Contradicting Objects: An Activity Systems Perspective Towards Transformative Learning

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Abstract

Despite decades of research on active learning, many university STEM classes are taught using less effective transmission-based approaches. Students are commonly considered to be "resistant" to active learning, and faculty are thought to continue using passive teaching methods due to a combination of capitulation to student demands and lack of time or incentive for change. We seek to problematize this perspective by using third generation cultural-historical activity theory (CHAT) to analyze the activity systems of faculty and students in two engineering core courses. We find that all participants show evidence of two contradicting objects: meeting the demands of *transactional schooling* and achieving *transformative learning*. They respond to contradictions between these objects in varying ways, leading to different course structures and different learning outcomes. Based on an understanding of faculty and students as invested in transformative learning but grappling with complex demands, we encourage a shift in perspective from offering faculty strategies that they can use to combat student resistance to active learning to, instead, considering the ways in which the disciplinary community can provide support in shifting activity systems to resolve contradictions and achieve transformation.

Introduction

Decades of research into reform teaching practices have shown that active learning improves student outcomes [1]-[4]. However, many STEM classes are still primarily passive, with lecture as the main teaching method [5]-[7]. One often-cited reason for this discrepancy is that students are "resistant" to active learning pedagogies [8]-[12]. Faculty, too, are reported to be resistant to adopting these pedagogies, sometimes because of the conflicting claims on faculty time [13] in a divergent rewards system [14], [15] in which teaching is (or at least, is perceived as) secondary to research output in the promotion and tenure process at research-based universities [16]. In short, a common understanding might posit that students, who care more about their grades than learning, prefer passive instruction, in which they do not have to do the work to actively construct their own understanding. Thus, they give lower student evaluations in courses taught using active learning pedagogies, even if they learn more in the latter courses [1]. Instructors, then, acquiesce to student resistance, unwilling to take the time away from their research to incorporate active learning pedagogies that would enhance student learning, because doing so would not be rewarded in the faculty evaluation process.

In this work, we take an activity systems approach [17] to problematize this understanding of student and faculty resistance to reform pedagogy. It builds on previous work in our group in which an activity systems lens has been used to understand student participation in clubs [18], rote *versus* conceptual learning [19], and an instructional reform initiative [20]. In the present study, we interview eight members of the faculty and student activity systems encompassing two concurrently-required core courses within an engineering department at a research university and characterize participants' understanding of these systems. In our analysis, we find that both students and faculty share two objects which are in contradiction. One object, *transactional schooling*, aligns with the common understanding that students want to achieve their desired grades with as little struggle as possible, while faculty instructors want to spend as little time on

teaching as possible while meeting departmental requirements, including receiving satisfactory student evaluations. However, each of our participants, to varying extents and in different ways, showed evidence of pursuing a second, contradicting object, *transformative learning*. Students are willing to struggle through confusion on the path to learning, and value learning for the sake of making a difference in the world, not just for a grade. Instructors aim to help students develop problem solving skills and conceptual understanding, regardless of the impact on their evaluations.

Students and faculty, then, may not simply be resistant to active learning: we claim instead that they are engaging thoughtfully with their environments, but are grappling with contradictions in their objects, and between their objects and the other aspects of their systems, and are responding in different ways, which sometimes enforce the primacy of traditional, transactional schooling. Here, we reframe the question of how improving pedagogical practices should be approached. Instead of asking how we can reduce student and faculty resistance to active learning, we ask: how can we, as an engineering education community, resolve the contradictions between objects to better support transformative learning?

Theoretical Framework

We use third-generation cultural-historical activity theory (CHAT) [17], as depicted in its original formulation in Figure 1, to understand the activity systems inhabited by faculty and their students. "Third-generation" indicates an evolution of the theory through three major iterations. First-generation CHAT, pioneered by Vygotsky, introduced the idea of mediation: the response to a stimulus was mediated by a cultural artifact [21]. An important contribution of this theory was that it emphasized the necessity of looking at the subject and their goals, or objects, within the cultural-historical context, which mediates their action. A common illustration of first-generation CHAT is a triangle connecting the subject through whose perspective the activity is analyzed; the object, or problem space, which drives the activity and leads to outcomes; and mediating artifacts or tools engaged by the subject in pursuit of the object [17].

