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Developing a Learning Analytics Dashboard for Undergraduate Engineering Using Participatory Design

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Developing a Learning Analytics Dashboard for Undergraduate Engineering Using Participatory Design

Universities have been seeking innovative ways to measure and track student learning outcomes and empirically identify the conditions that lead to their development. Academic analytics answers this call by focusing on the "intersection of technology, information, management culture, and the application of information to manage the academic enterprise" (p. 2)[1]. Using technology, the approach brings together large data sets, statistics, and modeling. Though it is typically used for administrative decisions, such as enrollment management, it can also be used to improve teaching, learning, and student success.[2]

Learning analytics is an emerging field that uses existing student traces to aggregate and illuminate student data through visualizations and dashboards in an attempt to improve learning outcomes. Though there are currently efforts both in vendor and academic arenas to try to understand long-term learning and decision-making effects of such dashboards, there appears to be a missed opportunity in the development of these dashboards in vivo using human centered usability practices. Missing from learning analytics research is an investigation of how students interact with data or how faculty can use data to change teaching.[3] Practices that select relevant data traces and develop dashboards *with* learners instead of *for* learners may lead to stronger student self-efficacy, build on existing social learning theory, and benefit from perspectives found within human centered design practices.

Our interdisciplinary team of faculty and graduate students from engineering education, computer science, human computer interaction, human centered design, learning sciences, and visual communications are following a mixed-methods, human centered approach to dashboard development that breaks new ground in learning analytics by involving the end users throughout the dashboard design and development process. In this paper we describe how such participatory design (PD) approaches may better inform development of and ultimate sustainable student use of computer-based dashboards that visualize learning analytics data. We present an example from our initial PD session with a group of undergraduate engineers.

Learning Analytics

The increasingly popular field of learning analytics is situated as an interdisciplinary research attempt to make meaning of latent and explicit student traces generated through networked interactions to increase learning or performance. This meaning making comes in large part by collecting any number of digital student traces like course management system log-ins, time spent on task, social networking, sensor tracking, etc. and applying practices found in *big data* analytics to provide students, instructors, and administrators with products such as visualizations more commonly referred to as *learning dashboards* to drive action.[4,5,6 ,**Error! Bookmark not defined.**] What this means to students, instructors, and administrators in terms of learning and the learning experience is still up for debate. However a clear divide remains between developers, designers, and researchers in the technical, pedagogical, and social domains concerned with this field of inquiry[7]. Additionally, and more concerning, is the conspicuous absence of student users interacting with researchers in the field.

Technological innovations that enable learning analytics could transform education because they connect data, delivery, and outcomes in a purposeful conversation. To be effective, all stakeholders must be involved in development, and so learning analytics must consider how to communicate findings to drive understanding and deeper learning.[8,9] Therefore, a primary goal of learning analytics research is to enhance learning by supporting learners through the creation of visualization tools, most often referred to as learning dashboards, with the explicit intent of improving learning, instruction, and decision making.[10] Researchers and developers of dashboard tools cite increasing student motivation, autonomy, effectiveness, and efficiency of learners and teachers as important drivers.[11] Creating meaningful learning dashboards is a way to support both self-efficacy[12] and self-regulation,[13] and in turn, improve learning by leveraging technology so a learner can observe their performance, compare their performance to a standard or goal, and then react and respond to the perceived difference through the creation of a feedback loop.[14]

Such tools that have seen success, most notably the Signals Project[15] and products developed in the vendor space within systems like Kahn Academy, Blackboard, and Desire2Learn, have made great strides in helping at-risk students. These learning analytics tools, however, offer little information as to whether or not the students actually desire these types of tools or the information that they provide. Unfortunately, until relatively recently with calls for articles on topics such as self-regulated learning and learning analytics, the literature tends to point to an explosion of interest in the development of tools that seem to be more about the framing of the discipline and regrettably less about learning and even fewer about students.

