Physics Learning Identity: Toward Development of A Model

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(Received 13 August 2012; accepted 27 October 2012)

Lecture classes enrolling hundreds of students are becoming the norm in college introductory science courses. Studies indicate that learning in large population enrollment traditional lecture courses correlates with lower course performance, reduced retention in the course (Gardiner, 1994; Borden and Burton, 1999) and as science majors (Kopeika, 1992; Hewitt & Seymour, 1999), reduced interest and motivation (Lord, 1999), and weaker grasp of meta learning goals such as critical thinking skills (Kennedy and Siegfried, 1997). However, the negative effects of large enrollment courses appear to be reduced by implementing some form of active engagement curriculum in place of the passive traditional lecture (Hake, 1998; Powell, 2003). Further examination of learning in active engagement classrooms suggests that the learning environment mediates the quality of knowledge built because the learning environment facilitates students in developing identities in relation to the discipline (Boaler, 2002). Therefore we must study student learning as identity development in addition to conceptual knowledge building. The purpose of this chapter is to build a model of social learning to frame the construct of physics learning identity. This will enable further development of analytical tools to measure and examine students' learning identity as they engage with the classroom community of practice.

I. Introduction

Students and teachers face multiple challenges in large lecture classes. Enrollment of over 100 students makes it *large*, and the instructor at the front of the class talking to passive students quietly taking notes makes it *lecture*. The studies on the effect of large enrollment courses on student achievement show mixed results. Kennedy and Siegfried (1997) observed no difference in student in achievement as measured by gains between a pre and post test in introductory economics. On the other hand, Borden and Burton (1999) conducted studies across disciplines that showed that large classes (over 100 students) had a negative effect on student performance compared to smaller classes (3- 90 students). Kopeika (1992) found that reducing class size from 200 down to 70 students contributed to increased graduation rate as well as improved academic level as reported by industry and graduate schools. While Kopeika's findings seem contradictory to the other studies, closer inspection shows that measured variables to represent student learning for the studies are not uniform across the studies. For example, Kopeika (1992) measured graduation rates, while Kennedy and Siegfried (1997) measured knowledge acquired. In addition, the instructional methods in the classes studied were not consistent from one study to the next which added another confounding variable making the results difficult to compare. However, the results indicate that large classes have the potential to reduce student achievement, but the negative effect may be offset by other factors in the classroom.

The identifying feature of a lecture class is students passively listening to the professor speak. This model frequently results in low interest and motivation (Lord, 1999), low and declining attendance over time (Gardiner, 1994), and high dropout rate for the course as well as for the program (Cooper & Robinson, 2000; Hewitt & Seymour, 1999; Kopeika, 1992). However lecture has its place—it is suited for tasks such as providing relevant context for an otherwise abstract concept, demonstrating a problem solving technique as an advanced practitioner, or showing enthusiasm for the subject (Cuseo, 1998; McKeachie, 1999). Particularly illuminating is that Kennedy and Siegfried (1997), comparing large classes and in small group discussion teaching modes, found that students learned content knowledge equally well. However, students in small class discussion settings were better able to gain deeper understanding such as critical thinking, problem solving and transferable skills. Furthermore, Powell (2003) reports that some college professors are adapting their teaching methods with peer instruction (Mazur, 1997; Crouch et al., 2007) to reduce monolog time and counter the impersonal effects of large-enrollment. One professor incorporated simple hands-on experiments that can be done in small groups in class so that the students can experience physics phenomena the way a real physicist does (Powell, 2003). This research suggests that lecture can be supplemented or replaced with alternate instructional modes that use active engagement to optimize the learning experience. Lecture has its purposes but incorporating instruction supporting having students actively engaged in learning is key to a successful learning experience.

Although large lecture classes can have negative effects on the quality of education, they are typically how introductory science classes are taught at the university level. Given that this trend is largely an institutional choice, individual departments and instructors often have little control over class size. Instructors do have control in how they teach, and many have incorporated teaching methods such as peer instruction (Mazur, 1997; McKeachie, 1999; Nichol & Boyle, 2003, Crouch et al, 2007), cooperative learning (Johnson & Johnson, 2001; McKeachie, 1999), investigative science learning environment (Etkina et al, 2006), and student-centered active learning environment for undergraduate programs (Beichner et al., 2007) to improve student learning through active engagement.

