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Exploring Constraints and Restrictions Experienced by Engineering Students while Engaging in Open-Ended Modeling Projects

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Abstract

An Open-Ended Modeling Project (OEMP) is a specific project type within engineering courses that has a loosely defined goal or problem with the intent to promote student agency in both solution finding and problem statement definition. In this work, we sought to understand how students experience or perceive constraints on their agency while developing an engineering model. Agency has been previously defined as an individual's capacity to identify and act toward self-selected goals. Prior work on restrictions to student agency has primarily focused on how engineering faculty classroom decisions, school policy, or school culture constraint students' agency. Less work has focused specifically on students' experiences with restrictions to their agency.

Nine interviews from students involved in OEMPs have been analyzed through inductive coding, starting with the three major codes from a prior study that focused on student agency: restrictions due to outside limitations, how the project is structured, and accountability standards. Results show a large expansion of the subcodes which are organized under the original three codes (which are now themes due to this expansion), with some additional interconnections between subcodes.

In the large expansion of the original codes three themes and several subcodes, subcodes emerged as either positive or negative restrictions, or in some cases may have been either positive or negative depending on context. In the discussion we first summarize the findings and then discuss how the results connect with previous studies or diverge such as the emergence of the accountability theme. The additions of these codes have implications for instructors, suggesting that they may benefit from more awareness of their role in activity structure by setting checkpoints to guide students through the open-endedness challenge. Overall, instructors using OEMPs may use this analysis to improve their student outcomes.

Introduction

Open-ended projects in engineering classrooms provide unique opportunities to develop skills and ways of thinking that prepare students for professional practice. An Open-Ended Modeling Project (OEMP) is a specific project type within engineering courses that has a loosely defined goal or problem with the intent to promote student agency in both solution finding and problem statement definition [1]. In this work, we have sought to understand how students make deliberate decisions while developing an engineering model. Though students exhibit agency while solving OEMPs (e.g., see [2]) and in general students' experiences and perceptions of agency has been studied in engineering [3], [4], [5], [6], they also experience restrictions from these projects. Unlike studies on students' agency in engineering, there is less work specifically on how students experience restrictions on their agency, instead prior work often focuses on how faculty (e.g.,[7]) or school policy or culture (e.g., [8]) constraint students agency. Therefore, there exists a need to analyze students' experiences with such restrictions. This analysis may shed light not only on student outcomes but also on instructor involvement. To explore this gap, we sought to analyze interviews from students who completed in an OEMP in their engineering coursework guided by the following research question:

Research Question (RQ): In what ways do students perceive or experience restrictions on their agency while solving an Open-Ended Modeling Project?

Firstly, there was a literature review to summarize past work on restrictions on agency, including a formal definition of agency itself. The authors then share the methods and the nine analyzed student interviews inductively, making note of significant observations through memos and concept maps. Results show a large expansion of the initial codes as subsets of the original three, with some as interconnected. The analysis also revealed a view of student decisions as self-imposed restrictions, leading to the conclusion that both positive and negative restrictions are present. These results show criteria for assessing student accountability, the benefits of individual to group work, and best methods of instructor support. There is also both agreement on past analysis of these interviews, as well as new codes shown throughout the three main subcodes.

Literature Review

What is agency?

Agency has been defined in many ways but is typically considered an individual's capacity to identify and act toward self-selected goals [9]. Whether an individual has agency is dependent on how a context is structured [10], [11] and an individual's perception of that context [12]. Moreover, agency or perceptions of agency are domain-specific and thus an individual who recognizes and enacts agency in one domain may or may not recognize or enact agency in other domains or contexts.

In education research agency has been conceptualized at many levels of scope, from broad student agency that applies across most learning contexts to narrow types of agency present in specific learning contexts. For instance, several authors have explored *learner agency* which involve students engaging in autonomous, self-directed learning while taking ownership and responsibility for their actions while interacting with instructors and the learning environment [5], [13]. Another, still somewhat broad, but more focused conceptualization is epistemic agency, is defined as students engage in knowledge building, evaluation and epistemic practices or skills of a given field or discipline [12], [14]. Epistemic agency has been studied in several disciplines including science [12], [15], math [16] engineering [2], [4] and education [17]. When learning environments support epistemic agency, students are empowered as partners in their own disciplinary knowledge building instead of being limited to passive recipients from disciplinary experts [12], [15], [17].

Other conceptions of agency are focused more narrowly. For instance, Svihla et al. [6] examined students' framing agency in an engineering capstone design project. They defined framing agency as the *decision-making* processes of student designers to "understand, define, and bound the problem" they were undertaking. Unlike learner agency above, this type of agency is constrained to a limited set of actions within a particular problem context. Therefore, as these studies demonstrate, agency is multifaceted and can be studied across a wide variety of domains and breadth of activities.