Human Centered Design

Participatory learning analytics research by Hickey, Kelley, & Shen[16] builds on the idea of action research found in the field of education, intersects with design-based research found in the learning sciences, and makes a logical leap to PD practices in found in human centered design. Human centered design (HCD), an interdisciplinary field sometimes referred to as user-centered design, is a practice where researchers and designers, often in engineering and design fields, work with participants as they develop new products. Often used to develop products and not overly concerned with education, the six approaches of HCD – participatory design, ethnography, the lead user approach, contextual design, co-design, and empathic design[17]– could hold the potential to bring research from across fields together, as action research, design-based research, ethnography, and empathic design share many similarities and offer one possible pathway to create dashboards *with* students instead of *at* students.

Why is this important to learning analytics? Friesen[18] suggests that student perspectives need to be taken into account explaining that, “Students' needs and their learning preferences are complex and vary over time; something similar can be stated about their engagements with printed text, to say nothing of their interactions with online and/or multimedia content” (p. 10). Similarly, George Siemens[9] suggests that, “The most significant challenges facing analytics in education are not technical. Concerns about data quality, sufficient scope of the data captured to reflect accurately the learning experience, privacy, and ethics of analytics are among the most significant concerns” (p. 394) leading many in the field to look at ways of including students in the research and design process. Our overall approach, summarized by Figure 1, meets this call by following PD of a learning analytics dashboard for undergraduate engineers.