Second-generation CHAT, pioneered by Leontiev [22] and operationalized by Engeström [23], expands activity systems to include factors related to collective, as opposed to individual, activity. In second-generation CHAT, an activity system (depicted by one of the two large triangles in Figure 1), is comprised of six interacting elements: the subject; object; and tools, as described above; and also the community of other actors in the activity system; the division of labor among members of the community; and the rules, explicit or unspoken, that regulate actions [23]. In this study, we are interested in two interacting activity systems: that of the faculty teaching courses and that of their students, taking several classes concurrently and balancing their time with other priorities. To analyze the interactions of these two activity systems, we turn to third-generation CHAT [17].

In third-generation CHAT, two or more activity systems interact, and, through this interaction, their objects take on dimensionality (Figure 1). Initially having formulated the theory in a healthcare context, Engeström describes $Object_1$ as "raw material," such as a patient entering a doctor's office, $Object_2$ as a "collectively meaningful object constructed by the activity system," such as the patient as a general representation of health or of an illness, and $Object_3$ as a jointly constructed object between both activity systems, such as a care plan agreed upon by doctor and patient [17].

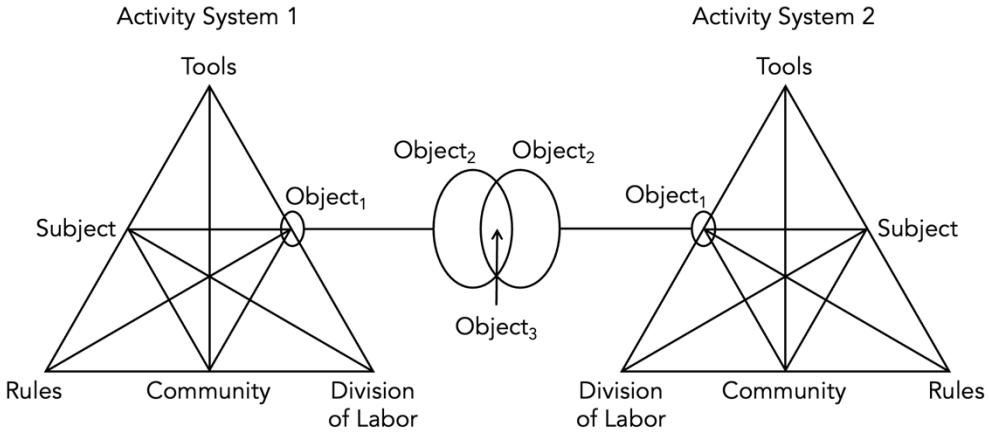

Figure 1. Third generation cultural-historical activity theory (CHAT) [17].

To align with the Findings from the study reported here, we have adapted Engeström's framework to fit our educational context, as shown in Figure 2. The faculty and student activity systems each are comprised of the six interacting elements discussed above, similar to those shown in Figure 1. The subjects of the faculty activity system are Ash and Birch, the two faculty instructors we interviewed, and their community includes other faculty, student instructors, staff support, and others. The subjects of the student activity system are students taking both Ash's and Birch's classes, and their community includes their classmates in those classes as well as other peers. We modify Engeström's depiction to account for a differing set of objects in this specific context. Unlike in Engeström's doctor and patient activity systems, we do not use the construct of $Object_1$. Additionally, both faculty and students have two distinct collaboratively meaningful objects – *transformative learning* ($Object_{2A}$) and *transactional schooling* ($Object_{2B}$), as explicated in the Findings – which we depict separately to facilitate analysis of their interactions.