Agency as a concept has received more attention specifically in engineering education research in recent years. Many studies have focused on how students perceive agency or what factors affect students' perceptions of agency [3], [5], [13]; while others explore how students enact different forms of agency including learner agency [18], epistemic agency [2], [4], relational agency [19] and framing agency [6]. Most of these studies frame agency as a positive influence in students' learning, although some acknowledge challenges students face when given more agency in their learning (e.g., see [2]).

Restrictions on Agency

As described in the last section, agency has been conceptualized and studied in several contexts or domains and this work has generally focused on the students' access to, perception of, or enactment of agency. A smaller body of work has begun to uncover the ways students may experience restrictions, constraints or limitations on their agency.

Recent work has explored instructors or school policy [7] or culture [8] influences how or what agentic opportunities (i.e., contexts or circumstances where students' agency is encouraged or supported) are deployed in classrooms. Akinci-Ceylan et al. [7] interviewed 18 civil engineering professors to identify reasons that supported or stopped them from using open-ended projects in their classrooms. Open-ended projects leave greater agency and decision-making to students. Some of the common factors that discouraged engineering faculty from providing these agentic opportunities in their classroom included lack of professional (engineering) or greater teaching experience, time constraints with implementing open-ended projects and concerns with conducting assessments for open-ended assignments. Dang [8] on the other hand, interviewed school administrators and surveyed students in Vietnam secondary schools to understand what factors mediated adoption of more student-centered educational policies the country has passed in recent years. They report that academic culture and policies affect how agentic opportunities from student-centered pedagogies, such as competition, peer pressure, conformity pressures as well as instructors support and instructors trust of students. Many of these cultural or policies may be considered a type of social structure [20] or a way in which things are socially organized or patterned that constrains or shapes what actions are or are not accepted within a given context. In summary, instructors, administrators and school culture or policy can have a sizable influence over the amount and type of agentic opportunities students may experience.

Turning more specifically to the classroom, some researchers have noted that students may resist or struggle with more student-centered or active learning opportunities [21], [22]. In contrast to above, however, students' resistance to agentic opportunities is in some regard an expression of agency, although perhaps not the one hoped for by educators. Nevertheless, research has also found that students become more acclimated to active learning or open-ended projects after more experience [2], [21] and Tharayil et al., [22] have identified several teaching strategies, such as explaining the purpose of open-ended projects, that reduce student resistance.

Another aspect of classroom learning and projects that may not normally be considered a restriction on agency is scaffolding, or providing pedagogical supports to help students learn and engage in difficult tasks [23]. For instance, in engineering, Chukaros et al [24]examined how an Open-Ended Modeling Problem or OEMP was written and interviewed the instructors to understand how learning goals were embedded through the task description. Many sections of the OEMP provided guidelines, prompts or suggestions to help the students to engage in engineering judgement as a key learning outcome. These results were then used to study how a student team was scaffolded through their OEMP experience. While guidelines, prompts, ordering of activities and others may not be as restrictive on student agency as the policies or instructor decisions on dis-including student-centered pedagogies, these scaffolds do encourage some actions while discouraging others, albeit with the goal of assisting learning and with the longer-term aspiration that these scaffolds can be removed eventually.

Work in this space shows some of the ways student agency may be restricted, however, many of the students focus on the larger context, instructors' views or actions as sources of restrictions. Some, like scaffolding, may also represent a positive or at least helpful restriction on agency, insofar as learning is concerned. There, nonetheless, remains a gap in understanding how students experience agency restrictions while working on open-ended projects, which may help paint a fuller picture of students learning and how to better support them.

Methods and Context

Study Context

This study was conducted in the immediate post-COVID era, at a private southern university with the alias Maroon University. The students were in either Statics or Dynamics undergraduate courses, and those in Dynamics courses had previous OEMP experience through the Statics course. OEMPs that students completed were class projects that required students to make assumptions, create free-body diagrams, and conduct an analysis of the assigned or student chosen system or scenario. In the statics course, the project tasked students to design a specific member of a hands-free medical mobility device as an alternative to crutches. In the dynamics course, students were given two OEMPs. The first OEMP asked them to identify which car was speeding in a car crash incident, and the second OEMP allowed students to select a system to analyze. Students were provided with resources such as product manuals and crash investigation reports along with the problem statement. Students worked individually for some sections of the OEMPs and worked on teams building on their prior work. These projects were weeks long, with either a culminating report or group presentation.

The problems were created to intentionally lack some details or be open-ended so that students had to make assumptions, gather information, and make other decisions about their problem-solving approach [25]. For the OEMP where students could select their own system, this was a team assignment, and they could select any system as long as it was within the minimal requirements of the assignment.

Data collection and participants

Nine students participated in a semi-structured interview after completing one or more OEMP. Participants are listed in table 1. The average interview time was 1:34:39, with a range of 01:04:11.370 to 02:16:16. In the interviews, students were asked to recall how they solved the OEMP and were prompted to provide more details if their description was sparse. Students were then asked to evaluate their model, provide their thoughts on the OEMP problem, and answer some demographic questions. Below is an overview of the students analyzed, the course taken, and the OEMP completed.