The goal of active engagement is to facilitate the students in developing their understanding through interaction with the scientific phenomena and social negotiation of the meaning of scientific concepts. However, development as science learners includes both the students' cognitive growth and shaping of an identity as the kind of science practitioner they want to be. The teacher's role then is to support student identities of interested and motivated practitioners of authentic scientist skills. To facilitate this process, students are provided with opportunities to communication through scientific argumentation, divergent thinking in considering multiple explanations and solutions, robust problem solving, and metacognition through reflection. In order to help students learn in this environment, teachers need to be sensitive to students' cognitive development along with emotional and motivational state (Cohen & Ball, 1999; Zull, 2011), cultural background (Nasir & Saxe, 2003; Seiler & Elmesky, 2007) and social orientation to the learning community (Brahmia & Etkina, 2001; Brown & Spang, 2007; Murrell, 2007). In other words, teachers must attend to the student as a whole learner.

II. WHY STUDY IDENTITY?

Using the communities of practice as a model for how groups of people with a common goal interact, Wenger (1998) describes identity as the way people understand how to be a part of a community. It can be an identity of inclusion with various levels of participation or exclusion with resisted attempts to participate (marginalization) or a decision to refrain from participating (non-participation). Wenger (1998) further asserts that "we accumulate skills and information, not in the abstract as ends in themselves, but in the service of an identity" (p215). In a classroom community, participation shapes the students' identity as learners as a result of the interactions designed to build conceptual understanding.

Not only do interactions shape identity, but the type of interactions with the community can impact the quality of learning through the development of disciplinary relationship as part of identity. Boaler (2002) has observed that students in different learning environments developed different relationships to the discipline because the learning environment engages them differently. Students in classes where they were passive receivers of knowledge developed a dislike and detachment from mathematics; students in classes where they were asked to actively contribute and make personal meaning regarded mathematics as a desirable and integral part of their lives (Boaler, 2002). Participation allows for the development of disciplinary relationships that impact if and how students become part of the community.

Given that interactions shape identity through disciplinary relationship and this development impacts the quality of learning, then it follows that we need to examine student learning identities and how they change in order to understand how the active learning environment influences student learning. Because student learning identity and the community mutually transform each other, taking this research lens allows for shifting the focus from single students, small groups of students, and to the whole classroom community. This malleability in the research model is essential and well suited to examining active engagement learning environments where interactions happen at multiple levels at the same time or shifting quickly over a short time.

In order to examine student learning identity, I will first define the context for learning and knowledge in this study. I will then examine what has been studied about the active engagement learning environment and situate learning identity in context specific, socially interactive models of learning. Using these models, I will synthesize the construct of *physics learning identity* that will be central to addressing the following research questions.

1. What are the students' learning identities as they enter and then experience the classroom community?
2. In what ways are environmental and social factors in the classroom community of practice related to identity development?
3. How are these aspects of learning identity related to student learning in terms of curricular learning goals?

III. LEARNING AND IDENTITY LITERATURE

A. Learning and Knowledge in Communities of Practice

Not only is the nature of learning constructed by each individual, it is also shaped by the environment and community in which learning is socially constructed (Doolittle, 1999; von Glasersfeld, 1995). Our understanding of the world is constructed from our interactions with and perceptions of the world. Wenger proposes that by engaging in social interactions, people develop ways to do things and make sense of their experiences to help deal with the world around them (1998). Developed as a model for describing how people work together on shared tasks and goals in the work place, a community of practice (CoP) is a group of people engaged in a common endeavor through social interactions in meaningful experiences (1998). This notion of a CoP is also useful in the school setting where the common goal is to learn through social interactions with others. As members interact in the CoP, they shape practices, or ways of doing things. The practices of a community are not merely adopted and assimilated by members of the community. Rather, the members mutually engage in negotiation to develop a common set of meanings of participation that characterize the community of practice. This does not mean everyone in the community engages in identical practices but that the practices are shared common ground from which new meanings and practices may be developed. Wenger makes a clear example of the idea of common sense which "is only common-sensical because it is sense held in common" (1998, p. 47). The practices of a community of practice are specific to that community because the members have a history of practice developed as a collective which becomes a shared repertoire that continues to be negotiated and evolve. This repertoire need not be unique to the community; it only need be shared understanding of meaning within 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 participation in making sense of experiences in the world (1998). This is an apt perspective to consider student learning because they are making sense of science ideas by thinking and behaving like scientists.