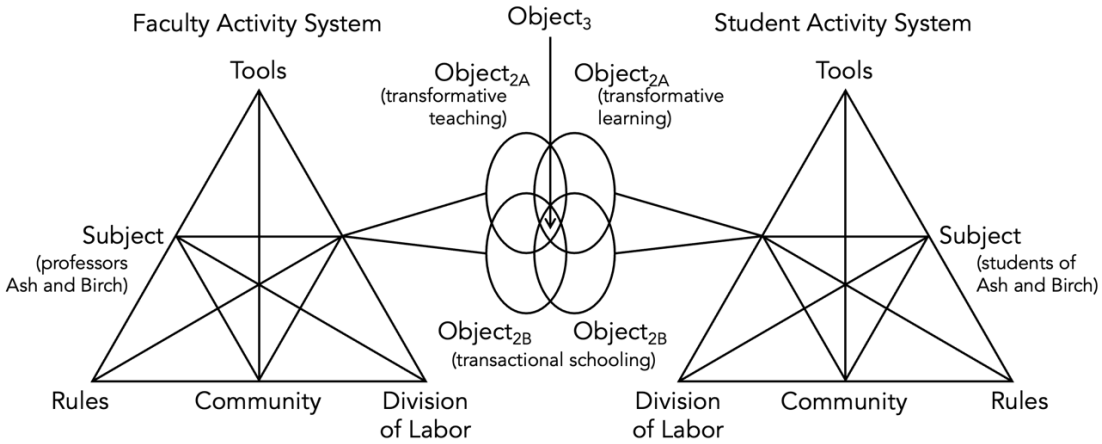

Figure 2. Third generation cultural-historical activity theory (CHAT) [17] adapted to the context of this work: the activity system inhabited by two faculty instructors, Ash and Birch, who teach concurrent required classes in the same department, and the activity system inhabited by their students. We find two distinct $Object_2$s and study the contradictions that must be resolved to reach a shared $Object_3$.

These dialectic objects reveal another aspect of activity theory: contradictions. Engeström describes contradictions as "historically accumulating structural tensions within and between activity systems," which can act as an impetus towards change [17]. In many cases, contradictions exist between different elements of an activity system; for example, Goodnough describes contradictions between the rules imposed upon teachers by prescribed curricula and their object of teaching students using inquiry-based methods [24]. In this study, we focus largely on contradictions within one aspect, the object of activity: namely, contradictions between transformative learning and transactional schooling. The resolution of contradictions is understood to be a mode of "collective journey" towards "expansive transformations" [17]; the purpose of this study is to explore the contradictions between the objects of transformative learning and transactional schooling, and how we as a community might move towards expansive transformation.

Methods

Participants, context, and positionality

This work is part of a larger ethnographic study in which the first author, a post-doctoral fellow, served as an instructor in an engineering department at a research-focused institution and studied the ecosystem of that department from within. The first author is a U.S.-born white woman with bachelor's and Ph.D. degrees in engineering who is now pursuing engineering education research under the mentorship of the second author, a U.S.-born white man with a joint faculty appointment in engineering and in education. Based on negative experiences as a student and teaching assistant at research-focused institutions, the first author began this work with a perception that many, if not most, faculty primarily pursued a transactional object in their teaching. Based on an understanding that faculty were motivated by student evaluations required for promotion and tenure, she advocated for changes to the incentive structure for faculty, especially in the evaluation of teaching, in the hope that such changes might provide a transactional motive for faculty to improve their pedagogy. Engaging in this research changed her perspective; while she still believes in changes to the promotion and tenure evaluation process, she now believes that such changes should be one part of a more holistic shift in faculty and student activity systems with a goal of recognizing and supporting their ongoing pursuit of transformative learning.

As part of the larger ethnographic study that forms the core of her post-doctoral research, the first author interviewed a range of community members, including undergraduate students, graduate students, and faculty, and observed classes and departmental events. For this study, we focus on two courses as a subset of that data. The courses taught by Ash and Birch are two required undergraduate engineering core courses taken in the same class year by all undergraduate majors within the department; as such, all of Ash's students are also in Birch's class, and vice versa. Participants include faculty instructors Ash and Birch, three supporting student instructors (for example, graduate teaching assistants), and three students who are all taking both classes. All eight participants consented to participate in the study. To protect participant anonymity, we use pseudonyms for all participants, do not disclose the racial or gender identities of the participants (thus using gender-neutral pronouns for all), and do not disclose the topics of the courses or in what year of their studies students typically enroll in the courses. Some of these considerations are likely significant factors in understanding the activity systems at play – for example, the rules

governing activity may be different depending on a participant's race or gender – but to protect anonymity, we do not explore them in this work.

