Designing For Diversely Motivated Learners

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1 ABSTRACT
In this paper, I present three case studies of students that represent different phases of interest development and commitment [1][2]. Based on this analysis, I conclude with four recommendations for better enabling learning across a diverse set of interest levels.

1.1 Author Keywords
Motivation; Constructionism; Engagement

1.2 ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms

Human Factors; Design

2 INTRODUCTION
The Stanford Learning Fabrication Laboratory (LFL) is the first in a line of FabLabs that are being launched with an explicit focus on education. Housed in the Stanford Graduate School of Education, the LFL represents a prototypical fabrication laboratory for K-12 schools. The basic framework for student work in the LFL builds on Papert's constructionism [3], which places a premium on student-designed, project-based learning experiences. More specifically, the curriculum is designed to give students an initial introduction to the tools and techniques available to them through small thematic projects: making a nametag on the laser cutter and vinyl cutter; creating a Rube-Goldberg machine from GoGo Boards and materials from the Dollar Store. After the students have been exposed to the capabilities at their disposal, they are given a number of longer, 4 to 5-day projects that are centered on a given theme, or a set of themes. For example, students may be asked to collect electricity usage in a location that they care about. Using that data they identify a problem, and subsequently come up with a solution and a prototype that addresses that problem.

Student learning in this space is a challenge because of the many dimensions in which students show progress. In this paper, we focus on the dimensions of motivation and interest. For interpreting individual student actions and interest, this paper primarily builds on the works of [1][2], but will also reference key ideas from [4][5][6][7][8]. Hidi & Renniger's [1] four-phases of interest development and Ito et al's [2] framework for levels of commitment: 'hanging out', 'messing around' and 'geeking out'; are central to describing the nature of student interactions in the LFL. We also use Bevan et al's [9] framework for looking at the structural and social affordances of learning environments, though we make the distinction that these affordances should be viewed as relative to each student, as opposed to being relative to the learning environment. By combining these theoretical lenses, we paint an intricate picture of each student, and later draw conclusions about how best to enhance learning in the LFL and similar types of learning environments.

3 CASE STUDIES

3.1 Jason – Geeking-out - Well-Developed Interest
Jason is a 9th grader at St. Francis High School. He is interested in video games, programming and curious about science. Jason has a high level of motivation and interest in digital fabrication, and is typically able to solve his own problems. Furthermore, he is able to see his work as pertinent to his life and as something that is important to. However he occasionally becomes disinterested when the workshop is overly structured.

Several episodes made it evident that Jason was both motivated and engaged. During the first month of the program, Jason and Hans were hovering around the door to the lab about half-way through lunch. Concerned that they didn't have food, I asked them if everything was okay. "Can we go back into the lab?" they asked. I didn't see why they should not be let in during their lunch break, and advised them to go knock on the door and Sharon would let them in. The two quickly went to the door and knocked politely. I stepped away and was quite surprised to find them sitting in the lobby when I came back. "Sharon said that we had to wait," they said in a sad and dejected voice. Hearing their response, it was as if they had been denied access to water, or some other basic necessity. In fact, during the second month of the program, the students were allowed to spend their lunch break in the lab, as they pleased. Almost every day Jason would quickly eat his lunch, and then return to the lab to do work.

Curious to know what these students worked on over lunch, I stuck around one day and performed an informal focus group with Alex, Hans, Jason and Michael. I asked them how the class was going. They all provided the same answer "fine." I then probed the students about what changes they would make. Jason was the first student to offer up the idea that they should be given more time to work on their own projects. After asking for clarification about what he meant by their own projects, Jason described his frustration with how long it took to make an anniversary card for his parents and that it would be nice to have more time for working on projects that weren't necessarily related to their class work. The goal of using the tools of the FabLab to do extracurricular projects suggests that Jason he saw the intersection between the lab and his home life. The lab was no longer another version of school, but a place for making culturally and personally meaningful artifacts. The connection between the LFL and personally meaningful artifacts was also evidenced in the pride and enthusiasm with which Jason presented his projects to his family and friends. His enthusiasm was partially because he was

able to successfully complete his projects, but also because the projects that he made had personal meaning to him.

Things did not always go as desired for Jason. On multiple occasions, Jason would disengage from the assigned task, or finish his work early and express frustration about having to wait for his peers.

Jason generally found that the program's structure thwarted his ability to make progress on his work. One day while the students were working on gifts for someone else, Jason found himself effectively "killing time." He had just gotten Sharon's attention, sorted out the details of his design and was looking forward to getting started on building his project. He asked Sharon when he could start working on it. "In 5 minutes" was the response that he received. Despite his enthusiasm and vigor to build this gift, he would have to wait before getting a chance to continue working on it. This, I believe represents another source of frustration for students that are at the "geeking out" stage. They are mostly interested in having the freedom to do their work, and bemoan restrictions that hinder their progress.

