

Physics Learning Identity of a Successful Student: A Plot Twist

Sissi L. Li* and Dedra Demaree†

*Catalyst Center, California State University Fullerton, Fullerton, CA 92831

†Department of Physics, Oregon State University, Corvallis, OR 97330

Abstract. Classroom interactions provide learning opportunities for understanding others and developing agency in a community of learners. Student learning identities were measured using a survey instrument targeting physics learning self-efficacy, expectations of classroom roles, and attitude toward social learning as components of physics learning identity. From a selection of students who scored relatively high or low on the survey sub scales, an academically successful student in an introductory physics course using an active engagement curriculum was selected to examine identity development. Findings indicate he didn't develop a sense of agency, nor did he feel a need to alter his participation, although there were ample opportunities to do so in the learning community. These results suggest that being a successful physics student in the traditional sense doesn't necessarily mean the student is successful at adopting meta-goals which are the non-content course goals of learning to think like a physicist. This student was prompted to engage meaningfully but didn't feel it was required for success which suggests that structural alignment is required to motivate students to achieve meta-goals.

Keywords: Identity development, agency, participation, community of practice

PACS: 01.40.Fk

INTRODUCTION

At Oregon State University, the introductory physics sequence is undergoing curricular reforms in a classroom environment that heavily utilizes active engagement in physics discussions as a learning tool. The curricular reform is modeled after the Interactive Science Learning Environment (*ISLE*) developed at Rutgers University with specific learning goals to support authentic scientist skills [1]. By providing opportunities for social interaction, we aim to support students' development as *agents* of learning who are capable of building their own knowledge and contributing to the learning community. Through these deliberately scaffolded experiences, students have opportunities to develop their physics learning identity with conceptual physics understanding. Individual differences and subtle variations in social interactions can lead to vastly different learning outcomes for individual students and for the class community [2].

We present a case study of a successful student as measured by consistently high course performance. However, this student was less successful as measured by his physics learning identity shifts which did not change significantly. He had the ability and knowledge from prior physics and math courses to perform the expected conceptual tasks while remaining fairly traditional in his ideas about how to learn physics. He primarily used a problem solving approach centered on finding the right equation and churning out the right answer. He was driven to find the answer and solve the problem because he thought he was supposed to; he was less interested

in exploring the reasoning space beyond the problem because it was often not needed to solve the problem. There was little motivation to change because his existing learning identity and cognitive abilities were adequate to obtain a good grade for the course. This suggested that motivating changes in learning identity will necessitate a change in the way the course is assessed in order to have structural alignment that includes the course meta-goals [3]. Using interview and classroom observation data, this paper will establish his attitude and orientation towards physics learning.

PHYSICS LEARNING IDENTITY

A community of practice (CoP) [4] is a group of people pursuing common goals through social interactions to build shared practices and knowledge. In this perspective, understanding how to be a member of a community is an important part of identity formation. This understanding can be informed by perception of expectations, choices in roles to take on, what counts as practices of the community and behaviors of other members. Identities can encompass perceived role, relationship with others, day-to-day social interactions, and experiences in other CoPs. Students have prior knowledge and experience to inform their identity development as they interact in the classroom CoP.

Identifying as a CoP member also includes alignment with the belief that practices are valuable for achieving the common goals, the perception that one belongs

and is valued in the CoP, and feelings of agency to affect meaningful change. Students' participation in the classroom practices can facilitate shifts in these components of learning identity. A common way to provide opportunities for participation is through scientific discussion and debate used in many curricula including *ISLE* [1]. Using interactive group discussions in large lecture courses, researchers report improved attendance over the term [5], students' perception that group activities help their learning [6], and improved affect towards the subject [5, 7]. We propose that alignment of assessments to the conceptual and instructional meta-goals serve to reduce frustration and confusion so that students feel more positively about taking charge of their learning.

METHODOLOGY

In Fall quarter of 2010, students in PH211 (first term of a large-enrollment introductory calculus-based physics sequence) were invited to take an online survey as a pre/post assessment. The validated survey measured physics learning identity in terms of physics learning self-efficacy and social expectations about learning [8]. Based on extreme high or low pre scores on the survey results, a subset of the students was selected. In this subset, ten students agreed to be video-recorded with wireless microphones on their desk in class; each of these students was recorded during 2-4 of the class periods in the term. A researcher observed and documented the types of activities that occurred in each lecture using a rubric to easily access recorded events.

Ten students agreed to participate in end-of-term interviews to explore the role physics plays in the students' daily lives. Individual semi-structured interviews were conducted using personal meaning maps (PMM) [9] which allowed the conversation to be student-driven while the interviewer asked the students to elaborate on the contexts in which students mentioned "doing physics". To create the PMM, each student was given a blank piece of paper with the word "physics" printed in the center and was verbally instructed to "write down as many words, ideas, images, phrases or thoughts as come to mind when you see or think of physics." Five minutes were allotted to generating the map; the remainder of the interview was used to discuss the PMM.