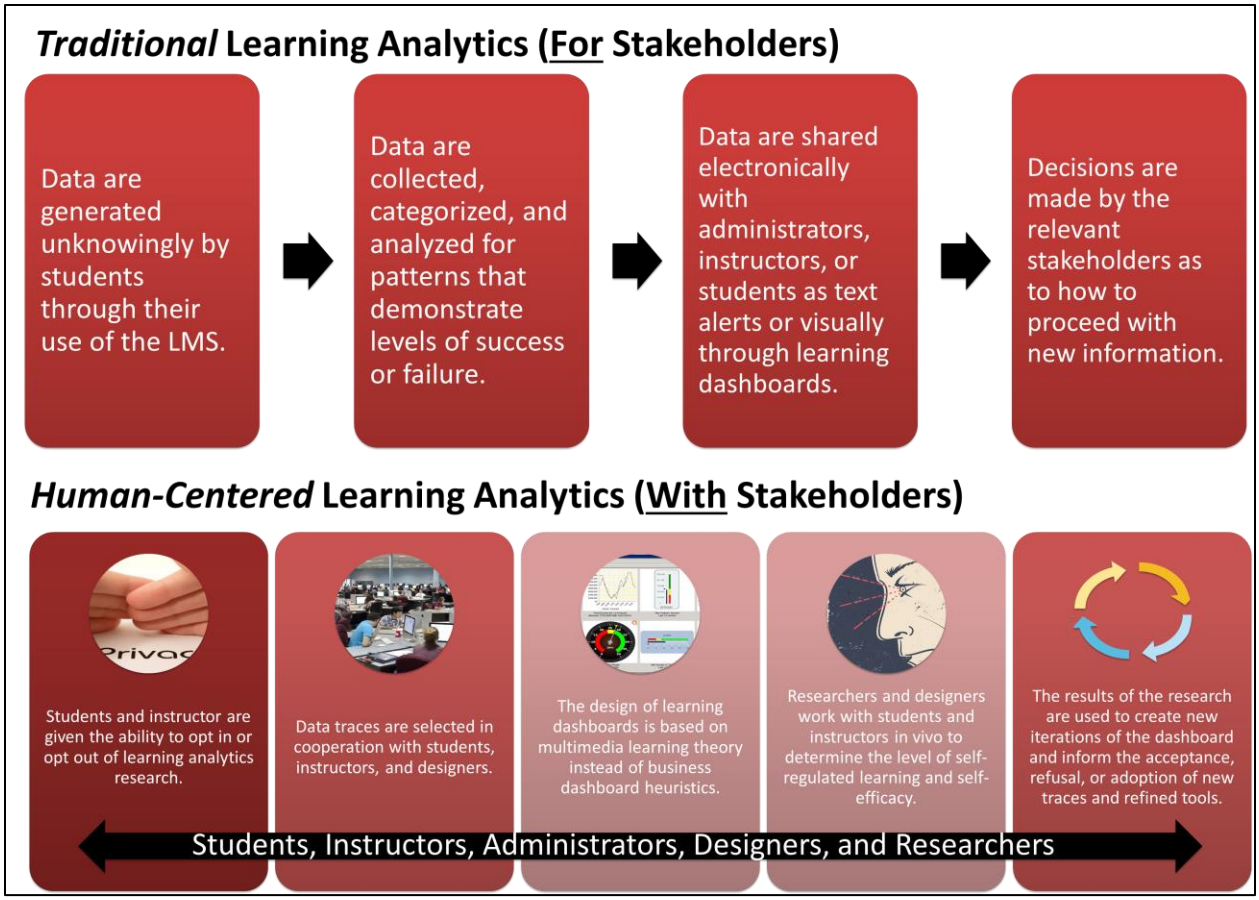

Figure 1. Summary of a human centered learning analytics approach, which guides our work.

Data and Methods

In this paper we report on the approach we took in our first PD session held in Summer 2014 with a group of eight engineering students enrolled in a first year general engineering course. Our objective is to demonstrate the PD process and describe example findings that emerged from this kind of design approach that traditional learning analytics approaches may have missed. We do not seek to generalize findings nor are at the stage of full dashboard development and implementation.

Researchers in attendance who participated in discussions and took field notes included: one faculty member in Engineering Education, one faculty member from the School of Visual Arts, one computer science doctoral student, one instructional design and technology doctoral student, and four engineering education doctoral students. The session's protocol was organized to gather the following information from the participants: 1) defining success as a university student, 2) identifying potential data streams and information, 3) usefulness of peer benchmarking data, 4) credibility and ethical issues with learning analytics, and 5) students' use of technology for learning. During the last third of the session, students split into teams and produced designs of a learning dashboard. Participants were given ample opportunities to express and discuss their insights on data visualizations, data streams and variables, and how these might merge together to create a dashboard to satisfy different users.

We analyzed the PD session in multiple ways. All participating researchers met to review field notes and identify initial impressions and consistent themes that emerged across the team. Data were also transcribed to allow for appropriate analyses and imported into NVivo, a qualitative data analysis software package. Both faculty members, the computer science doctoral student, the instructional design and technology doctoral student, and an engineering education doctoral student all took an initial pass through the data following an inductive, constant comparative method to allow themes to emerge from the text.[19,20] This process allowed the team to systematically examine themes across participants. The full team came together to discuss codes and developed a common code book. Sections of the transcript were then fully coded using the new codebook by both faculty members and the instructional design and technology doctoral student—one graduate student coded the entire transcript to maintain at least one consistent coder across pairs of coders. Following the individual coding process, both coders met to discuss differences in coded sections of the transcript and settle upon one final coded transcript. Using multiple coders enhances the reliability and trustworthiness of analyses.[21]

Results

Findings from this initial work will inform future PD sessions with students and faculty, help our team develop initial wireframes of a student-driven dashboard, and help determine potential data traces that will receive our focus as we carry out learning analytics quantitative modeling. Participants helped identify a variety of potential data points that could be funneled into a learning analytics model. These included the following:

- student records data, such as GPA, class schedule, financial information, personal backgrounds, contacts and family members, and criminal histories
- web surfing and downloads on university servers
- membership on different listservs
- social profiles (e.g., "Facebook is a way to measure your non-academic life.")
- student ID data (e.g., "There could be a program that just collects all the student ID data and compiles it, which would give the university a good indication of how you spend your time.")

