



# A Framework for Characterizing Changes in Student Identity during Constructionist Learning Activities

**Worsley Marcelo**, [mworsley@stanford.edu](mailto:mworsley@stanford.edu)  
School of Education, Stanford University

**Blikstein Paulo**, [paulob@stanford.edu](mailto:paulob@stanford.edu)  
School of Education, Stanford University

## Abstract

*In this paper we present a framework for examining meaningful changes in students' identity in relation to science and engineering. These identity changes could represent useful indicators for characterizing student engagement and interest in constructionist, project-based learning environments. The framework is described using data from a study with 12 high-school students that in which learners spent 6-hours a day in a digital fabrication lab for eight weeks.*

## Introduction

Recent work has highlighted that future career choice in science, technology, engineering and mathematics (STEM) fields is better predicted by students' interest and engagement than with academic achievement and course-taking (Maltese & Tai, 2011). Decades of prevalence of traditional instructionist approaches make this finding unsurprising, however, these new results are revealing an even clearer picture of the state of STEM education and bringing issues of motivation again to the forefront of the research community. As we consider interest and engagement, it seems apt to reflect upon what elements are central to these two concepts. In considering this, we draw upon *identity* as being integral to understanding, and characterizing, interest and engagement.

Accordingly, this paper presents a methodology for recognizing elements of student language that cue important aspects of their identity. Additionally, we present hypothesis and theoretically grounded arguments for understanding how these cues relate to student persistence and development.

We proceed by describing the theoretical underpinnings that we use to characterize student identity, followed by a brief description of the data set. We then move on to an in-depth discussion of our analysis, and, finally, discuss the emergence of certain identity traits through qualitative analysis of student discourse using our framework.

## Theoretical Framework

### Identity

The term identity can be associated with many different things and is often invoked at different scales. Viewpoints of identity have also experienced several changes in recent times. There has been a gradual shift from the "romantic" view of identity, in which one's identity was seen as a static entity that one has from birth, often times attributed to socioeconomic status, or social



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class; to the more modern view of identity as being a socially constructed, multi-faceted, dynamic set of personal characteristics (Lee & Anderson, 2009). These characteristics are ones that can change over time, are relative to one's peers, and subject to multiple interpretations by others. Nonetheless, a central idea that has persisted about identity is that it is a way of defining or describing an individual's discourse – behaviors, speech and thoughts. This is the level of understanding identity that we will use in discussing changes in students' identity in this paper. Furthermore, for the purposes of this paper we are primarily concerned with identity in terms three dimensions: *identity in language* - how individuals talk about themselves in relation to other entities; *identity in conflict* - the explicit and implicit conflicts in an individual's identities; *identity in development* - the ways that an individual's identity has come to be developed. We briefly highlight key elements of each of these three dimensions and their theoretical grounding, but present them more comprehensively in the Discussion section.

### Identity in Language: The Language of Identification

Identity in language is characterized by an individual's verbal discourse and the use of phrases such as "I am ...", "we are ..." and "it is." Here we posit that students' choices of "I", "we" and "it", are cues into the relationship that the individual has with other individuals and other objects within the learning environment, including artifacts created by them. Furthermore, we will look at how individuals choose to present information to others, either in a way that the speakers treats themselves as superior, equal or inferior to the listener. Some of this analysis is based on previous research on how experts and novices talk about different external entities, (Worsley & Blikstein, 2011) as well as linguistic analysis of science learners (Heath, 2012).

### Identity in Conflict - Explicit and Implicit Identity Conflict

The second dimension for analysis falls along the lines of identity conflict. Different from previous work on identity conflict (Agar, 1997, Fordham 1999, and Lee & Anderson, 2009) our framework looks at cases where an individual may have adopted a certain identity without having fully achieved that identity. For example, one can imagine a teenager who identifies him/herself as an adult. We see that this type of conflict can exist in both a positive and negative light, and we explore the implications of these identity conflicts as we analyze the data.