Pseudonym	Cohort and Course	OEMP context
Dylan	Cohort 1, Mechanics I	Hands-free crutch
Adam	Cohort 1, Mechanics I	Hands-free crutch
Geoffrey	Cohort 1, Mechanics I	Hands-free crutch
Cristina	Cohort 1, Mechanics II	Car crash and Self-selected model
Lane	Cohort 1, Mechanics II	Car crash and Self-selected model
007	Cohort 1, Mechanics II	Car crash and Self-selected model
Joe Wong	Cohort 1, Mechanics II	Car crash and Self-selected model
Andrew Cohen	Cohort 2, Mechanics II	Car crash and Self-selected model
Suguwara	Cohort 2, Mechanics II	Car crash and Self-selected model

Table 1 - Participants. Pseudonyms were selected by students while completing their interview

Data analysis

Interviews were transcribed and analyzed with thematic analysis [26]. Our initial codebook was informed by a preliminary analysis of students' experiences with restrictions on their agency that emerged from an earlier study of students' (primarily positive) agentic experiences [2]. The initial codebook from the prior analysis had three codes including: restrictions due to outside limitations, how the project is structured, and accountability standards. These three codes, derived through inductive-coding, were recorded in a theoretical memo [27] by a prior analyst and served as an initial template to a second inductive-coding round that sought to expand, extend, and elaborate on these codes. Although this was primarily a qualitative exploratory analysis, given that we started with previously identified codes, we anticipate that those codes would evolve or become more detailed through this analysis.

The student interviews have been analyzed through inductive coding. Author one went through and coded each interview, then discussed with author two about the validity of each code until agreement was reached. Author one wrote two memos after seeing significant results and developed a map of the existing codes. This map was then edited by author one after more analysis or discussion. The map and codes were shared with author three who had previously examined the data for a final round of checking the themes and codes.

Results

In this section we first overview the code structure, summary of code instances by theme and participant and then finally present codes falling under each of the major themes with example quotes and explanations.

Overview

Figure 1 displays a map of all existing themes and corresponding subcodes. The top row shows the three major themes: structure of the activity, constraints/limitations and accountability. Subcodes are color coded the same as each theme and organized underneath. Connections between subcodes are demonstrated with connected lines. Codes may be positive, negative, or both. Tables 2 - 4 display the code instances by each participant for codes falling under a given theme.

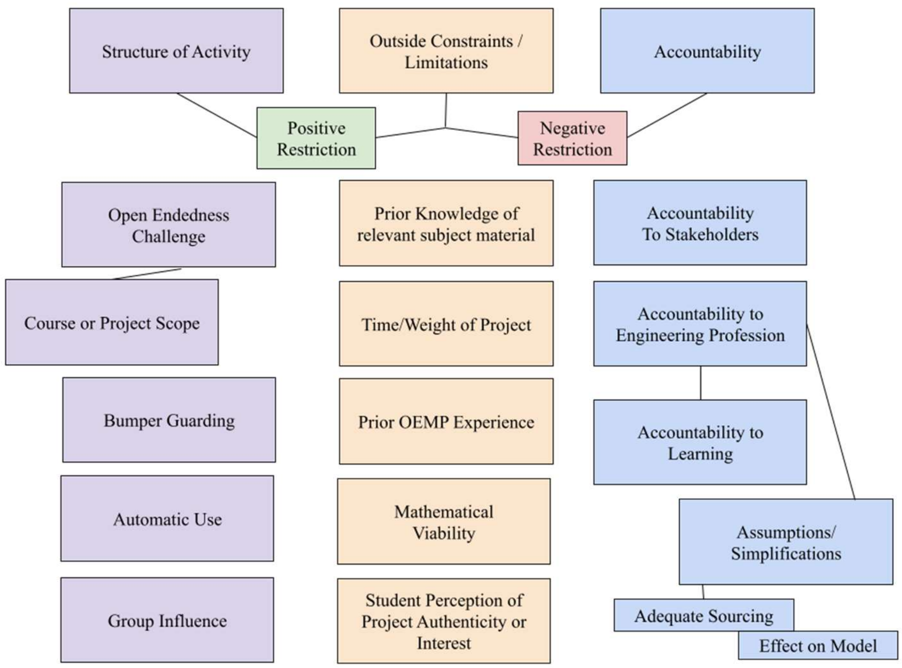

Figure 1 - Map of Themes and Subcodes

Table 2 - Outside Constraints/Limitations

	Cristina	Lane	007	Joe Wong	Geoffrey	Dylan	Adam	Andrew Cohen	Sugawara
Prior Knowledge of relevant subject material	3	4	2	3	2	0	0	0	2
Time/Weight of Project	2	3	3	5	0	3	1	1	7
Prior OEMP Experience	1	4	2	1	0	1	0	1	0
Mathematical Viability	0	0	0	1	0	1	3	1	1
Student Perception of Project Authenticity	0	0	0	0	0	1	1	1	0
Interest	0	3	2	1	0	1	0	0	1
Other	3	1	2	2	0	1	3	1	3

