ongoing mixed methods study is being conducted to examine the interactions and developments in this learning environment that give rise to these learning gains. The survey development presented in this paper will allow us to characterize individual students and the whole class as a way to inform the qualitative portion of the study.

NEED FOR A NEW INSTRUMENT

We want to develop an instrument to measure the characteristics that enable students to productively participate in building physics understanding. Existing instruments measure self-efficacy toward teaching science [6], and the sources of science self-efficacy [7] but not toward learning physics or toward learning science in an ISLE classroom.. Other instruments [8, 9, 10] allude to but do not directly address attitudes toward social learning. No instruments were found that address the issue of expected roles of CoP members. This project aims to fill that knowledge void and create an instrument that provides some information about student learning identity. This instrument is intended to be used as a first pass measurement to characterize students and guide researchers in understanding how students adjust to an ISLE classroom. The instrument may also be useful for practitioners. We can help teachers attend to potential student difficulties in adjusting to the learning environment and better support student learning in active engagement classrooms.

SURVEY DEVELOPMENT AND ADMINISTRATION

The survey was developed to examine student learning identity in the ISLE classroom CoP using four dimensions: expectation of student roles, expectation of teacher roles, attitude toward social learning and self-efficacy in skills promoted by ISLE. The survey consisted of 49 Likert scale questions. The questions probing expectation of roles and attitude toward social learning were created based on how we want to see students engage as central members in the classroom CoP. The questions probing self-efficacy in ISLE skills were modified from an existing biology self-efficacy survey [11] by substituting ISLE goals in place of the biology skills. The items were subject to face validation by a panel of experts.

The target population for this survey was students in an active engagement learning environment such as ISLE. We selected the calculus based introductory physics course which is required for most engineers at OSU, and consisted of 80-60% engineering majors and approximately 70% male students. The survey was available online [12],and was offered to 400 students in two lecture sections taught back-to-back by the same instructor using a curriculum based on ISLE and PI. Before the first day of class, 145 students took the survey in response to an email invitation from the course instructor. At the end of the quarter, half the class was asked to take the same survey as part of a homework assignment. This resulted in a matched sample of 85 students who took both the pre and post survey.

ANALYSIS

Factor analysis was conducted to refine the four original dimensions where question grouping was guided by literature and desired characteristics of student identity as defined by the instructor of the course. Exploratory factor analysis was chosen since more than half of the questions were created by the researchers rather than adopted from existing questions from validated surveys. For the factor analysis, student responses to Likert scale items were converted to numeric values (i.e strongly agree = 5, Agree = 4, etc) in order to use parametric analysis on the data. While the item responses were ordinal, the underlying constructs probed may be considered continuous and were measured by multiple items rather than any single item.

Exploratory Factor Analysis

The survey responses for 49 Likert scale questions were analyzed using exploratory factor analysis (EFA) with PASW (formerly SPSS). Analysis parameter selection was guided by the literature [13]. Principal axis factors was used as the extraction method to accommodate potential skewedness in the data, for example many students expecting traditional instruction. Direct oblimin rotation (δ=0, κ=4) was used to allow the factors to correlate as more than half the items were created and may not be completely independent measures. The Scree test indicated that four factors should be retained. All questions in retained factors had factor loadings above 0.4. The Kaiser-Meyer-Olkin (KMO) value was 0.679, just exceeding the recommended value of 0.6 indicating small but significant covariance between the factors which is consistent with the low amount of variance (37.6%) explained by the factors. Bartlett's Test of Sphericity reached statistical significance ($p<0.01$), indicating that survey questions are not independent of each other which allows them to be grouped into factors.

Resulting measures were created using the four factors in the EFA. These factors were checked for face validity by two researchers independently coming up with meaningful descriptions for each factor and then comparing for agreement. Each item had a factor loading of at least 0.4 with its own measure and less than 0.4 with all other measures, suggesting that each factor measured independent characteristics.

Item Selection

Factor 1 measures student self-efficacy in ISLE abilities using 17 items. One item addressing student role was dropped from this factor as both researchers agreed that it did not measure self-efficacy in ISLE skills. Furthermore, this item had the lowest factor loading (0.427), and its removal improved the internal consistency of the question groupings (Cronbach's alpha) for this factor.

Factor 2 measures the student's expectation to be a valued and contributing member of the CoP using 5 items. This factor incorporated items intended to probe student role, teacher role, and social learning attitude. This is consistent with Wenger's conception of identity as the way of being in the CoP rather than a purely individual idea of self-perception or a purely social view of one's place in the community. The two items with the lowest factor loadings were removed from this factor; one did not logically fit while the other improved the Cronbach's alpha when removed..