THE CASE OF ERIK

From the group of ten students, Erik (pseudonym) was selected as a case study because he was an interesting example with some contradictions. Erik succeeded in the course by traditional standards of exams and grades. His midterm and final exam scores were consistently high

and he earned an A in the course. On the start of term survey, Erik had moderately high scores for *social expectations about learning* indicating some alignment with the curricular goals except for *valuing group work* which was average. Using conventional metrics, Erik was a simple success story that would not warrant teacher concern. However, using interview and classroom observation data, we were able to probe how the learning environment was often inadequately aligned to support his identity growth as a physics learner.

Erik is a Caucasian male student taking PH211 for the first time although he has taken prior physics courses. At the time of the interview, Erik's major was nuclear engineering. He attended class regularly, often sat in the second row of the large (N=200) lecture classroom, and participated in group activities.

Personal Meaning Map and Interview

Erik's PMM consisted of a series of equations and lists of physics ideas related to his major as a nuclear engineer. During the interview he explained that he started his PMM with "random thoughts," and later he was trying "to go back to what physics means to me." His discussion about doing physics focused on problem solving through math equations to get the right answer, and explaining phenomena as a purpose for doing physics.

Math equations. A major facet of Erik's problem solving perspective involved using equations, a task at which he excelled. In his previous experiences with physics tests, he was expected to recall equations from memory and to solve problems quickly. When Erik explained his approach to problem solving, "it's just grabbing an equation and putting in the numbers." Beyond that, "there is not any further thought that I need." Erik explained further about his problem solving process.

I'd say that looking for patterns... gives you the equations you need. When you look at the physics problem you're trying to see what's happening, and you know last time I had a problem like this. So you relate the two patterns, you rate the likeness, you know which equations you need to solve. The goal is just basically getting a number.

Erik's explanation suggested that math equations are his primary problem solving tools. While he emphasized this plug-and-chug part of problem solving, he also appeared to be synthesizing connections between problems he encountered before to help him choose the appropriate equation. He reiterated this problem solving strategy throughout the interview. Based on his grade, this approach to problem solving appeared to be sufficient to accommodate his needs in this class.

Erik appeared to recognize phenomena explanation as a feature of doing physics, but his interview responses

suggested that he was not interested in "[understanding] the why but rather the how." In particular, he described how he would help others solve physics problems.

I can help somebody figure out what they need to do to get through the problem, but as far as understanding the why's behind it, it doesn't... I don't find it interesting. I don't care why it happens the way it does. I know it does and I can solve it. So I don't... when I'm helping someone else, I don't emphasize, "you use this equation because it makes sense *because* of this." You just use it because you do because that's what you're supposed to.

In this passage, Erik's words suggested that he views problem solving as answer-driven and that the problem solving process has been established by an external authority. Erik twice emphasized that explaining why is a part of doing physics that he doesn't want to do. First that he didn't find it interesting, and second that he didn't emphasize the "because" when helping others.

The word "because" is in italics in the quote above to indicate the tonal emphasis Erik used. The word was drawn out and spoken slower relative to the rest of the sentence as though it was laborious. In contrast, the last sentence describing his reason for his choice of solution was spoken more quickly suggesting that this was more straightforward to him. In sum, he appeared to view problem solving as a the task to "get through" rather than a situation to study at length.

Additionally, Erik appeared to have relinquished the authority to question or alter the problem solving process to an external source. Erik's disinterest in understanding "why it does" reinforced his unwillingness to be agentic in this process. From his point of view, there was little value in extending the problem solving tasks because "the easiest way for [him] to learn is to get a problem and practice, and just example after example."

Despite curricular goals intended to challenge his belief about problem solving, Erik seemed to remain unaltered while able to achieve success in the course assessments. This suggested that the assessments were not aligned with the course goals to support specific beliefs about problem solving. However, Erik demonstrated ability to engage deeply with physics. In the following classroom episode, he was engaged in sense-making once someone else initiated the task.

Classroom Observation

The discussion described involved Erik and two other students during lecture, and occurred in week 9 in a 10 week quarter. By this point in the quarter, the students have had time to develop a foundation of common meaning and practices to support their classroom interactions.

Students were asked to work with their neighbors and use energy bar charts to represent a cat that falls off the roof and interpret into mathematical representations. The problem description and tasks were shown on projector screens for the duration of the activity.

One curricular goal supported by this activity is to help students learn to engage in scientific dialogue that uses the language of curriculum. The problem was also open-ended so that students had to contribute to the problem by deciding what reasonable assumptions to make in order to answer the questions. At the start of the activity, Erik (E) readily worked with student 2 (S2) to determine what the problem asked them to do and figured out how to complete each task. Bold text indicate line number.

18 S2: We just need to define this...

19 E: The states. So initial is... exactly what it says, just after leaving the roof. [S2 writes in his notes]

20 S2: [looking at notes] Well, initial and final would be the same... but...

21 E: And then you have to state the origin is... the ground.

Both students clearly defined parameters such as initial and final states and the origin; this disciplinary practice was reinforced throughout the term. Both students said they "need to define" and "have to state" which indicating the belief that they have little choice in how to do the problem. The task-driven and low-agency nature of this exchange was consistent with Erik's interview assertions about his problem solving approach.