Table 3 - Accountability

	Cristina	Lane	007	Joe Wong	Geoffrey	Dylan	Adam	Andrew Cohen	Sugawara
Accountability to Stakeholders	0	1	1	2	0	0	1	0	1
Accountability to the Engineering Profession	0	0	0	3	5	1	1	0	0
Retroactive Learning	0	2	4	4	0	1	2	0	2

Assumptions/ Simplifications	0	0	1	6	1	3	0	2	3
Adequate Sourcing	1	1	1	4	1	0	0	0	2
Effect on Model	0	0	0	4	1	0	1	0	1
Other	2	6	6	2	4	0	6	0	3

Table 4 - Structure of Activity code instances

	Cristina	Lane	007	Joe Wong	Geoffrey	Dylan	Adam	Andrew Cohen	Sugawara
Open-endedness challenge	3	4	1	2	1	2	2	4	5
Course Scope	0	1	0	5	3	6	2	1	2
Bumper Guarding	0	1	1	5	1	6	1	2	4
Automatic Use	1	2	2	2	1	0	0	0	0
Group Influence	1	0	0	5	4	5	5	5	3
Student Led Decisions	1	2	2	6	1	2	0	0	1
Routine designs/ physicality	0	2	0	0	1	2	2	2	0
Other	5	1	1	2	0	1	0	2	2

Structure

Open-endedness Challenge

The Open-endedness Challenge restriction occurs when the open-ended structure, or lack thereof, leads students to either decision paralysis or a focus on unimportant or incorrect details. This is directly due to the level of structure students receive from a project and thus fits under the structure category nicely. This code is presented almost always as a negative restriction directly from students, with a notable exception. The following is a typical case where a student (Andrew Cohen) is comparing Mechanics I and II.

Well, the biggest thing is that the iWalk was already given to us, and I think we were given... I don't know if we were given the exact model or measurements or exactly, but this project was a lot more open ended so I think it was more difficult … This is one where it felt for a while like I guess also it ties into the open ended that it's harder to know if what we are doing is right or if... like are we going to be able to do this or do we need to switch to a different problem.

In this case, the student makes several points. Firstly, there is less structure in the Mechanics II project. Secondly, because there is less structure, the project is more difficult. Lastly, the student describes anxiety over problem definition. They elaborate by stating directly that because the problem definition is given, there is a concern of viability. The direct metaphor for this idea is "going down a rabbit hole". Alternatively, students may face additional restrictions from problem defining under Student-Led decisions. The direct solution to open-endedness challenge is bumper guarding.

Student-Led Decisions

While Student-Led Decisions may be considered simply as student agency, they are inherently restrictive as well. When a decision between several choices is made, one cannot act on the choices not chosen. This is seen mostly in the problem definition phase of OEMPs when students decide how to narrow the scope of their project. Because students must make decisions due to the project structure, the code falls under structure. This is more easily seen through an example like the one below from the student Joe Wong.

So, we were trying to find, based on our model, an ideal brake balance. And to do that, it was to find the moment of the brake in the front wheels and the moment of the brake in the rear wheels, and then compare them, basically. And then basically add them together and that's 100%, and see what's the percentage on each one. Because you'd adjust it in terms of percentage.

This really helps with our problem-solving skills, because we have one big problem, which is to find the brake balance of the car. And we have to break it down into little parts and do each task eventually, eventually. And as we learned from my other classes on design, we were learning about kind of like a schedule.

In this quote, the student describes their problem definition and how they were able to solve it. Firstly, since this project was chosen by the students, the very specific problem of finding the brake balance shows a direct decision made by the students. This is a self-imposed restriction which allows a thought process to form, which is what is described above. Every additional step decided after this is a smaller version of choosing a problem decision and thus the same self imposed restriction follows.

Bumper Guarding

Bumper Guarding occurs when the instructor builds in checkpoints throughout the project. These checkpoints can be purposely chosen materials intended to help students when struggling, or it could be a required meeting. For the dynamics chosen project, the latter is the case. Within the analyzed interviews, bumper guarding occurs as a positive restriction as the result is protection from negatively restricting elements of the open-endedness challenge and poor student led decision. Below is an example from Sugawara.

Before the check in meeting we hadn't decided on a single cohesieve model for our whole group. As a group we hadn't talked about how we were going to model it so a lot of us did a lot of different types of models. I know somebody modeled the weight of every single bar and someone modeled the entire thing with kinematics as opposed to other types of ways to model it. So after Dr. Weir's meeting we ended up, she said we needed to decide on what model we needed to use and we did that

The quote above describes Sugawara's group collaboration issues when designing their trebuchet. Instead of continuing with an unsynthesized attempt at design, this meeting drove the group to decide on a model. As a result, the group's process is restricted positively by given a specific action step.