Factor 3 measures a preference for reformed learning through interactive engagement with peers and instructors. This factor includes 5 items with only two having factor loadings above 0.5, and the Cronbach's alpha for this factor is low and suggesting that additional items are need to adequately describe this characteristic in a more self-consistent way.

Factor 4 had two items, and only one of the factor loadings was above 0.5. As the items did not logically fit into group with a meaningful description, factor 4 was removed from the final measures.

With these changes, Cronbach's alpha was calculated for factors 1-3 to measure internal consistency of items within each factor. These three factors explain 33.0% of the variance, which is low, but these three factors only use 27 out of 49 items in the survey. The results are summarized in table 1.

TABLE 1. EFA results.

Factor	Cronbach's alpha	# items
SE in ISLE Skills (1)	0.912	17
Valued member (2)	0.653	5
Interactive engagement learning preference (3)	0.617	5

PRELIMINARY STUDY

We administered the survey in Spring 2010 to a different group of students in the same course taught by the same instructor using the same curriculum. Pre and post surveys were administered in the same fashion as the EFA study. Each student was scored along the three factors by averaging the numeric values of the item responses. To examine relationships between the identity characteristics and student learning in terms of conceptual understanding and course performance multiple linear regression was performed on 55 matched pre/post survey responses. The predictor variables were pre, post and change scores (absolute difference between the pre and post scores) in the three factors. Normalized FCI gain and final grades in the course were outcome variables. To ensure that the student sample populations from the EFA study and this regressions study were equivalent, the pre-FCI scores were compared using a t-test ($p<0.001$).

Results and Discussion

Using pre, post and change survey factor scores in the regression model for predicting normalized gain, it was found that only pre-survey scores for factors 2 and 3, valued member and interactive engagement learning preference respectively were significant predictors of normalized FCI gain. The regression coefficients for factors 2 and 3 were 0.419 ($p=0.012$) and -0.363 ($p=0.003$) respectively. Using pre, post and change survey factor scores in the regression model for predicting final grade in the course, no significant predictors were found.

Student self-efficacy in ISLE skills (factor 1) prior to the start of class did not correlate with improved student performance in course grade and normalized FCI gain. This was surprising since other studies indicate it as a strong predictor of success in accomplishing a task [5]. It is possible that students did not have an accurate understanding of the statements which may affect the judgment of their ability to perform a specific ISLE task. In order to minimize this, factor 1 questions are being reworded to avoid ISLE-specific language. The lack of correlation may also be due to the time scale of self efficacy change. On a day to day basis, self efficacy may fluctuate significantly as a result of success or failure in mastery experiences. These fluctuations are likely to be hidden under the overall assessment over 10 weeks. Conversely, permanent self efficacy change can take significantly more than 10 weeks and a longer study is planned to address this issue. Additionally, studies indicate that self-efficacy can be both a predictor of success and a result of success [5]. As a result, self-efficacy measured this way may not be sufficient to describe competence in doing physics or succeeding in the course. To supplement these findings in the larger study, we are also examining the qualitative aspects of the classroom experiences throughout the course.

There is strong evidence that higher normalized FCI gains are predicted by higher scores in students' initial perceptions or expectations that they are valued and contributing members of the classroom CoP. This is consistent with Wenger's description that having agency as a central member can lead to success in the CoP [4].

Most surprising was that students who more strongly preferred interactive engagement learning (factor 3) prior to the start of class also tended to have lower normalized FCI gains. It is worth noting that even those who scored high on factor 3 had strong FCI gains well above those that would be achieved in a traditional classroom. This suggests that preference alone does not predict success in an interactive learning environment. However, it is well documented that students initially object to this type of learning environment but still demonstrate improved learning compared to traditional instruction [14].

Change in identity and attitude is a slow process, and it is not likely that a 10-week period alone is adequate to observe significant differences. We will do longer term studies now that our factors are vetted with this preliminary study.

LIMITATIONS AND FUTURE WORK

Identity in a community of practice is more than a static set of behaviors or attitudes. Rather it is fluidly changing over time and situated in the community with which one interacts. The survey was designed as a way to gauge students' attitudes, expectations and beliefs at the start and end of a term. To examine how student identity evolves on shorter time scales, the survey will need to be coupled with in-class observations and multiple interviews. Through this larger qualitative study, we intend to examine student learning identity situated in an interactive engagement learning environment. This will be crucial to understanding how identity development influences student learning including the ability to productively participate in the classroom community.

The preliminary findings suggest that with further improvements the survey has potential as a useful instrument for researchers and practitioners. A modified survey with improved wording in the items from the three factors, additional items to strengthen the weaker factors and review of the items for face validity by external reviewers including students are currently in development. Additionally, incoming survey data from other instructors teaching the same course will be used to make the survey more robust and widely applicable.

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