Later in the same activity, student 3 (S3) initiated a discussion with Erik about what system to select. This discussion involved a shift in agency where the students took on the responsibility to make choices about what to include in the system. Previously the choice about problem solving steps were accepted from perceived experts.

43 S3: [turns to Erik who turns to face S3] Would the system be the... I know it's the cat and Earth at least, but would the... roof be part of the system or...

44 E: It wouldn't need to be.

45 S3: Yeah...

46 E: Cause the only thing interacting is the cat with the ground, with the Earth due to gravity.

47 S3: Yeah.

48 E: That's our only interaction. We're going...

49 S3: It's pretty much just the position and place. [pause] Doesn't add or take anything away from it, except just gives it a position for the cat to be on.

50 E: It is what gives the cat the initial potential energy.

51 S3: Yeah.

52 E: Cause the cat got up there. That's what it amounts to. If you get up there you've expended energy, you have to gain that back to get back down.

53 S2: [E looks at S2's notebook] We didn't really write a mathematical representation, did we?

54 S3: [E turns to S3] Yeah. But technically though, if you expend the energy to go up and go back down, you technically... physically, in physics you gain... it's equal but when... biological sense, you don't get it back.

The open-ended nature of the question offered students space to contribute to the problem definition. The problem didn't explicitly ask for but implicitly required a system choice; the students in the above discussion chose to negotiate what the system should be for themselves. When S3 started the conversation, Erik was willing to explore the problem at length. Erik's reasoning at the start of the discussion used concise physics language, and his justifications mirrored reasoning given by the teacher who used interacting objects to decide what needed to be in the system. Erik cited interactions in his explanations twice in line 46 and 48. In contrast, the justifications of S3 tended more towards reasoning related to the physical situation; S3 explained the purpose of the roof in the problem in line 49 and pointed out the logical prerequisite and consequence of being on the roof. Both types of justification were accepted by the two students suggesting that the students were aware of the greater degree of flexibility afforded by the type of question and that multiple explanations were reasonable.

As the discussion proceeded, Erik's justification involved more of the physical situation and sense-making language (line 52) that sounded more like everyday conversation. This shift to everyday language suggested that Erik's reasoning perspective was moving from how physicists think to how he personally thinks. This shift appeared to hold his attention strongly enough that he was only momentarily distracted in line 52 by S2's comment that they have not completed the task. Erik did not answer S2 except with a brief look and immediately turned back to the conversation with S3 in line 54. In this instance, the openness of the task and interaction with S3 may have provided a context in which Erik appeared to become interested in the "why's" of the problem.

DISCUSSION AND IMPLICATIONS

Erik has the ability to do physics problems in this class to earn a good grade. In the episode described, his initial problem solving approach was consistent with his answer-driven attitude in the interview. The classroom interactions and an open-ended problem that implicitly required sense-making afforded Erik opportunities to engage in problem solving as meaning-making in addition to answer-seeking. Erik's participation and persistence in thinking more deeply about the problem demonstrated that he was able to do physics this way but did not usually choose to do so. This suggested that he had the ability but did not consider it a valuable practice.

These observations suggest that Erik didn't see any compelling reason to change his beliefs about the nature of learning even though there were pedagogical elements used in the course that reinforce the practices of a physics learner in this class. His existing learning identity was not sufficiently and appropriately challenged because he could achieve success in the course without shifts in his ideas about the nature of learning physics. This may be a result of a mismatch in the structural alignment between the course assessments and course meta-goals to promote physics learning identity change. This mismatch constrains meaningful change in learning identity because student grades do not reflect identity formation as a physics learner or motivate changes in physics learning identity.

While the current curricular reforms are designed to and can aid the development of authentic scientist practices, this study reinforced the idea that we need to also consider the students' prior experiences and existing learning identity in order to align the structure of the course to reflect shifts in physics learning identity. Using the set of tools described in this study, we can examine some aspects of learner identity to inform the design of instruction and assessment to support the course meta-goals.

ACKNOWLEDGMENTS

The authors wish to thank members of the OSUPER group and the Catalyst Center writing group for their contributions to this work.

REFERENCES

1. E. Etkina, and A. V. Heuvelen, *Research-based reform of university physics* pp. 1–48 (2007).
2. S. Li, and D. Demaree, *PERC Conf. Proc.* **1289**, 25–28 (2010).
3. D. T. Brookes, and E. Etkina, *PERC Conf. Proc.* **1413**, 11–14 (2011).
4. E. Wenger, *Communities of Practice: Learning, Meaning, and Identity*, Cambridge University Press, 1998.
5. J. L. Cooper, and P. Robinson, *New Directions for Teaching and Learning* pp. 5–16 (2000).
6. E. K. Henriksen, and C. Angell, *Physics Education* **45**, 278 (2010).
7. A. Yazedjian, and B. B. Kolkhorst, *College Teaching* **55**, 164–169 (2007).
8. S. L. Li, *Learning in a physics classroom community: Physics learning identity construct development, measurement and validation*, Ph.D. thesis, Oregon State University (2011).
9. J. H. Falk, T. Moussouri, and D. Coulson, *Curator* **41**, 107–120 (1998).