

Assessing Physics Learning Identity: Survey Development and Validation

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Abstract: Innovative curricula aim to improve content knowledge and the goal of helping students develop practices and skills of authentic scientist through active engagement learning. To students, these classroom practices often seem very different from their previous learning experiences in terms of behavioral expectations, learning attitude, and what learning means. We propose that productive participation in these learning environments require students to modify their identity as learners in addition to refining their science conceptual understanding. In order to measure changes in learning identity, we developed a 49-item survey to assess students' 1) expectations of student and teacher roles, 2) self efficacy towards skills supported in the Investigative Science Learning Environment (ISLE) and 3) attitudes towards social learning. Using principle components exploratory factor analysis, we have established two reliable factors with subscales that measure these student characteristics. This paper presents the survey development, validation and pilot study results.

Keywords: Assessment survey, Self-efficacy, Identity, Communities of Practice

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INTRODUCTION

University introductory science courses are usually core requirements with large student populations, leading to high student to teacher ratios. These classes are frequently taught with traditional instruction where the lone instructor gives a speech behind a podium while the students listen quietly. An examination of large enrollment classes reveals that they are often plagued by low attendance [1], high course drop out and failure rate [2-4], and low interest and motivation [5]. Other studies show that classes of over 100 students had negative effects on student performance compared to classes of 3-90 students [6].

Using the force concept inventory [7] as a standardized tool for comparing conceptual understanding of Newtonian physics, R.R. Hake showed that student learning gains in introductory physics classes using direct instruction are very low regardless of class size. Conversely, classes using some form of active engagement (AE) instruction showed significant increase in conceptual learning gains in class sizes ranging from under 100 to over 200 students [8]. These studies indicate that while large classes can result in reduced student learning, there appear to be factors that can lessen or even counter those effects. In order to make informed changes in the way we teach, we must seek to understand what these factors are and how they support student learning.

Various collaborative learning curricula were developed with opportunities for instructors to connect with students and attend to the factors that mediate students' development [9-12]. In the calculus-based introductory physics courses at Oregon State University, we have adopted the investigative science learning environment (ISLE) developed by Ektina and Van Heuvelen [12] as a curriculum with the goal to help learners develop skills of authentic scientists. In curricula like ISLE, we are asking students to construct knowledge for themselves and to apply their understanding to real problems even in unfamiliar contexts (among other goals). Assessment of these goals means examining to what extent students are achieving fluency with specific scientific skills. This leads to three consequences in assessment: 1) exams are valuable provided they address the type of problem solving and applications promoted by the curriculum, 2) attitude towards social learning and authentic scientist abilities including communication of science ideas must be included in the assessment of learning goals, 3) the students' changing identity as learners is reflective of their development as authentic scientists.

The testing materials are typically solely under the instructor's control. The remaining consequences address changes in student identity as learners. We believe that these changes are facilitated by the AE learning environment and provide a measure for achievement of the curricular learning goals. To

understand how these changes are supported by AE based instruction, we need to be able to assess student learning identity as starting points for potential change. Existing surveys do not address all of these issues. Therefore, the first step to studying these changes is to develop a reliable instrument to measure student physics learning identity (as defined in the next section) for examining changes over time and influences on conceptual understanding.

Learning Identity In Communities of Practice

According to Vygotsky, social interaction is “central and necessary to learning and not merely ancillary” [13]. This is reflected in practice as proponents of social learning find improved performance on tests and course grades as well as attitude and interest in science [9-11,8,14]. Wenger proposes that by engaging in social interactions, people learn by making sense of their experiences that help them function in the world around them [15].