Constraints/Limitations

Prior OEMP Experience

A Prior OEMP Experience restriction occurs when students find navigation through an OEMP easier after already completing an OEMP. This is a restriction since Mechanics I students did not have Prior OEMP Experience, and thus found related challenges with structure, notably with the Open-endedness Challenge or Assumptions/Simplifications. Prior OEMP Experience exists as a negative outside limitation. This categorization was chosen since the restriction cannot be lifted by changes to the structure of the project.

A strong example of the Prior OEMP Experience restriction occurred in the Lane interview.

It was a little easier in the idea that I knew what to expect. I knew that you're not given a lot of information that you're given the freedoms, that you have to make the assumptions. In Mechanics 1, the idea that I just made an assumption to make a calculation, that was very new and that was very hard for me to get used to. So in Mechanics 2, I came into it knowing, you know what, I can define the assumptions how I want them. And then if they make sense, then use them in the calculations. And so that was a lot easier for me to do.

The student here describes an increase in confidence with assumption making as a result of completing the Mechanics I OEMP, and, as a result, navigates the Mechanics II OEMP more easily. The restriction element is stated outright with the admission that assumption making, a necessary component of the OEMP in Mechanics I, was difficult since it was a new concept. If the student had had prior exposure to this concept, their experience within the Mechanics I OEMP would be different.

Prior Knowledge

The prior knowledge description is a limitation on the skills or knowledge a student brings to an OEMP. This is commonly due to larger curriculum course sequences, but may also be due to personal projects pursued outside of academics. This may also be due to the sequence of topics covered within the class that the OEMP takes place in. Prior OEMP experience is a special case of this. Prior knowledge as a restriction is generally shown negatively. The following excerpts from the Cristina interview demonstrate this concept.

We basically just used as a calculator. It wasn't writing a MATLAB script. I know some groups did that and those looked really complicated. I know ours is just, that way we could work on it together and didn't get really mixed up and messy. We just use sheets.

I know some classmates have already taken others, like programming and other maths.

Here, the student is stating their feeling that MATLAB is complicated for the purposes of the OEMP. Later in the interview, this student also states that they had not taken a programming course, but other students in the class had. This is a clear example of a particular course being of potential use to the project, but, because of course sequence, unavailable to some students. This demonstrates a difference in prior knowledge affecting how students interact with a problem, thus posing itself as a restriction to process.

Student Perception of Project Authenticity or Interest

This occurs when a student gives an opinion on their level of interest in a project or how authentic they feel the project is to their view of the engineering profession. This may additionally affect how the student interacts with the project. Since personal opinions are not inherent to project structure, this is an outside limitation. This code may be positive or negative, but most often presents as positive.

I definitely didn't expect to get a question that there's really no right answer. And I mean, I would expect this question in a design course, but not necessarily in a statics course. But I like the way that it sort of molds the two together and shows where engineering actually goes and comes from. -Adam

In this scenario, the student attributes a high level of authenticity to the OEMP given. They also specifically mention that the OEMP given was more indicative of a design course. Because of that categorization, students may limit the types of learning outcomes they expect from a non-design course. Additionally, if this student attributed this project with a low authenticity, would this have further affected participation and outcomes?

Accountability

While the restrictions due to structure and outside limitations have an intuitive connection, the connection between accountability and restrictions is non-trivial. Accountability falls under restrictions, as it includes instances where students are forced to reflect on themselves and their models. Accountability, while not a formal part of the structure, is not optional for making a model up to a collegiate standard.

Figure 2 below is an overview of a full student accountability process. Not all students completed this in totality.