We arrange the remainder of this section under themes that arose from the focus groups that we were not necessarily anticipating and present supporting qualitative data from the focus group (Figure 2). Such themes and elements may not have come under consideration had we not followed the human centered design process.

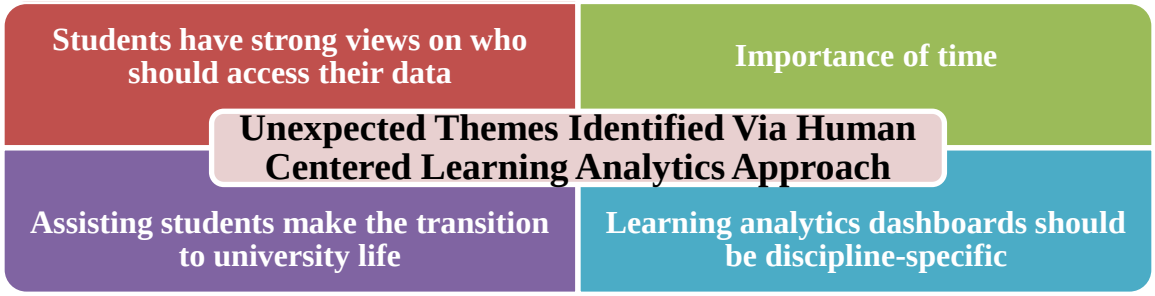

Figure 2. Unexpected themes emerging from the human centered learning analytics design

Students Have Strong Views on Who Should Access Their Data

One portion of the PD session focused on data privacy and some of the ethical considerations associated with learning analytics, as summarized by Figure 3.

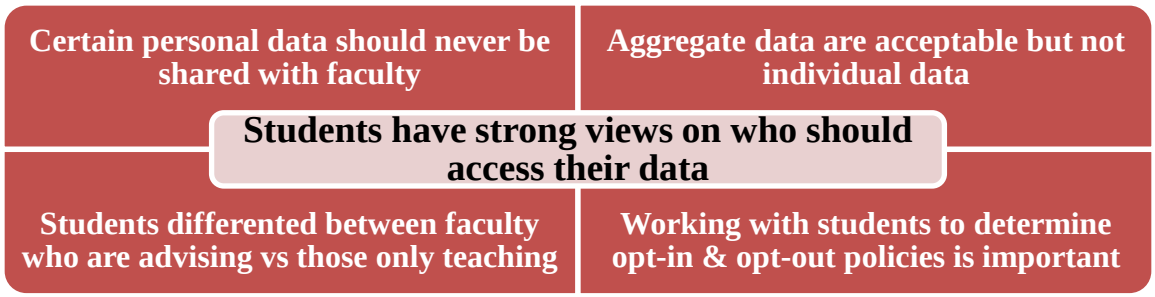

Figure 3. Summary of theme 1.

Students laid out some basic data that faculty members in particular should not be able to access under any circumstance, such as social security number, financial information, and personal health information. They also cited the importance of students maintaining the authority to determine what individual data are shared across the institution. As one student noted:

> There are some students that don't want to share everything with others . . . A lot of information is not unique to the learning situation. It is a student's responsibility not a faculty one.

Rather, students felt more comfortable being able to opt in or out of each aspect of any kind of learning dashboard put into practice:

> [Student 1]: I would opt out of all but. Well other students may feel differently so to provide that would be good. [Student 2]: Student2: It allows for the data to exist and without forcing all of the students, you wouldn't want to but I wouldn't care so why not?

Students also described different circumstances where faculty members should and should not be able to access academic-specific data. When asked about faculty accessing students' grades in other classes, one student noted, "Should they need to have access to that? They shouldn't need to, but I do not think it matters if they do." Another student was a bit more cautious:

> So that [decision to grant access of my information] ultimately comes down to the goal of the faculty member. I do not know who makes the call for that. It is bad for a faculty member [to have access to other course grades] since you do not want them to treat you differently or stereotype you based on a previous or other work—that's wrong. However, they are still an educator so it is their responsibility to know how you are doing in your educational experiences as a whole. So in that sense it is critical for them to have that information available to them.