Wenger’s idea of a community of practice (CoP) is a group of people engaged in a common endeavor through social interactions in meaningful experiences. This was developed as a model for describing how people work together on shared tasks and goals in the work place. The ISLE classroom might be thought of as a CoP where the common endeavor is to learn to become scientists. As members of a CoP interact with each other, they shape practices by contributing their ideas and negotiating the meaning of existing ideas of what is expected or appropriate for that community. This notion of shared contributions is aligned with goals in many active engagement teaching strategies. The CoP is also fluidly evolving over time where “persons and practices change, re-produce, and transform each other” [16]. This temporal nature of the CoP means the relationships between variables such as facilitation of learning, classroom practices, and assessment of conceptual understanding must also be studied over time with a developing history. For individual members, this history is the trajectory along which members become more or less involved in shaping knowledge and practices of the community. Wenger describes knowledge as competence in dealing with the world and thus the act of learning is the process of gaining competence through participating in the CoP. To be successful learners in an AE classroom, students must develop identities where they have the ability and permission to participate in the CoP in which they feel they belong. By studying how identity trajectories change, we can gain insight into how to support students in becoming more involved and in control of their in-class learning.

Learning And Identity Development

Members of the classroom CoP have identities which encompasses their perceived role, their relationship with others, their day to day interactions with others, and their experiences in other CoP. Identity also includes the individual’s past experiences which inform about the roles played and interactions within the classroom CoP. Additionally, identity includes an aspect of alignment where the individual believes the practices within the community are valuable. Lastly, self-efficacy theory indicates that people are most likely to persist and improve at a task if they believe that they are capable of succeeding [17].

DEVELOPING A SURVEY INSTRUMENT TO DESCRIBE LEARNING IDENTITY

Wenger’s notion of identity in a CoP is the way we know how to be a member not only in a classroom community, but in each community of our lives. Identity is guided by interactions and perceptions as a result of participating in the CoP. Identity can be extended to a more holistic concept of a nexus of multimembership which is a compilation of our identities in each CoP of which we are members. While this is beyond the scope of this study, we acknowledge that there are factors beyond a single CoP such as a physics class that can significantly impact identity development. For this study, members of a CoP have identities informed by four sources, their 1) self-image, 2) expectations about their roles and behaviors, 3) perception of how others view them, and 4) experience of interacting with others.

These sources shape the identity in terms of feelings of belonging and being capable, ideas about what members of this CoP do, and judgments about whether participating in the CoP is worthwhile.

To measure characteristics of a large student population, a survey instrument is the natural choice. Existing instruments measure self-efficacy toward teaching science [18] and sources of self-efficacy [19] but not specifically for learning physics or in an ISLE classroom. Other instruments [20-22] allude to but do not directly address attitudes towards social learning. Hence, an instrument needs to be developed to measure student characteristics that contribute to identity as learners.

METHOD

The survey was constructed to probe four dimensions of physics learning identity: 1) expectations of student roles, 2) expectations of teacher roles, 3) attitudes about social learning

environments, and 4) physics learning self-efficacy. This instrument contains 49 statements for the students to rank on a five-point scale. Seventeen self efficacy questions were modified from an existing instrument [23] with responses about the student's confidence level where 1 = "not at all" to 5 = "totally." The remaining statements were created by the researcher based on the CoP framework with responses ranging 1 = "strongly agree" to 5 = "strongly disagree." The items were subject to face validation by a panel of experts consisting of four science education researchers and focus group discussions with four students enrolled in introductory physics courses. The reviewed items were used to create an online survey on the physics department website. An additional item was included in the survey to check if the students were reading each item before responding.

The target population for this survey was students in a large-lecture AE learning environment using the ISLE curriculum. We selected the calculus based introductory physics sequence (Ph21x) which typically enrolls 60-80% engineering majors and approximately 70% male students. For this pilot study (fall 2009) the online survey was administered to students enrolled in the first term of the three term sequence. Prior to the start of term, the course instructor sent a welcome email to the 400 students enrolled in the course and invited them to take the survey on a voluntary basis. Before the first day of class, 130 students submitted complete survey responses and were used in the analysis. Due to the voluntary nature of the survey, the responses may be biased. However the scales established in this study for measuring aspects of student identity are valid because items are grouped within a scale based on how they correlate with each other.

DATA ANALYSIS AND RESULTS

The items in the survey are analyzed using principle components exploratory factor analysis (EFA) and reliability analysis to create subscales for use. The survey responses for all 49 items were analyzed in SPSS version 18 using principle components EFA with varimax rotation. This method uses the component with the biggest variance and allows for subsequent component rotations to account for the maximum variability in the data. This analysis was selected since more than half of the items were newly developed by the researcher for new scale creation. Only factors with eigenvalues over 1 and factor loadings over 0.40 were retained [24]. The self efficacy dimension formed independent factors with no items crossloading on multiple factors. The items for attitudes about social nature of learning, and expectation of student and teacher roles formed factors containing both dimensions. Consequently they were combined into a single dimension describing student

social expectations about learning within the classroom.