### Identity in Development - The Nature of Establishing and Developing an Identity

The final dimension that we analyze relates to the elements that help students develop or maintain a given identity. In order to examine this dimension we are interested in looking at the ways that an identity is formed, in terms of acquisition or learning (Gee, 1999) and the external factors that help promote the development of that identity. According to Gee (1999), Yoder (2000) and Wenger (1999), the formation of identity is *experiential*, and is not formed in isolation. Accordingly, we look at ways that external factors influence identity formation as a lens for analyzing individuals' perceived identity.

## Data

The data for this study comes from 12 high school students that participated in a two-month digital fabrication and invention class. Students worked in a constructionist environment, being situated in a hands-on, multi-disciplinary environment where they were challenged to do a variety of STEM activities and build a variety of artifacts (Papert 1980, 1991). Students participated in a special program that replaced the 6 hours that they would normally spend at school, with an



opportunity to engage in construction of meaningful artifacts and ideas. The high school students were predominantly in the 9<sup>th</sup> grade; three of the students were females. All of the students self-selected to take part in the study by signing up for a digital fabrication and invention class at their high schools. Students worked with a team of 15 teaching assistants that would take turns facilitating the activities. Projects were student-directed and involved environmental engineering, robotics, electronics, mechanical engineering, engineering design, music, art, computational modeling, physical fitness, and more. All of the projects required the students to learn a new piece of technology, and typically involved computer programming in NetLogo (Wilensky, 1999) or in Cricket Logo (a version of Logo customized for the GoGo Board (Sipitakiat, Blikstein, & Cavallo, 2004; Blikstein & Sipitakiat, 2011)). Approximately half of the projects were collaborative, while the other half were individual. Students worked on a given project for three to four days prior to presenting their work to their peers. Finally, at the conclusion of the class, students presented their work to teachers, parents and researchers.

Students participated in one-on-one interviews with a member of the teaching staff in one month increments. The one-on-one interviews consisted of questions that asked students to design a certain invention or device. For example, one of the questions was to design a piggy bank that automatically counts the money as it is dropped in. There were also questions that asked students to explain a certain social or natural phenomena that can be characterized by exponential growth or power laws, a principle that they explored extensively since one of the sections of the activities was dedicated to agent based modeling. All interviews were transcribed, and serve as the primary component in the discussion that follows. Transcripts ranged in length from 15 to 40 minutes

## Data and Discussion

### Identity in Language: The Relationship between “Me” and Other Entities

In this section we examine the way that people talk about themselves in relation to the machines that they built, and the models that they were asked to explain. In Table 1, we present the frequency of ‘I’ (or ‘we’), ‘you’, ‘it’ and ‘the’ occurred within a spoken utterance.

Pseudonym	I	you	it	the
Gunther	0.34	0.34	0.04	0.27
Francis	0.23	0.05	0.24	0.48
Thomas	0.25	0.05	0.36	0.34
Peter	0.20	0.17	0.32	0.31
Eric	0.36	0.05	0.30	0.29
Kyle	0.05	0.07	0.36	0.53
Violet	0.16	0.13	0.45	0.25
Shannon	0.28	0.14	0.16	0.42
Sadie	0.24	0.05	0.30	0.42

Table 1 – The fraction of ‘I’ (‘we’), ‘you’, ‘it’ and ‘the’ in student exit interviews 1 month into the program