Ultimately the group of students reached a consensus that faculty members should have access to academic data if they were serving in an advising role, but that would not be the case if the faculty member only served in a teaching role.

Finally, we heard varying perspectives from the students on data access based upon the purpose of using the data. As one student argued:

> I respect the different views on faculty, but I would almost take it from a different perspective. How they are going to be using it? Let's say you guys are doing research and you are doing this scenario where you are looking at everything as a whole . . . of your dots in a million dots; that does not bother me. But if it is a teacher that I have, and they are just going to look to see if she is bad in all her classes or is she just doing well in this one, or whatever they wanted to know . . . so aggregate versus individual.

Importance of Time

Students repeatedly pointed to time elements as being an important characteristic of a dashboard and saw value in incorporating scheduling or time management to lead to their overall success, as summarized by Figure 4.

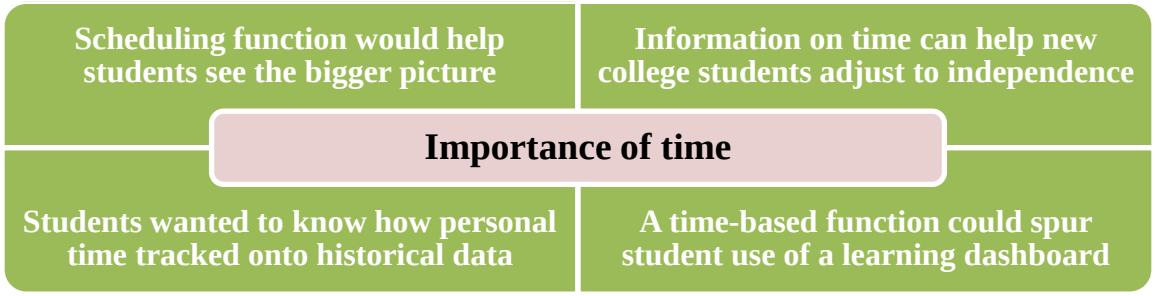

Figure 4. Summary of theme 2.

A scheduling function within the dashboard could be useful in helping students maintain sight of the bigger picture instead of focusing on individual courses. As one student noted:

> You might have three tests in three different classes on the same day and then two days later you have another test. So you are not thinking about how you are doing on each individual piece. You're not thinking about the big picture.

Other students expanded upon this idea and described how mobile notifications would be helpful for keeping track of due dates and appointments. They noted the utility in having calendar integration capabilities where dates and times sent in emails or in class materials could automatically auto-populate onto a calendar system.

Beyond basic scheduling, students wanted to know how their personal time on tasks related to their classmates' time on tasks, historical data, and performance data. Such functionalities that bring awareness to those relationships could enhance students' metacognition and their ability to self-regulate their learning processes. For example, one student described that knowing how long it took students enrolled in previous courses to complete a given assignment provided insight on his understanding of the class material. Students agreed that a dashboard that made such data available would be valuable, although there was some disagreement in how such information might be useful. One student saw that as an opportunity to identify the appropriate peers to seek out for help:

> If my classmate is spending a half an hour [on an assignment], and I'm spending like an hour or more, that's me wasting time . . . that's like one of my biggest pet peeves is wasting time. So if I see that it takes somebody thirty minutes, then yeah, I would group

> up with them, talk to them about why does it take me so much longer . . . like you know seeing their perspective on things

Contrastingly, another student felt like knowing averages for the class would be helpful as a data point but argued that such information was only so meaningful:

> The only thing that I would be interested in for that perspective is knowing just kind of the average time on a whole of the class takes to work on it . . . I think anybody else's time on it is going to be a poor measure of how much progress I need to make on the assignment, and how much time I need to invest in it . . . I don't think anyone can tell me how much I need to work or not work on it on a specific assignment to achieve something.