For both dimensions, the same EFA was conducted to refine the items into subscales. Items in both dimensions were divided into 3-7 subscales and these factors explained 60-63% of the variance in the social expectation of learning and physics learning self-efficacy. Reliability analysis was conducted on the factors from the EFA of each dimension. Reliable factors met the criteria of Cronbach's alphas above 0.65 and item-total correlations over 0.40 to indicate items measuring the same concept within each factor. Items were dropped from a factor if doing so improved the reliability reflected in the Cronbach's alpha. The item-total correlation criterion was lowered to 0.3 for newly created items. The physics learning self-efficacy factor contains three subscales using sixteen items. All three subscales had high reliabilities with Cronbach's alphas over 0.70 and item-total correlations over 0.45. This was expected since the items were modified from an existing validated instrument [23]. These three subscales are consistent with the conceptual framework and the curricular goals of ISLE; the subscales measure 1) self-efficacy in communicating physics knowledge, 2) self-efficacy in problem solving using the learning cycle in the curriculum, and 3) self-efficacy for succeeding in math and physics which is expected to predict higher actual success in those disciplines according to self-efficacy theory [17].

Items from the social expectations about learning factor contained four subscales with sixteen items. All four subscales had acceptable reliabilities with Cronbach's alphas over 0.65 and item-total correlations over 0.35 which is above the 0.30 criteria for new items. The first three subscales in this factor describe 1) teacher and student as learning team, 2) valuing group work for learning physics, and 3) being a valued member of the classroom community. These subscales are consistent with the notion that being a member of a CoP means that one values the associated practices used and contributions from community members. These three subscales also reflect key characteristics of knowledge and practice development as socially constructed. The second subscale has a low but acceptable Cronbach's alpha (0.65) and a few low item-total correlations. This subscale is a reasonable start for newly created items that on inspection of the item text have good face validity. Since the participation with members in the CoP is key to learning, it will be important to retain and refine this subscale through improved wording of text and additional items. The fourth subscale is student as responsible for learning; it is consistent with the curricular goal for increasing student agency. This subscale will help differentiate between learning environments where the responsibility to "make" students learn lies with the teacher versus the student. These results suggest that the items created for this

dimension are a reasonable start but need refinement to strengthen the overall reliability. The items that did not load onto factors may be inspected and rephrased for clarity. Additional items may also be created based on the subscales established in this study to strengthen the reliability.

CONCLUSIONS

After removing items that did not load onto factors and dropping items from subscales to improve reliability, 29 of the 49 original items were retained and grouped into reliable subscales. While this fraction is low, it is reasonable since many of the items were not previously validated. Of the items modified from an existing instrument 16 of 18 of the original items were retained with high reliability. These results indicate that we have developed a useful instrument that can be used in research on student learning identity in AE learning environments.

A limitation to the use of this survey is that it does not address all aspects of identity; identity is a rich and complex part of a person and a simple survey with two factors cannot adequately describe the subtleties of identity. Therefore, the survey is intended to be used in conjunction with rich qualitative data to gain in depth understanding of how learning identity and classroom science learning relate to each other.

As a first pass measurement to characterize students in conjunction with qualitative studies, this survey can be used to understand how student identity develops in an active engagement classroom. The ability to categorize student identities provides a means to examine the details of various facets of identity including:

1. Characterization of each student to be sorted into high, medium and low ranges on each subscale/factor
2. Fine grained correlation analysis of high/medium/low scores in each subscale with assessments of student conceptual understanding
3. Characterize the class as a whole to help the teacher support student learning

We have developed a preliminary instrument that addresses some aspects of learning identity and demonstrated its reliability through statistical analyses. In future work, we will refine the items to improve reliability and use the instrument in conjunction with qualitative data to examine learning identity in a classroom CoP.

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