Data sources and analysis

The principal data sources for this work are semi-structured interviews with all eight participants. All interviews were conducted in person with the first author, audio-recorded, transcribed, and qualitatively analyzed by the first author. Interviews lasted approximately one hour, and all took place around halfway through the semester. Instructor interviews included topics such as professional history, including career backgrounds; details of the classes they teach, including size, format, structure, and support; course design considerations; assessment practices; goals and challenges for students; professional development experiences, especially around teaching and learning; and impressions of faculty incentive structures, especially tenure and promotion, where applicable. Student interviews included topics such as motivation for choosing the major; student learning goals, including both skills and perspectives; student beliefs about their instructors' goals and priorities; experiences with assessment; and alignment between instruction and learning goals. The interviewer asked follow-up questions throughout the interviews.

The general goal of the project was described to participants at the beginning of the interview as follows: "The purpose of the research is to gain insight into how instructors in higher education make instructional design decisions, such as whether and how to incorporate research-based pedagogical innovations. We are particularly interested in how instructors' environments, including department culture, university policies, resources, etc., contribute to those decisions, which in turn affect students." At the end of each interview, the interviewer asked participants if they had any other comments that might be useful for the project.

Transcription was performed using Microsoft Word, and qualitative coding was performed using ATLAS.ti software. The first author coded the interview transcripts using deductive, or *a priori*, coding [25] based on the theoretical framework, third-generation CHAT [17], to identify the elements (subject, object, community, rules, tools, and division of labor) of each (student and faculty) activity system, and discussed coding decisions with the second author until consensus was reached. The resulting interacting activity systems diagram was very complex and was meant as an analytical tool rather than a discursive one. The findings reported below were distilled from that diagram to identify key themes.

Findings

We focus here on the contradictions between four objects: $Object_{2A}$, *transformative learning*, and $Object_{2B}$, *transactional schooling*, each of which exist as a different object for students and for faculty (Figure 2). Our long-term goal is to work towards a collectively constructed $Object_3$, which requires resolving the contradictions between all four objects. We begin with $Object_{2A}$ and $Object_{2B}$ in the faculty activity system, then in the student activity system, and then explore contradictions between faculty and student understanding of each object.

Contradictions between faculty objects

One of the faculty, Ash, expressed an object of covering all of the course material while helping students to develop physical understanding. Some aspects of their teaching are consistent with an

object aligned with transactional schooling. For example, the first time they taught the course, they developed a daily schedule, to which they adhered in subsequent years. When they received positive student evaluations, they took that as a sign of success and did not try to change the course: "I had good evaluations early on, so I didn't have to spend too much mental energy being like, 'well, how do I improve it?' I mean, it was good… it's working, it's fine." Asked how much of their time they spend on teaching-related activities, Ash estimated about 25%, and, asked how much of tenure evaluations they believe are based on teaching (i.e., their perception of a *rule* governing the evaluation of teaching in their activity system), they estimated about 30%, so "within the error" they are spending an appropriate amount of time on teaching.

However, Ash also demonstrated elements of a more transformative object. They repeatedly stated that they want students to "understand what is physically going on." They said that they tell students, "'don't memorize a bunch of equations and get lost in the [math]. Yeah, that's a tool, that's not understanding anything, right? … The math will tell you the number, but it doesn't tell you why, it doesn't tell you physically what's going on.'" To that end, they incorporate a small number of conceptual questions (*tools* in pursuit of transformative learning) on homework and exams, but only as one part of a calculation-based problem; "I wouldn't make a whole problem like all qualitative, that seems intense." They also incorporate some group work in class (another *tool*). For example, they described deriving equations and asking students, "'what coordinate system are they? So how are they related conceptually? Talk about it with your neighbor.' And then we would step through kind of after giving them time to work on it." Then, Ash shows students how to solve the problem, "and then at the end, I give them more time to chat. Like, does the result make physical sense to you?"