As these first year students were still early in their programs and adjusting to life on their own, they also pointed to how such a dashboard especially could help with that transition, perhaps more so than with their in-class learning. The participants were most excited about the potential for a dashboard to coalesce information that they could use to make informed decisions about how to spend their time and not waste time waiting. For example, one student noted:

> This is going to sound off topic, but going with the tracking, I would love to know how many people have recently swiped into McComas [Gym] so I know if it's too busy . . . Also if the washer and dryers are full, that would be good [to know].

Other students cited similar ideas, such as "what busses are coming, you can see the schedule to see how long it is going to come." We noticed in the design part of the PD session, each team of students incorporated such time-based information elements into their designs. Therefore, though such elements were outside the scope of the original intent of our learning analytics dashboard, the PD session suggested that such elements may be useful for initially drawing students to the platform. Driving student traffic to the dashboard should be an important consideration in its eventual success.

Assisting Students Make the Transition to University Life

In addition to helping with time management, students pointed to the potential usefulness of a dashboard in easing the transition into university life, which was also outside the scope of our original learning analytics design (see Figure 5).

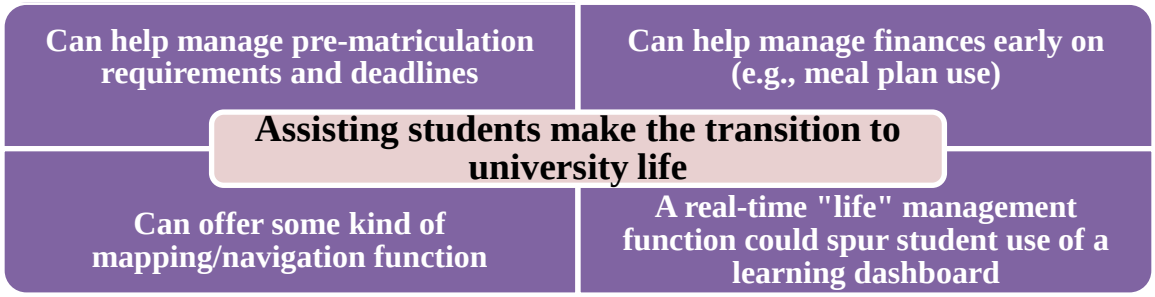

Figure 5. Summary of theme 3.

Students pointed to a variety of "life" ideas that would ease the transition from attending high school and living at home with mom and dad to being on campus. A single dashboard

environment would have been helpful during the summer prior to matriculation, as described by one student:

> Like a checklist, I could never find one. You know it was a little overwhelming because I didn't know. I didn't want to miss something. There are just so many things you have to turn in, your health stuff, the financial [forms], contacts, and I just didn't want to miss something and later on miss the due date . . . so I was jumping around going to every little thing just to see if it had a due date

Demonstrating the added value of a dashboard to a student before they arrive to campus in this manner could potentially be a way to encourage later usage for functions related to learning.

Once on campus, students pointed to a number of different applications of a dashboard that would help ease their transitions to university life. For example, "You're obviously not going to know where any of the buildings are . . . just [knowing] the place itself, so like where the dining halls are, or where your classes are and all that." Other students pointed to having early troubles managing their meal plans because they did not have the information in an easy to access location like a dashboard:

> My only real issue was like managing your meal plan. I kind of made a little mistake… like not eating steak every day. I went to the little smoothie shop in the [dining hall]. Ooh, pricey. So I was like oh, I will spend 15 flex dollars a day. Sigh, it was not great. I was supposed to spend like 15 actual dollars a day, so like 7 and a half dollars, so uh, I was out of money by like October.

Developing a system that helped students recognize these "life" transition misconceptions in real-time as opposed to later in the semester would have a real value proposition for students.