Since for now we are simply counting word frequencies without any consideration for the context, the goal is to simply investigate if there is any approximate regularity or pattern in the use of such words, even given the open-ended nature of most of the interview questions. Table 1



immediately reveals Gunther and Eric as outliers in their relatively high use of ‘I,’ 34% and 36%, respectively. This is in contrast to Kyle, who only used ‘I’ in 5% of the times where he used ‘I,’ ‘you,’ ‘it’ and ‘the.’ Gunther also demonstrates an extensive use of ‘you,’ 34%. Gunther is a unique case on the opposite extreme for use of ‘it;’ recording the word far less frequently than his peers. Finally, we see that Kyle uses considerably more ‘the’ utterances than any of his peers. While these numbers provide some insights, we are still left with a number of questions about what these words really signal about identity. For this analysis, we will turn our discussion to a deeper qualitative analysis, in order to highlight three distinct patterns in students’ utterances in the interviews: using ‘I’ as a way to express a sense of connection and achievement; using ‘the ...’ or ‘it’ to express a sense of disconnection; and using ‘the ...’ or ‘it’ in conjunction with ‘you’ to adopt an instructional discourse – trying to teach the interviewer about something or simulating a teaching scenario. In the following paragraphs we present examples of each of these and discuss their significance.

### ‘I’ as a sense of achievement

Eric is a student who liked to work by himself. When asked to work in a group, Eric would typically relent and proceed to work on his own. During the first month of the program, Eric designed an alarm clock that he was quite proud of. Even though the alarm clock had not turned out as intended, it featured bright lights and an intricate design, and Eric received several compliments on his creation. It is telling to note that Eric used 72 ‘I’ utterances in his transcript, with the majority of them being used while describing his alarm clock and how it functioned. Here is an excerpt from the transcript in which Eric uses several ‘I’ statements.

[03:22.0] Eric: Was, uhh, I used, wh < - > umm, my original design was to etch in a bunch of lines that I would then cover with the, uhh, what I would then use for the, umm, as my, like...

Uhh, like...I don’t know what the word is. Like, guide for the, where I put the EL wire.

[03:44.0] Interviewer: Ohhh.

[03:44.7] Eric: So, umm, I then etched it in but then I realized that, umm, I used too many lines and they were all too close together and I wouldn’t have enough connectors for EL wire to cover all the spaces, so then I just used less lines and...

[03:59.8] Interviewer: Mmhmm.

[04:00.1] Eric: I was then, I, I’m, I was still was left with a lot of etched lines left....

We see that the majority of Eric’s utterances included the word ‘I’. This is significant because Eric could have just as easily described everything about his alarm clock without ever using the word ‘I.’ Consider the transformation of the following sentences that produces the same description of the alarm clock’s operation.

*Original:* Was, uhh, I used, wh < - > umm, my original design was to etch in a bunch of lines that would then cover with the, uhh, what I would then use for the, umm, as my, like... Uhh, like...I don’t know what the word is. Like, guide for the, where I put the EL wire.

*Without ‘I’ (or ‘my’):* Was, uhh, the original design was to etch in a bunch of line that would then be covered with the, uhh, they would then be used for, like.... Uhh, like...the word escapes me. Like, guide for where to put the EL wire.

The fact that Eric chooses to describe how he constructed his system making extensive use of the word ‘I’ is reflective of the sense of accomplishment that he had received by building it (Heath, 2012). Accordingly, he used more personal language as a way to share the depth of that personal connection.



## Disconnecting From the System

When Eric was describing his alarm clock, his language was characterized as being very personal. However, after talking about his alarm clock, Eric was asked some questions about one of his other projects. This project was not met with the same level of success (see excerpt above). In this excerpt, Eric is describing a sprinkler system that he designed. But his level of connection, and the extent to which he takes ownership of the sprinkler system, differs greatly from how he felt about the alarm clock.