While Ash seems satisfied with their use of active learning, the literature suggests that active learning pedagogies such as problem-based learning [26], [27] and productive failure [28] would ask more from Ash, such as giving students confusing problems to grapple with on their own. However, any incorporation of active learning and physical understanding is transformative relative to the norm. Additionally, Ash's prioritization of teaching also takes a step away from the transactional, going beyond the minimum expected by the rules of their system. They participated in teaching professional development programs (*tools*), initiate teaching-related conversations within the faculty *community*, and described teaching as something that is important to them: "I love that aspect of the job … [and] care tremendously about it".

Ash showed no evidence of thinking of the transformative and transactional objects as contradictory or even separate; to Ash, covering all of the course material on a schedule is not incompatible with students developing physical understanding, and developing physical understanding is not incompatible with spending the prescribed amount of time on teaching. The contradiction still lingers under the surface, however. For example, Ash taught the course for the first time remotely, so "I had to put together slides and I don't generally like teaching entirely from slides." Despite multiple in-person deliveries since this initial remote development, and despite thinking a less slides-heavy practice would be preferable, they still use their originally developed materials (*tools*) with little modification; "the way I do it is a little bit of an artifact." The implication is that there is a contradiction between the objects of student-centered, transformative pedagogy and the demands of a transactional system, in which re-developing course materials to best serve student learning would not be rewarded commensurately with the time required, especially if, according to student evaluations, "it's working, it's fine."

For Ash, the two objects of transformative learning and transactional schooling and the contradictions between them are influential but unacknowledged. Birch, on the other hand, feels the contradictions deeply. The object of transformative learning is prominent: they focus on helping students to develop problem solving skills – "'how do I solve a problem? How do I think about something that I don't know the answer for right away upon sight'" – and describes those skills as "hard. This is it's a new brain skill. It is definitely a new muscle to build." To work on building this muscle, they have changed their practices responsively to the students. They restructured the course multiple times in the last several years, largely by integrating problem-solving into class time and advocating for the addition of a weekly problem-solving session (a *tool*, governed by *rules* about both credit hours and student instructor *division of labor*). When students were struggling with concepts, "I tried to spend more time on problems. I… let go of some of the content, which is fine. Instead… of trying to get through more of the content, I try to build a lot more practice setting up problems… you know, 'OK, first sit down and try to sort through yourself.'" When it comes to content and pacing, "I'm trying to roll… with the need and try to be flexible with my schedule."

However, aspects of transactional schooling contradict with and make more difficult Birch's object of transformative learning. They recognize that they are acting counter to some of the *rules* of their system, which were shaped by an object of transactional schooling, and thus are out of step with their *community*: "I try to do a lot of conceptual learning. I put aside some of the calculations, et cetera for it, but I think I am sort of the outlier. I'm an– I'm the odd one out and I'm aware of that." Asked if they think about student evaluations when planning a course, they said "I sometimes do think about it because [of promotion] and I think it, you know, evaluations do get under your skin." However, despite the transactional currents in the activity system, Birch still makes teaching decisions in pursuit of transformational teaching: "But I mean… do I try to teach better just for the sake of, like, tenure and promotion? And the answer is no. I probably put more effort into it than I would have if I was just trying to get over the bar. Yeah, I do it because I like to." A graduate student who has served as a teaching assistant for Birch's course was more direct: "when the course evaluations come in, it's always good for [Ash]… [Birch] is always lower… [But in Birch's class] they're actually learning, so I don't know."

Contradictions between student objects

Each of the interviewed students exhibited aspects of a transactional schooling approach. They acknowledged that grades are a measure of success for them and feel that grades are an important factor in achieving career goals like admission to graduate programs (governed by *rules*) or a lucrative post-graduate job offer; one student choose to major in this engineering discipline in part because "you get the most amount of jobs, and the starting salary is high." When it comes to grades, another student said, "I feel like the way I measure– like the quantity I have for my success… is my grades, and if in an easier class I get better grades then, like, just the natural conclusion is that there was a good teacher." The implication is that both students and professors are seen as successful if students get good grades, regardless of their understanding of the material.