Learning Analytics Dashboards Should Be Discipline-Specific

Student participants emphasized the need for any learning analytics dashboard to be designed specifically for undergraduate engineers (see Figure 6).

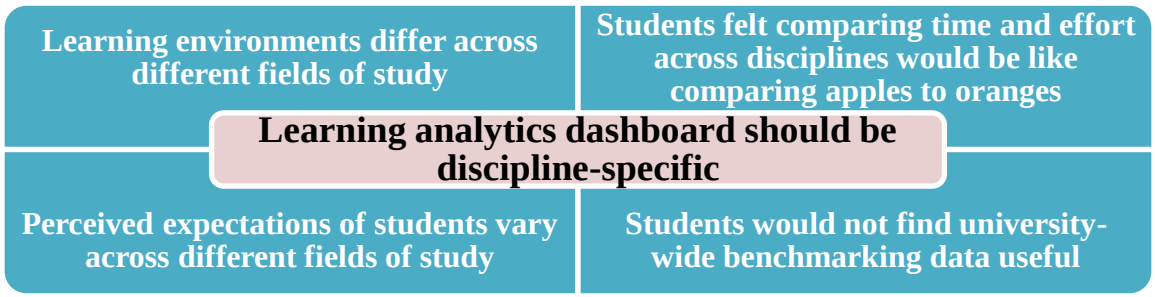

Figure 6. Summary of theme 4.

Participants consistently pointed to differences in learning environments and perceived expectations of students in terms of academic rigor. As one student noted when describing the potential utility of benchmarking himself to students from across the university, "I can't say I think I could compare myself to someone in a different major. I think that's kind of comparing apples to oranges." Another student agreed with this sentiment:

> Maybe it's only important to compare yourself to other people within your major. But the reason I say that, is for me at least, if I know that someone is better than me [academically], it gives me more motivation to do better than that kid.

One other student noted:

> I have a lot of friends that are outside of engineering, and not that I like look down on their majors and look down on the work that they've done, but you can see how they might be doing really well in this, but it can't really be compared to what I'm doing over here [in engineering]. And so that's why I might say that their data is different.

Even when describing available free time and the potential usefulness in a dashboard helping structure and manage outside of class time, student participants continued distinguishing between academic disciplines:

> I mean engineering is obviously going to take a lot more effort and a lot more time than any of those majors can, so I'm not sure if you can compare how much free time you have and ask [non-engineers] for how much free time they've got.

Though we will continue pressing this issue in future PD sessions, it was evident that these engineering students strongly felt like learning dashboards that aim to provide benchmarking data should remain discipline-specific to be useful.

Conclusion

In this paper we argue for a human centered design approach to developing a learning analytics dashboard. Instead of designing a system *for* students, we are designing a system *with* students. Such an approach should better inform development of and ultimate sustainable use of learning analytics dashboards. Results from our initial PD session held with a group of undergraduate engineers identified the features of learning dashboards that students deem necessary to spur their interest and engagement with the systems. We demonstrated the value of taking such a human centered design approach by identifying several themes of features that students described that our team may not have considered in developing a learning analytics dashboard without student input. These themes included: 1) Students Have Strong Views on Who Should Access Their Data, 2) Importance of Time, 3) Assisting Students Make the Transition to University Life, and 4) Learning Analytics Dashboards Should Be Discipline-Specific.

What became evident in conducting this first PD session was the need to engage students throughout the process. Indeed, students demanded agency throughout the process, including how we should expect them to engage with such a system. As one student summarized:

> So when you're creating a dashboard [do you want to] instruct the student or inform the student? . . . The general thing behind it, you know at least from my perspective, is that students want information, but at the end of the day they want to make the decision themselves . . . I think they'll be frustrated by a system that's built that thinks it's smart enough to be able to make a decision.

As our team moves forward through subsequent PD sessions with students and faculty, we are confident that our final dashboard designs meet the stipulations specified by students and users, who will ultimately determine our project's uptake and eventual success.

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