[05:42.7] *Eric: So, umm, it, like, the sprinkler... So the idea was it wouldn't go on when it's dark, rainy, or cloudy becau < - > rainy or cloudy cuz it was there when it's moist and it doesn't need watering and then it'd be programmed to turn on when it was sunny and then for twenty minutes it would only for then.*

[06:19.6] *Interviewer: Okay.*

[06:19.8] *Eric: And it would just save, like, a bunch of water and money and stuff.*

Instead of statements like 'I designed ...' Eric used, 'the sprinkler system' and 'it.' In a few instances he does still use 'I' language, but these are utterances that would have been difficult to externalize. To be more concrete, consider that Eric's first excerpt consisted of 128 words, and 12 occurrences of the word 'I.' The extended version of the second excerpt, truncated here to conserve space, consisted of 169 words and contained only one occurrence of the word 'I.' Thus we see a contrast in how use of the word 'I' signals different levels of identification with a given entity, and varying depending of the success and sense of accomplishment of the project.

## Using 'You' in Conjunction with System Language:

Looking at Table 1, one sees a number of individuals who used a combination of 'I', 'you' and 'the' statements. One hypothesis is that this was the students' attempt to emulate the academic discourse of someone who teaches or instructs. As individuals that are still entrenched in the education system, these students are likely to encounter several teachers who utilize "you-oriented" instructional statements like "first you take the bottom number and..." in order to adopt a more conversational teaching discourse. As such, this emulation of instructional discourse may be a demonstration of an increased mastery in a domain, or at least a self-perceived mastery (Worsley & Blikstein, 2011). More specifically, the use of 'you,' may be similar to the ways that experts describe ideas or devices for less, or equally, knowledgeable individuals. Given the amount of time the students spent on their projects, they may have begun to self-identify as experts about their own projects. Therefore, for them to take on this identity as an expert of their projects is quite telling of how their identity has changed in the process, even if only in this limited domain. To further explore this, we examine an excerpt from one of the students who is describing to the interviewer how they would design a piggy bank that automatically counts coin values.

[00:00:14:04] *Francis: Okay. This is kind of cheating because one of the things my father got me for Christmas was a coin jar that does exactly that. What you do is have for the part where the coins go in, a little < ahh > lever that looks like that and depending on how far it's pushed down you could tell the size of the coin and therefore the value of it because all coins are different sizes. And then you can just record that with some software that is in GoGo because GoGo as far as I know can't display numbers like just tell it display number.*

As an individual who used to own such a piggy bank, Francis feels like an authority on this topic, and projects that self-perceived authority in how he describes the system. For one listening to him speaking, one gets the idea that he is a teacher explaining this idea to a student.

By looking at the use of the verbal discourse associated with personal pronouns, neutral



references, and neutral references combined with professorial language, we can identify the extent to which students identify with, or relate with, the subject matter that they are discussing. Even within the same interview, as was the case for Eric, one can use these cues to observe how the students related to the different projects that they worked on.

### Identity in Conflict

Having looked at some of the identity cues that are triggered from an individual's specific language, we now look at a more macro-level analysis of how the different identities that someone has may be in conflict. More specifically, we present three case studies of individuals that show how conflicting identities can be indicative of a student's learning trajectory (Wenger, 1999; Yoder, 2000), and how the nature of the conflict dictates whether or not that individual is "in-bound" or "out-bound."

We begin by again looking at Eric. Reading his transcripts, one notes that he has a deep interest and excitement in engineering design. In fact, near the end of his interview, Eric states that his career goal is to be a Disney Imagineer. To this end, Eric is confident in his ability to do engineering design. However, a conflict arises when Eric realizes that he has not yet attained the level of expertise to be a practicing engineer. We see this develop in the following excerpt where Eric has just finished describing how to build his automatic piggy bank. The last question in this series challenged students to defeat their own system, i.e., to find a way to cheat the piggybank system that they had described just moments before.