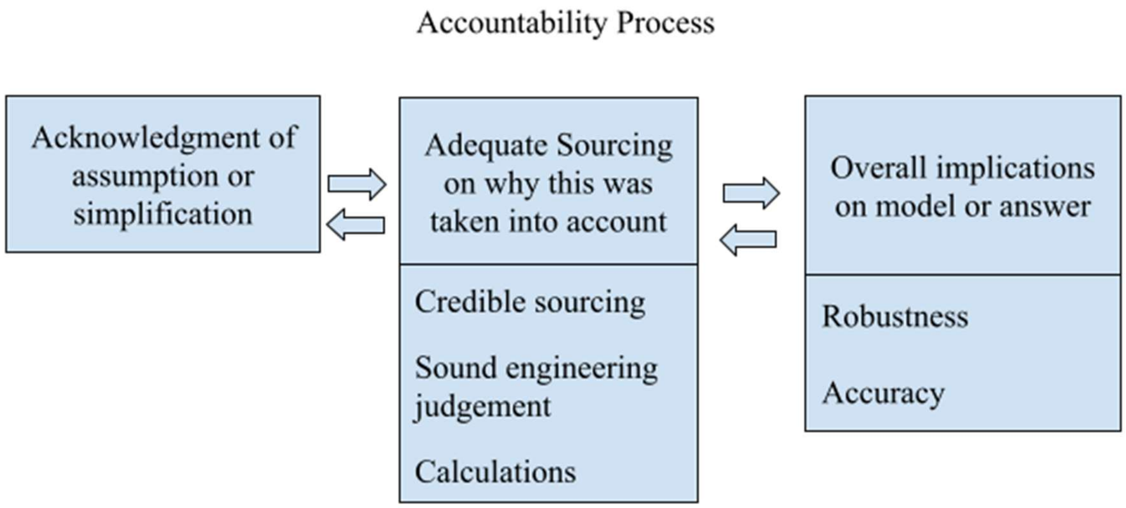

Figure 2 - Accountability Process

Accountability to Stakeholders

Accountability to Stakeholders is identified when a student makes reference to any theoretical user of their design, or a person who would be affected by the design. This is straightforward in most cases as the students are modeling physical systems, although it should be mentioned that it may not be as relevant in certain dynamics projects analyzed here. For example, a sports wheelchair has a clear user, whereas a trebuchet is not as clear. This may affect how often this code is seen. Below is an example from the student, Lane.

And so, then we went, okay, what's the average weight of a person in North America? Just to kind of give the most general situation that was 178 pounds. So then we could... In our MATLAB script, when we plugged 178 pounds…

In this case, the student is considering the weight that should be used for calculations. Since the student states the average weight, they are thinking of a physical user interacting with the iWalk. Moreover, the choice of the average weight could imply a thought of a range of weights that could interact with the hypothetical product.

Accountability to Learning

Accountability to Learning describes a thought process in which a student, upon reflecting, states changes they would make to their OEMP problem-solving process. This demonstrates accountability, specifically to learning, as the student is actively analyzing the correctness or effectiveness of their model. The following is an example from 007, a dynamics student.

So yeah, in that case, like because friction does do work on it. Yeah, and I could have like done that and like checked to see if the, if they got similar answers, but there's probably other forces that were doing work, I just wrote this one first. And I didn't. I should have like wrote and checked doing another way.

Rather than just stating their process and assumptions, the student acknowledges a potential shortcut during the work calculation. By stating missteps rather than just a recount, this student is continuing their learning process after the project is finished, and is proving accountable to their learning of class material. It should be noted, however, that the interview style may allow for this to happen more naturally.

Assumptions/Simplifications

The assumptions/simplifications code is recognized whenever a student makes an assumption or simplification that affects their model or problem-solving process. Below is an example from Andrew Cohen, who was designing a handcar. The follow-up subcode from this involves a citation or reasoning, and a subsequent explanation as to how the model would be affected.

And for the bars we made weightless we assumed those would be pretty light compared to the rest of the car anyway. No slip, that was another assumption between the gears since those have teeth, that was a reasonable assumption. And I think no slip between the wheel and the ground is reasonable because it is heavy and on a train track.

Here, the student is exercising engineering judgement, citing the existence of teeth, to justify their no-slip condition. They then compare weights to physically justify this again. Because the students have a traceable train of thought, this is an accountable assumption.

Discussion

In this discussion we first briefly summarize the key findings of the study and then address how this work connects to or diverges from past research. Finally, we note implications for instructors. Turning to the summary first, our results above address the gap of understanding how students experience restrictions. The results indicate an expansion of the original three codes into distinct themes relating to the structure of the activity, outside constraints or limitations and accountability. Several subcodes also emerged under each of these themes, some of which are interconnected. These connections can be seen most clearly in figure 1. Most restrictions are both positive and negative, although some exist in the interviews analyzed as generally positive (e.g. Bumper Guarding) or generally negative (e.g. Prior OEMP Experience, Prior Knowledge). Accountability codes have led to the development of a model to assess the level of student accountability, seen in figure 2.

The results from this study show both some similarities with past research on student problem-solving experiences and their experiences of agency as well as some notable distinctions. One the side of similarities, other studies on problem-solving and/or open-ended projects, including OEMPs, have noted that student interest and their perceptions of the authenticity of a task, as identified under the outside constraints theme in this study, can have a strong impact on how their interact with it or that it may affect other learning or affective responses [1], [2], [28]. For instance, Swenson et al. [28] found that interest was sometimes related to a positive affective experience in problem-solving. Prior work has also uncovered that past experience with open-ended projects, again identified under outside constraints theme in this study, can make subsequent attempts less strenuous (e.g., [2]). While these works did not emphasize how lack of interest or lack of experience operated as a restriction, they nonetheless identified similar mechanisms to the study at hand.

Conversely, some results diverge from prior research. Perhaps most notably, while restrictions on student agency are often viewed negatively (e.g., [7], [8]) this study found restrictions were sometimes helpful for students, for instance in the bumper guarding code under structure of the activity. The sometimes-positive impact of restrictions on agency may indicate that these restrictions are standing in or operating like scaffolding [23] which often simplifies or provides support to help students undertake tasks they may not otherwise be able to undertake. Nonetheless, some restrictions did negatively impact students, suggesting careful analysis of restrictions and their impacts is necessary. For example, instances of negative impact were reported under Outside Constraints with the subcodes Prior OEMP Experience and Prior Knowledge and under Structure with the subcode Open-Endedness Challenge.