Another element of transactionality was evident in student perspectives on their time. One student expressed a willingness to put in work to learn, but to a limit: "you can always do more, but like… can you just not spend any more time on something because you have other classes and you need to sleep, you need to eat?" Considerations of time usage also extend to asking questions in class.

One student, who said they ask questions in class "all the time," said, "I feel like the vibe is that I'm wasting class time asking this question, and I'm confident enough that I don't care, right?" They justified their frequent question-asking with explicitly transactional logic, saying, "I'm paying for this class, I have every right to ask as many questions as I want." Another student, however, had a different perspective on asking questions: "there are people that are asking smart questions… so it can feel, I think, intimidating. Because… you're sitting there and you're, well, yeah, I didn't even know what half those words meant, so how am I possibly going to ask a question and not sound dumb?" This student asks questions more "in office hours than in lecture, because a lot of times the lecture time is limited." Even if asking questions in class would enhance their learning, they prioritize an object of covering the material in class, following unspoken *rules* about how class time is spent and what kinds of questions ("smart" ones) are worth asking.

However, students also expressed evidence of objects aligned with transformative learning, which are often in tension with transactional aspects of their activity systems. The student who chose engineering in part because of job and salary considerations elaborated a second motive: "I want to do research and I want to, like, you know, be able to manufacture like a new antidepressant because that's such a huge issue… It's incurable. It's just treatable… As someone who dealt with that, … I understand. … I want to be able to, like, do that and … I want to do research and you need a PhD," but in order to get a PhD, "[applications are] always like 'list your GPA.' They're always like, 'we recommend having a GPA higher than 3.0.'" This student wants to learn engineering to make a difference in a real-world issue important to them, which is a transformative approach, but cannot escape the transactional need to get good enough grades (according to the *rules* governing graduate school admission) to do that work, let alone the transactional fact that "we need money to live in today's world."

Another contradiction arises in Birch's class, where students are given problems to grapple with in groups before submitting an answer. Asked if this practice helps their learning, one student said, "I think it's a good tool, [but] it's kind of annoying… [because] it's also graded on correctness." Students value problem-solving and are open to transformational learning practices such as problem-based learning, but the object of transactional schooling gets in the way: how can students be comfortable grappling through a state of confusion when the *rules* around grades punish them for not knowing the answer?

One student described consciously working to transition to "learning for the sake of learning as opposed to learning for the sake of being able to replicate it at some point," and another described the decreasing importance of grades in how they measure their success: "A lot of [students] have in the past measured success through grades… I think the grades is a byproduct of understanding at this point. I will get good grades if I understand the content and I just want to understand the content… [so that] I can explain it to somebody else… if I can explain it to someone else, I understand. I just, like, my success is my understanding."

Contrary to a transactional object of wanting to get a good grade with as little work as possible, students described a willingness to struggle through confusing problems: one student said, "I'm totally fine with being uncomfortable," and another said, "I really want to succeed, and I really want to work hard." This is compatible with a transformative learning object of, as Birch put it, building a new problem-solving "brain skill" or "muscle." However, there is a contradiction between how students and faculty conceive of the work of transformative learning.

Contradictions between student and faculty objects

Students expressed that in Ash's class, the amount of struggle is manageable and conducive to learning. One student described the exams (*tools*) as "fair," with an appropriate level of challenge: "I didn't feel like that they were just like formulaic… I felt that they were similar to the homework problems, but like I definitely like had to think about them. But I felt like it was enough thinking, and also enough like OK, I've seen this before, you know. I mean, it was like– it was like a nice mix." Another student made an analogy between learning engineering and fixing a car. In Ash's class, they said, "I am walked through how to fix the car and then [Ash] is like, 'OK, go fix this slightly more complex car. Good job. You've asked a couple of questions now go do it again, with an even more complex car. Good job.'" To these students, the balance between transactional schooling and transformative learning in Ash's class feels comfortable, and, like Ash themself, they do not experience any contradictions between the two objects, or with Ash's methods or pursuing the objects.