In addition, the nature of social interaction means that students will have a say in shaping the practices of the classroom community. In other words, knowledge and practices are developed and negotiated in a shared manner so that members become authors and defenders of knowledge. This notion of shared contributions is aligned with goals in many active engagement teaching strategies so that it is one indicator of how competent the students are becoming. The CoP is also fluidly evolving over time where "persons and practices change, re-produce, and transform each other" (Lave, 1993, p68). 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 rather than at a single point in time. For individual members, this history is the trajectory along which members become more or less involved in shaping knowledge and practices of the community. By studying change along trajectories, we can gain insight into how to support students being more involved and in control of their classroom learning.

B. Learning and Identity Development

The students' identity is the result of engaging in a CoP "because learning transforms who we are and what we can do" (Wenger, 1998, p215). The type of identity and how it develops can influence the quality of learning that result. Additionally, people interact in multiple CoP's throughout their daily lives and form identities that shift as they move between each CoP. The incorporation of these multiple identities is the concept of a nexus of multimembership (NoM). While this is beyond the scope of this study, there are factors beyond a single CoP such as a physics class that can significantly impact identity development. Knowledge of the learning identity that students bring into class and understanding of how this identity interacts with the learning environment are crucial for successful facilitation of learning through active engagement. For the purpose of this study, I will focus on examining aspects identity relevant to engaging in a classroom learning environment.

A first step to examining identity is the individual's self-image. While self-image is only a part of identity, it can be highly influential in how we decide to interact with others. Studies show that how you think others see you (perceived other appraisal) depends more strongly on how you see yourself (self-image) rather than how others actually see you (actual appraisal) (Tice & Wallace, 2003). Therefore, how people think of themselves will strongly influence their choices as they interact with others. However, considering learning as social interaction means identity also encompasses perceived role, relationship with others, day to day interactions with others and experiences in other CoP. Identity also includes the individual's past experiences which inform about the roles played and interactions in the classroom CoP. Additionally, identity includes an aspect of alignment in which the individual believes the practices and how they are done are valuable. Thus an identity of a central member of the CoP includes actively participating in social interactions with others, perceiving and being treated as a valued member who can affect change in the practices, and believing that engaging in these practices will achieve the common endeavor.

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 (Bandura, 1997). Self-efficacy is a person's belief that he/she is capable of succeeding at a specific task. This belief is influenced by four sources: (a) mastery experience of personal success, (b) vicarious experience of seeing others succeed, (c) social persuasion, and (d) physiological and affective states (Bandura, 1997). The advantage of an active engagement classroom is the increased opportunities for mastery experience which is the strongest factor for improving self-efficacy. In addition, this learning environment makes vicarious experiences more visible through social interactions with peers. In comparison, a traditional lecture classroom primarily supports vicarious experience of seeing the teacher succeed and social persuasion from the teacher that students are able to succeed in the class.

In sum, an identity of a central member of the CoP includes actively participating in social interactions, perception of being treated as a valued member who can affect change in the practices, belief in the ability to engaging meaningfully with the community, and belief that these practices will achieve the common endeavor. This identity development informs the students' attitudes and affect for the common endeavor of learning science. For example, the interactions specific to science can be very different from everyday interactions; it is perfectly acceptable and encouraged to engage in argumentation in science whereas most everyday interactions aim to avoid conflict and confrontation because it is seen as hostile or impolite (Belenky et al., 1986). Therefore learning to be a member of the science community is not only to acquire the ways of interacting and thinking, but also how to accommodate those ways into the member's existing ways of interacting. The socially interactive curriculum thus both requires knowledge of theses ways of interacting and provides opportunities for students to make sense of and contribute to these practices.