Another theme from this study is the accountability theme. Students reported multiple types of accountability, such as to their own learning or to potential stakeholders of the products they design. This type of restriction on student agency appears to have received limited attention in the past, but it has a variety of impacts such as unveiling a level of student metacognition (accountability to learning) and awareness or empathy (e.g, [29]) with users. Additionally, the accountability process depicted in figure 2 shows an emerging identity or awareness of the field of engineering and their future responsibilities.

Implications

The themes and codes identified here have implications for instructors, suggesting that they may benefit from more awareness of their role in activity structure by setting checkpoints to guide students through the open-endedness challenge. Additionally, results indicate criteria to assess the level of student accountability to the engineering profession. For example, the ability for a student to explain simplifications and the effect on the overall model may indicate a fuller accountability score. The accountability process model demonstrates this. The structure of the OEMP may be affected by class scope, grade weighting, and the time commitment required from students. Furthermore, elements of OEMP structure may be upheld as beneficial from this analysis, such as individual work before group involvement. Overall, instructors using OEMPs may use this analysis to improve their student outcomes.

Conclusion

This study explored how students experience restrictions on their agency while undertaking an open-ended modeling problem in statics or dynamics classes. While agency restrictions have been studied before, they have typically been studied as decisions outside of students' experience or control (e.g., [7], [8]). This study sought to uncover how students experienced restrictions on their agency and how these affected their problem-solving process. The experiences of nine students revealed three different themes, structure of the activity, outside constraints or limitations and accountability each with several subcodes. While the results showed some connections to past work, such as the impact of interest or past experience with open-ended projects, they also revealed that restrictions can be both positive or negative and sometimes may overlap with pedagogical scaffolds (e.g., Churakos, 2024). The results from this study may be of interest to engineering faculty who use or are planning on using open-ended projects in their class by providing a set of restriction categories (e.g., accountability and structure activity) on how students may experience restrictions and whether these restrictions may be helpful or unhelpful to their learning. Future work will see to expand the set of interviews analyzed and further develop when restrictions are experienced as positive or negative and how accountability processes unfold.

References

[1] J. Swenson *et al.*, “A taxonomy of emerging engineering modeling judgment in undergraduate engineering courses,” *J of Engineering Edu*, vol. 114, no. 4, p. e70011, Oct. 2025, doi: 10.1002/jee.70011.

[2] C. Schimpf, E. Komolafe, and J. Swenson, “Exploring how Students Grapple with Agency in Open-Ended Engineering Problems,” in *2023 ASEE Annual Conference & Exposition Proceedings*, Baltimore , Maryland: ASEE Conferences, Jun. 2023, p. 43613. doi: 10.18260/1-2--43613.

[3] A. Guerra, D. Jiang, X. Du, I. Abou-Hayt, and A. F. Valderrama Pineda, “Examining engineering design students’ perceptions of agency for sustainability in a problem- and project-based learning (PBL) context—a Q methodology study,” *Int J Technol Des Educ*, vol. 35, no. 2, pp. 723–746, Apr. 2025, doi: 10.1007/s10798-024-09912-7.

[4] C. Damsa, “Networks, Artifacts and Agency: Examining Engineering Students’,” 2023.

[5] X. Du, A. Lundberg, M. Ayari, K. K. Naji, and A. Hawari, “Examining engineering students’ perceptions of learner agency enactment in problem- and project-based learning using Q methodology,” *Journal of Engineering Education*, vol. 111, no. 1, pp. 111–136, 2022.

[6] V. Svihla, T. Peele-Eady, and A. Gallup, “Exploring Agency in Capstone Design Problem Framing,” *Studies in Engineering Education*, vol. 2, no. 2, p. 96, Dec. 2021, doi: 10.21061/see.69.

[7] S. Akinci-Ceylan, K. S. Cetin, and B. Ahn, “Faculty Perceptions on Teaching Ill-Structured Problems in Engineering Classrooms: A Conceptual Model for Enhancing Comfort and Support,” *Journal of Civil Engineering Education*, vol. 152, no. 2, p. 04025018, 2025.

[8] M. T. Dang, “Mediating factors for student agency: perspectives of school leaders and students,” *Front. Educ.*, vol. 10, p. 1643768, Oct. 2025, doi: 10.3389/feduc.2025.1643768.

[9] A. Bandura, “Social cognitive theory: An agentic perspective,” *Annual review of psychology*, vol. 52, pp. 1–26, 2001.

[10] J. Munson, “Negotiating identity and agency amidst pedagogical change: The case of student push back,” *Journal of the Learning Sciences*, vol. 30, no. 4–5, pp. 646–675, Oct. 2021, doi: 10.1080/10508406.2021.1954522.

[11] A. C. Barton and E. Tan, “*We Be Burnin’!* Agency, Identity, and Science Learning,” *Journal of the Learning Sciences*, vol. 19, no. 2, pp. 187–229, Apr. 2010, doi: 10.1080/10508400903530044.