[12:28.7] Eric: *Hmmm...Anything cheat my own system... Nope I'm too good, they can't get past me.<laugh> I can't even get past my own system. So yea...*

[12:41.9] Interviewer: *Can you think of any other way?*

[12:43.5] Eric: *Ahhh, maybe... Is there supposed to be another way? Or...*

When Eric asks "is there supposed to be another way?," he has been forced to come to grips with his own lack of knowledge concerning the question at hand. Heretofore he had maintained his confidence and answered all of the questions with resolution and conviction, save the occasional disclaimer that "he's not a good drawer." However, when this conflict happens, he is expressing frustration, and genuine uncertainty. Based on the work of Liscombe et al. (2005) and Forbes-Riley et al. (2009), we believe that this conflict between the level of confidence that Eric maintains and the uncertainty that he just expressed is a point that demonstrates his in-bound trajectory towards being an engineering-designer. He could have easily given up on the problem, and maintained that there was no way to cheat his system, but instead he momentarily puts aside his confidence, and his identity as a budding engineering-designer, to admit the need for help.

A similar conflict arises for Shannon. However, Shannon's conflict differs in that, while Eric had developed this identity of wanting to be a Disney Imagineer before coming to the workshop, Shannon did not have such aspirations and found empowerment in the workshop. We briefly look at the conflict that she faces while trying to design the automatic piggy bank and then return to our discussion.

[00:08:47.30] Shannon: *That's OK. Um, you would have one slot with maybe.... Um, I don't know. It seems like it's a very common design, like on the vending machines and... like, there's one single slot. I was thinking that you'd have a lot of lasers, like, to see how large the coin you would put in would be...*

[00:09:17.70] Interviewer: *OK.*

[00:09:18.40] Shannon: *...but it seems like it would be a bit difficult. Then again I thought programming a Roomba would be difficult and it wasn't so... Mm...*

To provide context for the last statement that she made, roughly a week before the interview,



Shannon, along with her project group, sat down with one of the teaching assistants to brainstorm how to design and program a Roomba robot. At first, the three girls were quite perplexed as to how one would go about programming a Roomba. However, after working with the teaching assistant for about 15 minutes, the girls had not only figured out a set of behaviors that they could use to dictate the Roomba's movements, they had actually programmed the behavior and tested it out using a robotics kit. It is in reference to this experience that Shannon is referring. She is indicating that the experience of programming the Roomba was powerful for her, and it increased her confidence in her ability to do programming-related tasks. Having realized this newfound confidence, she was surprised by the difficulty that she was having in tackling a problem that she perceived to be difficult, yet solvable. Again, we see this conflict as being an indicator of change within the student, and a marker of her in-bound trajectory towards engineering design.

Finally, in the space of identity conflict that produces growth, we consider a quotation from Sadie. Sadie was a 9<sup>th</sup> grade student who initially seemed apprehensive about fabrication, and appeared to be more interested in the social aspects of the class than she was about digital fabrication. She encountered internal conflict during the exit interview and unintentionally hints at it.

[0:03:51.9] Interviewer: *Could you write a program to make that, to do that?*

[0:03:59.3] Sadie: *Like, me? Or, like, anyone?*

[0:04:00.9] Interviewer: *Yeah, you.*

[0:04:01.8] Sadie: *Um, it would probably take me a few tries but I think I could.*

In the above exchange the interviewer asks Sadie if she can write a program to control the temperature of a room given the appropriate sensors and actuators. Sadie responds by asking for clarification on if the interviewer means 'you' in general, or "you," as a specific reference to Sadie. What is interesting is that if Sadie was confident in her own ability to write the program, disambiguating the meaning of 'you' would have been irrelevant. If she could write the program then, the answer to the less constrained, general question of whether or not a program could be written would have also been positive. Instead, Sadie's question suggests that she is just now recognizing her identity as being someone who is able to write computer programs, and that this additional identity is in conflict with her previous conceptions of her own abilities. Even so, after some hesitation, she makes it clear that she has begun to identify herself as someone that can write computer programs. As such, her conflict and her response to that conflict, indicate that she is on an in-bound trajectory.

For Eric, Shannon and Sadie, the digital fabrication and invention course offered a space to become increasingly confident in their ability to design and build. In some cases this increase in confidence was greater than their actual increase in engineering design ability. Nonetheless, this appears to be an instance of social validation (Gee, 2001) in which one's identity only has meaning if it is validated by others. In the following case study we see an example of the opposite.