C. Learning is Situated

Just as learning in each individual is different, the setting in which learning occurs also play a significant role in enhancing or impeding one's ability to construct meaningful understanding (Greeno, 1998). In this view, learning is the attunement of the student to the constraints and affordances in the learning environment in order to participate in the negotiation of meaning through social interactions (Lave & Wenger, 1991). The same idea in different contexts can make the idea seem distinctly different. For example a savvy shopper might be able to figure out how much is saved at the 65% off sale, but that same person in math class might struggle mightily trying to calculate 65% of the speed of the train heading northwest. Differences in context can be much more subtle. Students asked to report a measurement to an instructor, a friend or in a formal report were found to different answers depending on the stated audience (Taylor et al., 2009). In order to achieve the goal of education in supporting students to take what they learn and use it when they leave school. Therefore educators must attend to the details of the learning context to support productive learning in the classroom and connection to contexts beyond the classroom.

The constraints and affordances of the learning environment have many sources. Subtleties in the way learning is verbally facilitated can have considerable impact on how students engage in learning activities (Li & Demaree, 2010). In an analysis of verbal prompts given prior to and during small group activities in an active engagement introductory physics classroom, students appeared to participate more when the instructor (a) provided hints, (b) gave instructions with "I" or "me" (I want you to do this, draw a diagram for me), (c) rated the difficulty of an activity, and (d) made explicit that students are being held accountable (Li & Demaree, 2010). While these prompts increase instances of participation, they do not necessarily affect the sustained duration of participation in the same way. For example, giving hints and asking guiding questions during the activity increases overall participation but lowers continuous participation during the allotted time. Providing hints and asking guiding questions can constrain participation because student conversations are interrupted to listen to the instructor. However, providing this help can also afford lost or confused students the scaffolding needed to become comfortable enough to share their understanding with their peers. These findings warrant the need to closely examine the classroom discourse and the quality of participation facilitated.

The physical space in which the class is held is another part of the classroom context that impacts learning. This is an oft overlooked variable because teachers usually have little control over the room assignments. The physical environment can strongly suggest specific student behaviors and roles. Sommer (1967) found that when students can make direct eye contact with ease, they are statistically more likely to engage in discussion; however, this effect may be canceled other factors such as noise or crowdedness leading to the perceived best seats in the room not being optimal for visual contact. For students entering a lecture hall with more than 100 seats in front facing rows, it is likely to suggest that it is not appropriate to turn around to speak to another student. Recall that students often enter a large enrollment class with little experience or expectation of social learning. With these pre-conceived notions about learning and a physical environment that appear to reinforce those notions, it should not be surprising that teachers report a lengthy period of adjustment before students regularly make productive use of social learning activities in class.

From the teachers' perspective, they need to be aware that physical features of the classroom can support or hinder their instruction, and they need to have flexible classroom features that can be modified to suit their style of instruction (Weinstein, 1981). Gibson's (1986) notion of environmental affordances states people are guided in what to think and how to behave in part by the arrangement and materials that make up the physical features in the classroom. Hence it is natural for teachers assigned to teach in a classroom with stadium seating to feel lecture is the default mode of instruction; similarly, students seated around a conference table may feel more inclined to speak up and contribute because the space suggests collaboration. Graetz and Goliber (2002) caution that using "the classroom in a manner that does not agree with its affordances… may lead to a negative emotional response" (p. 16). The physical layout of a room can convey the behavioral expectations to participants (Weinstein, 1981). As a result of these expectations, users may react with a negative emotional response to the space being used for the unexpected. For example, asking students to perform small group experiments in a tightly packed traditional lecture classroom may cause the student to feel that the experiment is impossible to perform and not take the lesson seriously. Consequently, it is crucial for teachers as facilitators of classroom practices to be aware of their own assumptions about the physical features of the learning environment as it is brought to bear upon the quality of engagement and learning in the classroom.

Furthermore, the quality of learning involves both the conceptual learning and productive relationship towards the discipline. Boaler (1998) studied two high school math learning environments which she calls "open" and "closed" classrooms. The open classroom is characterized by the teaching "philosophy that students should encounter a need to use mathematics in situations that were realistic and meaningful to them" (p49). As a result the teacher was a resource for explaining concepts students found they needed as they worked in collaborative groups on open-ended problems. This led to the students being the driving force with some agency in the direction of their learning. The closed classroom utilized a traditional curriculum where the teacher explained new concepts with lecture followed by students passively completing related exercises in class without challenging the tasks or the authority figures.