[12] E. Miller, E. Manz, R. Russ, D. Stroupe, and L. Berland, “Addressing the epistemic elephant in the room: Epistemic agency and the next generation science standards,” *J Res Sci Teach*, vol. 55, no. 7, pp. 1053–1075, Sep. 2018, doi: 10.1002/tea.21459.

[13] D. Jiang, B. Dahl, J. Chen, and X. Du, “Engineering Students’ Perception of Learner Agency Development in an Intercultural PBL (Problem- and Project-Based) Team Setting,” *IEEE Trans. Educ.*, vol. 66, no. 6, pp. 591–601, Dec. 2023, doi: 10.1109/TE.2023.3273177.

[14] J. H. Nieminen and L. Ketonen, “Epistemic agency: a link between assessment, knowledge and society,” *High Educ*, vol. 88, no. 2, pp. 777–794, Aug. 2024, doi: 10.1007/s10734-023-01142-5.

[15] J. L. Alzen *et al.*, “Characterizing relationships between collective enterprise and student epistemic agency in science: A comparative case study,” *J Res Sci Teach*, p. tea.21841, Dec. 2022, doi: 10.1002/tea.21841.
[16] W.-Y. Zhan and N. L. Louie, “Promoting epistemic agency and reinscribing boundaries in mathematics education,” *International Journal of Educational Research*, vol. 123, p. 102271, Jan. 2024, doi: 10.1016/j.ijer.2023.102271.
[17] C. I. Damşa, P. A. Kirschner, J. E. B. Andriessen, G. Erkens, and P. H. M. Sins, “Shared Epistemic Agency: An Empirical Study of an Emergent Construct,” *Journal of the Learning Sciences*, vol. 19, no. 2, pp. 143–186, Apr. 2010, doi: 10.1080/10508401003708381.
[18] J. Agarwal, C. Schimpf, and D. Evenhouse, “WIP: Perceptions of Agency in an Introductory Engineering Design Experience,” in *2024 IEEE Frontiers in Education Conference (FIE)*, Washington, DC, USA: IEEE, Oct. 2024, pp. 1–5. doi: 10.1109/FIE61694.2024.10893549.
[19] T. Bennett, C. Schimpf, and J. Agarwal, “An Exploratory Study of Relational Agency in First year Open-Ended Engineering Design,” in *2025 IEEE Frontiers in Education Conference (FIE)*, Nashville, Tennessee: IEEE, Nov. 2025, pp. 1–6.
[20] R. Archer, “Structure, Agency and the Sociology of Education: Rescuing analytical dualism,” *British Journal of Sociology of Education*, vol. 20, no. 1, pp. 5–21, Mar. 1999, doi: 10.1080/01425699995461.
[21] J. B. Perry, E. Buten, A. Nightingale, E. Treadway, and A. Johnson, “Designing and Implementing Open-Ended Problems in Engineering Science Courses”.
[22] S. Tharayil *et al.*, “Strategies to mitigate student resistance to active learning,” *IJ STEM Ed*, vol. 5, no. 1, p. 7, Dec. 2018, doi: 10.1186/s40594-018-0102-y.
[23] B. J. Reiser, “Scaffolding Complex Learning: The Mechanisms of Structuring and Problematizing Student Work,” *Journal of the Learning Sciences*, vol. 13, no. 3, pp. 273–304, Jul. 2004, doi: 10.1207/s15327809jls1303_2.
[24] K. Churakos, E. Markham, J. Swenson, and A. Nightingale, “Understanding the Effect of Scaffolding on Introductory Ill-Defined Problems in Engineering Education,” in *2024 IEEE Frontiers in Education Conference (FIE)*, Washington, DC, USA: IEEE, Oct. 2024, pp. 1–9. doi: 10.1109/FIE61694.2024.10893350.
[25] E. Treadway, J. Swenson, and A. Johnson, “Open-Ended Modeling Group Projects in Introductory Statics and Dynamics Courses,” in *2021 ASEE Virtual Annual Conference Content Access Proceedings*, Virtual Conference, 2021.
[26] V. Braun and V. Clarke, “Using thematic analysis in psychology,” *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77–101, Jan. 2006, doi: 10.1191/1478088706qp063oa.
[27] A. Strauss and J. Corbin, *Basics of Qualitative Research*. Thousand Oaks, CA: Sage Publications, Inc, 1998.
[28] J. Swenson, E. Treadway, and K. Beranger, “Engineering students’ epistemic affect and META-AFFECT in solving ILL-DEFINED problems,” *J of Engineering Edu*, vol. 113, no. 2, pp. 280–307, Apr. 2024, doi: 10.1002/jee.20579.
[29] J. L. Hess and N. D. Fila, “The manifestation of empathy within design: findings from a service-learning course,” *CoDesign*, vol. 12, no. 1–2, pp. 93–111, Apr. 2016, doi: 10.1080/15710882.2015.1135243.