However, the contradiction between Birch's and students' ideas of transformative learning is clear. Extending their car analogy, the student above said of Birch's class, "we were given lots and lots of tools, but we were never actually showed how to fix the car… just like, 'all right, fix the car yourself,' which– I understand engineering is a lot of application, but I feel like you have to show me how to fix the car before I can, like, build my own… You can't just be given tools and then figure it out on your own. It takes way too long." Students expressed being "fine with being uncomfortable," but only if there is a more traditional resolution, "like you all come back together again and, like, it's explained." Another student said, "I totally get that I am a college student and that my hand should not be held, but I don't believe I'm asking for my hand to be held. I think, like, I just need a little bit of assistance."

Students seem to want from Birch the same balance of problem-solving and explaining that they get from Ash, and do not believe that asking for additional didactic teaching (a *tool*) is in contradiction with an object of transformative learning. Birch, however, believes that students need practice grappling with the unknown, even if it causes discomfort. On one exam, "when they were left alone with the exam, they were like, completely lost [about] what to do." Birch acknowledged their discomfort but emphasized the importance of learning how to "think about something that I don't know the answer for right away upon sight." It seems that for Birch, part of transformative learning involves learning to work through discomfort, and so the discomfort is necessary and cannot be removed. The teaching assistant was again more direct: "The whole point is for you to [be] learning and struggling… You have to work through it. Yeah, I don't think they've had to do that too much so far."

There are also contradictions between student and faculty ideas about the object of transactional schooling, most notably around the importance of grades. One student said, "we actually got into a whole class argument with [different engineering professor] about GPA because [the professor] was like, 'it doesn't matter at all,' and we were like 'that is so fake news.' Like [the professor was] like, 'it doesn't.' We were like, 'it does, like for grad school, they're going to look at it. It's not going to be the most abiding factor ever, but they're going to look at it, right?'" In their interviews, Birch mentioned grades only in referring to low exam scores as a "big reveal" of areas of student struggle, and Ash only in answering a question about how final letter grades are calculated. In a way, this is not surprising – in a transactional education system, students receive good grades and

faculty receive good evaluations, so students think about grades much more than their instructors do – but it is interesting to observe that neither group seems particularly focused on what the other is receiving in the transaction while being acutely aware of what they are getting.

Discussion

In a simplistic, transactional understanding of higher education, students aim to receive good grades with minimal work and confusion, which affirms their identity as good students and aids in their pursuit of career opportunities. In parallel, faculty aim to cover the requisite material in ways that will satisfy the students, leading to positive student evaluations, which contribute both to their promotion and to their identity and recognition as good teachers. From this perspective, students are thought to be resistant to active learning because it interferes with their transactional (and only) object, and faculty who wish to use active learning pedagogies to improve student understanding are given talking points [8] and strategies [12] to help bring students on board with active learning within their individual classes without sacrificing their good student evaluations.

We take a wider perspective, seeking to understand the activity systems in which students and faculty operate and how those systems impact their attitudes and actions towards teaching and learning. In analyzing these activity systems in the context of two core engineering courses, two contradicting objects emerged in both activity systems. One object is indeed aligned with transactional schooling: faculty acknowledged demands on their time, the importance of student evaluations, and a need to cover certain content areas, while students recognized the importance of grades to get a job or get into graduate school, and a desire for content to be explained clearly to avoid any confusion. However, a second object which we call *transformative learning* also emerged. Faculty stated goals of helping students develop physical and conceptual understanding of the course topic and strengthening their "brain muscles" of problem solving, while students acknowledged that struggling and being wrong can lead to learning and hoped to use their engineering knowledge to help people in the real world, not just to get a grade or a job.