The final note about Jason is his relative lack of socialization. Jason was seldom found talking with his peers about non-class related concepts, but instead would normally be found doing work on his own, or sitting at the computer doing some other solitary task. At times this meant watching television shows or playing games. At one point I observed him watching "The Big Bang Theory" and another time he was playing Minecraft. All of this is to say that for Jason the social affordances and structural affordances of the curriculum were relatively low. That said, the structural affordances, in terms of physical machinery, were definitely an asset for Jason.

From the above, we see that Jason is a student that is bent on "geeking-out" when it comes to digital fabrication. He is full of ideas for projects that he would like to complete in the lab, and many of these projects hold both personal and cultural meaning to him. Jason intentionally structured his free time as to be able to spend more time in the laboratory, and only seems to have a hard time when asked to participate in activities that were well-structured.

3.2 Delia – Messing Around - Emerging Individual Interest

Delia is also a 9th grader at St. Francis High School. She is less pronounced about her interests and motivations, but demonstrates an emerging interest in digital fabrication and invention. This emerging interest is seen in the effort that she puts forth, her creativity in coming up with innovative solutions, her willingness to learn new things and her reliance on help from facilitators to complete her projects.

The majority of my interaction was Delia centered around two topics: her final project, and my daughter. In some respects, this mixed interest in non-classroom related content and the technical details of her project accurately characterizes where Delia is in her level of interest development.

Delia's final project "Geometry Strengths and Weaknesses" entailed several complicated technological components – Digital Whiteboards, Intelligent Tutoring and GoGo Boards. However, Delia was not previously familiar with any of the tools. From the onset she knew her project was complicated, and would start any description of her project with, "it's complicated." Despite the various complexities of her envisioned solution, Delia spent considerable effort to bring her project to completion. The first example of her extra effort is the hours she spent at home building a 40 PowerPoint slide prototype of her application. At that point, she didn't know that there was a way to use the PowerPoint slides in her final project, but she was motivated enough to do it anyway, as an intermediate product. She later showed additional commitment by learning some Visual Basic so that she could add programmatic behavior to her PowerPoint presentation. This task took several hours to complete. Additionally, she worked diligently on a fairly complex GoGo Board-spinner, which used two GoGo Boards, 8 LEDs and 10 photovoltaic cells. Finally, Delia showed uncharacteristic engagement and motivation in that she reached out to the facilitation staff over email, on multiple occasions, as the final expo drew closer. Taken together, these efforts, in the form of learning new material and working after-hours demonstrate Delia's interest in this area.

Delia's willingness to engage the teaching staff, both over email and in person, also demonstrates recognition that she needed additional support. While there were times that she wasn't sure of the right questions to ask, she did not let that keep her from moving forward (Alberdi et al 2000 in [7]). She carried this same persistent mentality into her face-to-face interactions, to the point where she *expected* just-in-time help. On one occasion she even got upset that it took me a few minutes to realize that she was trying to get my attention. This explicit expectation, and her visible frustration when help didn't come, suggests that she acknowledged her lack of familiarity with the different technologies, and, more importantly that she cared about the project [10]. The need for assistance is also important because it makes it evident that she is likely still in the 'messing around' phase [1]. In this way Delia appears to have a greater need for the structural affordances of the program than does Jason.

In terms of motivation and interest, Delia also demonstrated high satisfaction from completing her project. She was very explicit in expressing her excitement "I can't believe it all works. I love you right now. Give me a high-five." The gravity of this statement makes clear both the amount of effort that she put into her project, as well as how excited she was that the project actually worked. Thus we see that Delia was deeply moved and enthused about her project and how it turned out.

Finally, in terms of social affordances, Delia was much more likely to engage in social interactions than Jason. Moreover, she engaged in discussions on a large variety of topics, many of which centered on peoples' personal lives. She also engaged in discussion about the design of her project. In so doing, she quickly became an expert on the intricacies of her GoGo Board-based spinner. This expertise created grounds for her to engage in technical discussions with mechanical engineering graduate students [5]. In short, Delia leveraged social interactions as a way to learn more about people and to gain inroads into the domain of digital fabrication.

3.3 Shawn - Hanging Out - Situational Interest

Shawn is a 10th grader at St. Francis High School. In terms of traditional classifications of student behavior, Shawn would be considered a trouble maker. Early on in the program, Shawn was one of the students that needed to be pulled aside and talked to about making good choices, since he was often disruptive and disrespectful to the facilitation staff. His behavior can be best described as that of someone who was "hanging out" and who had triggered situational interest. This categorization is based on his demonstrated increase in knowledge, and the enthusiasm associated with this additional knowledge; and the motivation that he brought to structured activities. Furthermore, his inability to remain on task and his response to challenges suggest that Shawn was still in the stage of situational interest.