Kyle is a student who appeared to have received a lot of positive feedback in his traditional classes. In fact, during the start of the second month he shared with the entire class about how his teacher had selected his geometry project as one of the best he had ever seen. In the digital fabrication and invention environment, however, Kyle struggled. And instead of recognizing his struggles and trying to improve on problems that he experienced he typically chose to neglect them. We see this by examining a pair of excerpts from Kyle where he describes the tic-tac shooting gun that he designed with a colleague.



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[00:00:03:11] Interviewer: *Is this design < – > why did you use light sensors? Is it designed to catch someone who is using a light or something or is it just a way to control it from a distance?*

[00:00:03:24] Kyle: *It's just a way to control it from a distance actually.*

...

[00:00:04:59] Interviewer: *I see. Cool. Did it work out as well as you wanted?*

[00:00:05:03] Kyle: *< Hmm > yeah, actually it did.*

In the first exchange we see Kyle respond and conclude his statement with the word ‘actually’. When listening to Kyle’s statement, and the way that it’s said, it’s apparent that Kyle had not really thought through this part of the design, and was simply going along with the interviewer’s suggestion. In this way, we would argue that the very inclusion of the word ‘actually’ at the end of the sentence is an overstatement suggesting that this *actually* wasn’t their intention. And, in fact, the inclusion of the light sensors was largely motivated and partially implemented by one of the facilitators. To this end, the students may have merely included it to satisfy the facilitator, and may not have truly taken ownership of it. Beyond this, their description of its purpose seems to suggest that they had not truly considered the utility of adding this component.

In the latter exchange, we see this word ‘actually’ come up again. This time it is in the context of Kyle having any ideas for improving his gun. In this instance he attempts to resolutely state that there were no improvements that he wanted to make. Of course, this occurred after he pauses to think first, as indicated by the ‘hmm’. Moreover this response is in direct contrast to how Kyle and his partner were then attempting to make modifications to the gun so that it would shoot farther. However, in both of these instances of conflict, Kyle attempts to maintain the identity of a strong confident student. We would argue that this demonstrated Kyle’s outbound trajectory from this engineering design community. As a source of comparison, even students who constantly struggled to complete their projects, and were regularly reminded to get back on task, were willing to propose modifications or improvements to their system, but not Kyle. In the face of conflict, he decided to take the safe route.

## Identity in Development

In addition to seeing how conflict impacts an individual’s identity, and how we can characterize their trajectory, we also examine the ways that the student’s identities are developed, and the impact that this has on them. We frame this discussion in terms of acquired identity and learned identity (Gee, 1999), where we are again focusing on the individual’s identity as an engineering designer.

### Acquired Identities

In only three of the interviews that we conducted did we find that the students were engaged in a community or peer group that fomented their appreciation of engineering design. Two of these three students described the interaction as being with their fathers. Francis describes a toy that his father got him as a resource that would allow him to “cheat” in solving the automatic piggy bank problem. And as we previously observed, this resource, and presumably other such devices, influenced Francis’s identity as a builder.

However, simple exposure to a device in the home setting does not always facilitate becoming an expert with that device. This fact is suitably displayed by the experience of Violet. Like Francis, Violet had owned an automatic piggy bank as a child. However, Violet had no idea as to how it operated. There was a different culture in her home than the culture in Francis’ home. This is partially characterized by the way that Violet talks about the piggy bank. Instead of attributing its





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ownership to a specific family member, as did Francis, Violet simply remarks that she used to have one. This is suggestive of her not having the resources to build a strong identity in terms of being an inventor, despite having the same device as a child.