Boaler (1998) found that students in the closed classroom spent more time on task but they learned math as set rules and equations. Furthermore, their problem solving was "cue-based" where math reasoning was guided by what they perceived the teacher wanted and routines in the exercises such as problems ordered with increasing difficulty. Students in open classrooms more frequently found the math interesting and recognized they had agency and responsibility in learning. Compared to the closed classroom students, those in the open classroom scored higher on standard tests (NFER), were more proficient at an open-ended applied problem solving task, and performed comparably in traditional close-ended math questions. These results indicated that (a) we cannot only look at course grades or test scores as measures of student learning, (b) the expectations in a learning environment can have significant influences on student understanding about the nature of learning in the discipline which has implications on affect, interest and motivation, and (c) student perception and exercise of agency allow them to develop into legitimate members of the classroom and disciplinary community so that they are interested in pursuing the discipline.

D. Learning Occurs across Settings

A single community of practice does not stand on its own. Instead it is interconnected with a myriad of other communities of practice in which an individual is a member. This is apparent in the way individuals identify themselves. In the community of physics class a student might consider himself a mediocre student. In the community of the softball team he might view himself an excellent pitcher. In the community of his study group, he might be the one with great insight on 20th century British literature. Communities may overlap anywhere from significantly to hardly at all. As he travels between each community, he adjusts his identity within the community as well as takes a portion of one community to interact with the other community. The example highlights the need for a holistic view of how these communities interact on mutually interacting connections.

Learning cannot be viewed as a single event in time and space, but rather a series of connected experiences in different settings that we bring to bear on our interpretation of our interactions with the world. My scope of research on learning is deliberately focused narrowly on what happens in the classroom in order to start with a manageable analysis. I am aware that the rest of the students' experiences contribute significantly to their learning process. By establishing tools for probing learning identity, I can later expand the scope to include a more complete view of the learning process.

IV. Physics Learning Identity

Given that learning is integrally tied to the context and that learning is the process of transforming identity, I want to examine learning identity and its relationship to learning goals of the classroom. The broad notion of disciplinary learning identity as defined here can be applied to any specific branch of science or humanities. In defining physics learning identity, I am making the distinction that there are expectations, attitudes and norms that characterize doing physics and shape the identity that results in doing physics. In order to articulate what I mean by identity, it is necessary to be specific about what kind of identity because it is context specific. In order for the definition to be useful in practice, it is also necessary to be able to answer (a) what is it and what isn't it, (b) how to know if it is present/missing, and (c) how to determine how much there is**.** Before that, I will define each part of the term.

Using Wenger's notion of identity in a community of practice, we suggest that identity is the way we know how to be a member in a specific community. 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 (NoM) which is a compilation of our identities in each CoP of which we are members. While this is beyond the scope of this study, I 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.

1. their self-image,
2. their expectations about members' roles and behaviors,
3. their perception of how others view them, and
4. their experience of interacting with others.

These inputs shape the identity in terms of feelings of *belonging* and being *capable*, ideas about what members of this CoP *do*, judgements about whether they are *aligned* with the goals of the CoP and if participation is *worthwhile*. In this sense, identity is always measured with respect to interactions with others.

In the classroom, the goal of the CoP is to help students learn, or to gain competence in dealing with the subject or field of the course. The most common identity is usually one of being a learner who is in the community to become more competent at using the *skills, tools, and knowledge* associated with the course. Often this is true even for those who view themselves as the teacher or more advanced students. Each member may be learning something different; students encountering the subject for the first time may be learning to use the context specific language and grammar, more experienced students may be re-negotiating their pre-existing ideas, while the teacher may be learning to see through the students' eyes. For this study, I am interested in understanding student learning through identity development. Hence, I will focus primarily on examining the learners' identity as they interact in the classroom as a community of learning.

In this sense, the students' learning identity is defined as the kind of learner they are with respect to:

1. their self-image: self-evaluation of the quality and kind of student they are,
2. their expectations of other members' learning identities in terms of the roles and behaviors,
3. their perception of how others view them as learners, and
4. feedback from social interactions with others.

The first three sources of learning identity originate chiefly from how the individual sees their interactions with others, while the last source stems from opportunities to interact in the classroom CoP. Consequently, the inspection of learning identity must include data from the individual as well as the community with which the individual participates. Using this construct of physics learning identity, I will be able to probe student learning as identity development by establishing analytical tools to quantitatively measure and qualitatively examine learning identity as engagement with and relationship to the classroom community of practice.

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