We see students not as grade-seekers avoiding challenges, but as subjects of complex activity systems who are navigating a network of rules with conflicting demands on their time and conflicting objects enculturated throughout their educational journeys. They are navigating the contradictions between the objects of *transactional schooling*, in which they are evaluated for correctness and those assessments have important implications for their careers, and *transformative learning*, for which they grapple with uncertainty in pursuit of understanding. We see faculty not as research faculty aiming to meet the minimum teaching requirements, but as teachers who care deeply about their students' growth. They, too, are navigating the contradictions between the objects of *transactional schooling*, in which student evaluations are the primary mode of evaluating their teaching and departmental norms encourage lecture-based instruction, and *transformative learning*, for which time spent helping students construct conceptual understanding is worthwhile.

Using an activity systems approach helps us to understand the current state of the system and can also serve as a starting point to plot a path forwards. From this perspective, focusing on giving instructors strategies to combat student resistance can be seen as adding a tool to the faculty activity system. However, without changes in other aspects of the system, this focus risks putting the onus on individual faculty to figure out how to use those tools to swim upstream against the other pieces

of the system, which were built to reinforce traditional, transactional schooling. Instead, we ask ourselves, how can we as a community shift all aspects of our local and disciplinary activity systems to reduce these contradictions? How can we help faculty and students to navigate existing contradictions in ways that encourage transformative change?

Shifting an activity system is undoubtedly a complex undertaking, but communities might start by analyzing their local activity systems and seeking ways to modify each element to provide multi-dimensional support for transformative learning. A key aspect of activity theory is the recognition and analysis of dialectic interactions between different elements of an activity system. Making a change in one element, such as by adding a tool, can lead to contradictions with other elements, and the resolution of those contradictions can lead to transformations. To a faculty activity system built for traditional, transactional education, the faculty interviewed for this study have added a new object of achieving transformative learning, which has led to contradictions with both the original object of transactional schooling and with the rules, tools, community, and division of labor in their systems. We can support the object of transformative learning by shifting the other elements of faculty and student systems to resolve these contradictions in transformative ways.

For example, we might shift rules by changing the way that teaching is evaluated, promoting more formative assessment of teaching that foregrounds growth, and how students are assessed, decreasing the importance of canonical correctness in favor of conceptual understanding and learning. We might work to enhance community, providing both new and experienced instructors with mentors and communities of peers with whom to grapple with the challenges of shifting their practice. We might examine the division of labor, asking whether additional teaching assistants or undergraduate learning assistants [29] might support faculty working to change their courses. These suggestions are intended only as a starting point; we encourage others to examine the particulars of their own activity systems to determine what shifts might be transformative in their contexts.

Conclusions

Many approaches to improving university-level engineering teaching assume a transactional motive for both students and faculty. In such an understanding, students aim to get good grades with minimal work, and are thus resistant to active learning pedagogies, and faculty are then hesitant to use such pedagogies due to their perceived potential negative impact on student evaluations, which affect their career trajectories. In this work, we sought to understand the activity systems in which students and faculty operate, focusing in particular on their objects. We interviewed two faculty instructors, three student instructors, and three undergraduate students engaged with the classes taught by both faculty instructors. We found evidence of an object aligned with *transactional schooling*: for example, faculty recognized the impact of student evaluations, and students described the importance of grades for their future careers. However, all participants also described a second object, which we call *transformative learning*, that was in contradiction with the first. Both instructors emphasized physical understanding and a deep care for student learning, but the demands of simultaneously pursuing a transactional object, particularly in terms of time and student evaluations, made teaching for transformative learning challenging. Students described similar contradictions: they were willing to work hard to learn and to make a difference, but the demands on their time and the need to achieve good grades made it difficult for them to focus on transformative learning. Finally, there were contradictions between student and faculty

conceptions of both objects, in particular regarding the appropriate balance between explaining content to students and allowing them to practice solving problems through their confusion.

Unpacking student and instructor activity systems helps us to understand the starting point for a path towards transformative learning. Instead of designing interventions for faculty and students we assume to be motivated by transactional objects, we can see that both faculty and students are already pursuing an object of transformative learning but are inhibited by contradictions within an activity system designed around transactional schooling. Thus, instead of asking how we can change faculty and students to teach and learn differently, we instead advocate for asking how we can shift their activity systems to support them in their pursuit of transformative learning.

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