One glimmer of Shawn's engagement took place early in the program. The students were designing small gifts, and Shawn was struggling to find a good recipient for his gift. He had offered to make a gift for a facilitator, but the offer was turned down, because the facilitator didn't think that Shawn was being serious. While Shawn continued to think about a recipient for his gift, Bjorn started to express confusion about how to make a triangle in CorelDraw. Without hesitation Shawn helped Bjorn. Bjorn successfully followed Shawn's instructions and after completing the task, Bjorn and Shawn smile and exchange a hand shake. Through this interaction Shawn experienced a moment of empowerment. Someone who was typically viewed as the class clown was able to make a meaningful contribution to someone else's work. As evidenced by their smiles, this felt good. In fact, in later weeks, when Shawn and his friends needed to do work in CorelDraw, Shawn was typically the person in the driver's seat. Accordingly, we see that Shawn, through his engagement in LFL activities developed proficiency with CorelDraw to the point that he was able to assist his peers.

Shawn had another moment of extended situational interest later on in the program. The students had some down-time before receiving their pre-workshop surveys and interviews, so I approached Shawn, Bjorn, Josephina and Euclid with the challenge of creating a nametag for a group of middle school students that would be visiting the next day. Somewhat to my surprise the quartet unanimously jumped at the opportunity. In the course of a few minutes, the four students who were arguably the most disruptive and the least attentive, were now working together to come up with a keychain for a group of middle school students. In the process, they worked collaboratively, traded ideas with one another, managed to come to a consensus, and then started to engage in background research in order to better determine what to make. This represents a significant level of interest and engagement, and the effort was largely coordinated by Shawn. This episode suggests the presence of triggered situational interest that was mediated by presenting the students with a structured, clearly defined task that they could effectively manage themselves.

The final example that I'll mention from Shawn is his culminating project, Cash Rules Everything Around Me (C.R.E.A.M).The game is a spin-off of Monopoly, but is themed after rap artists. On the first day of the project, Euclid and Shawn were extremely definitive in describing the intricacies of the game, and all that they wanted it to do with it. They left for lunch that day, with a big picture of what they wanted to do, but without anything concrete about the actual game. When they came back from lunch the pair was encouraged, by a facilitator, to continue working on their game. This suggestion was met with the response, "This is just too hard. Can you we do something else? We just can't make it work. Bjorn was right. Can't we just switch to something else?" Shawn and Euclid had gone about as far as their initial motivation could take them, and they had finally run out of steam. To this end, we believe that they would have preferred a more constrained assignment with a smaller set of options. Thus, we, again see a case of triggered situational interest, where, perhaps, offering the students more structure would have made tackling the assignment more manageable, and perhaps would have carried their initial situational interest further.

In terms of social affordances, Shawn tended to view the LFL as a place to hangout and socialize with friends. Only a small portion of the discussions that he had were explicitly related to class content, and he was always very good about finding ways to integrate things that were of interest to him into his projects. Examples of this include: his request to use characters like Rick Ross and Howie Mendel in the items that he laser cut, and the gifts that he made for others. Perhaps, this was a way for him to trigger and maintain his own interest in the LFL assignments. Regardless, relative to his peers, Shawn was the student that was more interested in socializing than working. As a final piece of evidence of this, recall that Jason fought to get admission to the lab during lunch. Shawn, on the other hand, almost always needed to be ushered back into the lab by one of facilitators. And even after being prompted to return, Shawn tended to drag his feet since he would have preferred to spend his time hanging out with his friends.

4 RECOMMENDATIONS

Through the cases of Jason, Delia and Shawn, we see three students with different levels of motivation, interest and engagement, as well as different learning needs. We also saw three students that experienced the affordances of the same learning environment very differently. Recognizing these differences is fundamental to our recommendations.

1. Identify students' phase of interest development and commitment level early on in the program. This is useful because it will provide an additional metric for assessing the success of the program [1][2].

2. Develop a curriculum that has explicit entry points and fall backs for students of different levels of interest development [1][4][5][7]. While the goal is not to stratify students, it helps to have prompts or tasks that students can complete when they need additional scaffolding for an assignment.

3. Develop additional laboratory demos that can help spontaneously capture student interest [8]. For students that are not familiar with a specific domain, or who are simply struggling to remain engaged, having demos may help keep them focused. One can imagine that, if exposed to enough such diversions, or perhaps, the right diversion, students like Shawn may find something of profound interest [5].

4. Develop hands-on mini-projects that students can do in short periods of time. Having these structured projects available can help expose students to novel ideas that may trigger their

interest and help them better recognize the role of different scientific phenomena in their everyday lives [7][8]. At the same time, these are the types of things that students can work on, while the "geeking-out" students work on projects of their own volition. These types of projects also provide additional exposure in a structured and sufficiently scaffolded setting.

5 CONCLUSION

The opportunities available through the student directed digital fabrication labs are plentiful. Students have the chance to engage in meaningful project based learning in a non-threatening, supportive environment. By recognizing and planning for involvement from students of all levels of interest, the LFL, and similar spaces, can truly be a place where individuals from all backgrounds are able to be successful and stay fully engaged.

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