To further emphasize the idea that it is the interactions that matter, consider the experience of Gunther. Gunther is another of the students that continued to work on his project after it ended. In two separate instances of his interview, he alludes to discussions with his dad and experiences that his dad had shared with him, that helped inform his understanding of classroom material. This is not unlike the argument that Gee (2003) makes against those that reference decontextualized language, in that this home language and experience gives Gunther better knowledge to learn complex concepts.

*[0:06:58.9] Gunther: Because things, very unpredictable things happen like this < snaps fingers > or this < snaps fingers >. It's like, you know, two or three years ago I forgot what, my dad's a buyer for Men's Warehouse. And suddenly on the east coast it's really cold temperatures hit. Suddenly, you know, it was the beginning of summer. And, you know, they didn't have many large coats and stuff in the stock but they had to get them there. So things like that will change. You know, trends and stuff. So, I think that nature is still in charge and a bunch of things can happen that we won't even think of.*

Here we see the student refer to his dad in order to provide an example of changing trends. This same student later says the following:

*[0:09:14.5] Gunther: Um, Smoking is a past example and that kind of happened the same way. My dad was telling me, that kind of happened the same way the cell phone thing is happening. These studies would just kind of pop out, um, or not randomly so to speak, but they just kind of happened. And then over time that led to people realizing, oh, smoking is bad. So, you see, so, that's another example of a phenomenon.*

Again, an interaction with his father offers him an easier entry into some of the phenomena that were studied during the engineering design class. In these three cases, therefore, we see diverse cases of the influence of families in identity formation. In the two examples, we saw how Francis and Violet, despite having owned the same object in their childhood, had very different experiences with it with diverse impact on their identity as builders. Gunther, along the same lines, had meaningful interactions with his father about a variety of natural and social phenomena, mentioned them in the interviews, and showed to be comfortable in the position of explaining scientific ideas.

### Learned Identities

Other students, however, had to approach engineering design from the learned perspective. Even though they were able to draw on previous experiences, they still exhibited great difficulty in engineering design, because they had not been exposed to a culture of design at home. Thomas offers a glimpse of this in his interview while trying to come up with the design for a device that can automatically count money.

*[0:14:13.8] Interviewer1: OK. Do you have any speculations as to how they do that?*

*[0:14:18.0] Thomas: How? I have no idea how earthly < ?? > matters of the money, other than maybe, like, um, like a grocery store, they have that laser scanning thing.*

Thomas is unable to conceptualize a money sorting device, and generally has a hard time even approaching the problem. Even though he was extremely motivated by the course, because he was operating from a learned identity, he encountered additional challenges. that required additional intentionality. Through the course of the class, we learned that Thomas has not had the same access or support in building and tinkering as some of the other students. He faces a larger barrier to entry into the inventing community; and without the external culture that promotes an



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invention identity it is harder for him to continue beyond the scope of the classroom.

The students that were able to move beyond the classroom have access to resources that can help facilitate their inclusion in the inventing and building communities. Furthermore, for these select students, the inventor identity was part of their acquired culture; but for the majority of the students, it was merely a learned behavior that they were just then being exposed to.

## Conclusion

This paper's primary contribution has been describing and presenting a framework that can be used for identifying meaningful changes in student's identity through spoken utterances. Additionally, using transcriptions of student utterances we have been able to exemplify how the dimensions of identity in language, identity in conflict, and identity in development are manifested through a constructionist learning experience. Furthermore, we have looked at some of the possible impacts that a laboratory-based constructionist learning environment can have on student identity formation, maintenance, and development, with a particular eye towards seeing how conflict can help identify students' STEM trajectories. As we continue to grow this exploration of the role of constructionist learning environments on student persistence in the engineering disciplines we will maintain a keen awareness of how student identity may be changing. Furthermore, we will begin to also analyze student language, identity conflict, and external factors that promote identity development, in the day-to-day laboratory dialogue. All of this will further our goal of developing automated techniques that will allow us to systematically validate the learning that takes place in constructionist learning environments in a way that privileges learning processes over learning outcomes.

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