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WIP: Alignment and Misalignment of Instructor Values Between Research and Teaching

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Introduction:

This work-in-progress paper describes initial analysis of three interviews from a twenty-interview study of thermodynamics, fluid dynamics, and transport professors. The goal of the larger study is to better understand how university faculty view modeling in their research and classrooms, and how that understanding contributes to the world of technical classrooms. To do this, we use the situative framework of figured worlds [1], [2], [3]. Figured worlds are socially constructed spheres where people behave in accordance with collectively imagined roles, acting within context-specific values and truths [3], [4]. "School World" encompasses technical engineering classrooms. Students and instructors play out their figured identities: performing scripted behaviors like quiet note-taking or hand-raising and reinforcing a bounded context where knowledge comes from authority and quickly solving well-defined, single-solution problems is highly valued [4]. For students, the goal of School World is to get good grades and appear smart to peers; for instructors, it is to efficiently progress through content and get good course evaluations while appearing knowledgeable [4].

In recent literature, School World has been contrasted with Engineering World, a more expansive realm where engineers work collaboratively with a goal of solving problems, often with many possible solution paths [4], [5]. As undergraduate engineering majors, students' academic work primarily exists in School World. Once they graduate, many of these students transition into the workforce where School World practices do not apply. However, this might not be the case for their instructors. Within the context of their work, faculty are spread between two distinct cultural worlds: School World and the world of academic research (Research World). While teaching, faculty members partake in the cultural practices of School World, a world in which they themselves once engaged as a student . However, faculty members' research laboratories are more expansive: problems are ill-defined, and collaborative problems-solving and creative modeling practices are necessary to progress towards their research goals [4], [5], [6], [7], [8]. While School World and Research World may have similar problem types and share key practices, Research World has different characters (student researcher, post-doc, laboratory technician, professor etc), goals (publication, grant awards etc), storylines (discovering a new phenomenon, forming interdisciplinary collaborations etc), and identities. These features make it a distinct figured world.

This study:

While other contributing characters influence School World (administrators, teaching assistants, etc), it is largely an organization of students and faculty. Research has been conducted to look at the possibility of bringing engineering practices into the classroom through complex, realistic tasks in small-group problem-solving sessions [4]. That work tries to understand how students interact in School World and Engineering World, as well as their flexibility to move between the two worlds. Is a similar understanding possible for faculty?

In this work-in-progress paper, we begin to shed light on how faculty see themselves— and their students — in both School World and Research World through the following research questions:

1. When comparing faculty descriptions of their research activity and their teaching activity, what are the similarities and differences in their expressed values?
2. How do faculty values contribute to the culture of School World?

Methodology:

Participants and Data Collection:

Twenty semi-structured, approximately one-hour interviews were conducted with engineering faculty from across the United States who (1) are conducting (or recently conducted) research in thermodynamics, fluids, or heat transfer and (2) are teaching (or recently taught) a core undergraduate course in one of those subjects. In the study population, male and female, pre- and post- tenure, and a wide span educational experience are represented. These faculty are from universities of different sizes, public and private, and departments including Chemical and Biological Engineering, Mechanical Engineering, and Nuclear Engineering.

IRB approval was obtained and an informed consent process was followed for each interview. Practice interviews were conducted to refine questions and create a succinct protocol. The first half of the interview focused on the participant's research. The second half focused on their teaching, in part through discussion of a specific problem. The interview protocol, with progression notes, as well as the discussion problem, can be found in Appendix A. Interviews were recorded and transcribed for analysis.

Analysis:

For this WIP paper, we analyzed three of the twenty interviews. These three were chosen because each was from a different school, gender diversity was reasonably representative of the study population (one woman; two men), and they were all given the same final problem (see Appendix A). We give the three participants the gender-neutral names of Ari, Blair, and Cori. Atlas.ti was used to code the transcripts through an emergent coding process that took place over the following rounds: 1) Familiarization: The researcher familiarized herself with all three recordings and marked the main sections and interview questions in Atlas.ti. 2) Initial Coding: The researcher focused on one interview: Ari. She created a vast set of specific codes that surrounded any aspect of the research questions in the broader study. She then grouped these codes into the overarching categories of "Research" and "Classroom," among others. "Research" codes related to participants' research and mostly take place in the first half of the interview. Similarly, "Classroom" refers to conversations around participants' teaching practice and mostly take place in the second half of the interview. The researcher then coded the other two interviews, adding codes where needed and iteratively adding new codes to previous sections and interviews. 3) Theme Creation: Once all three interviews were coded, the researcher began grouping codes into themes. Most themes spread across multiple categories. Themes were developed iteratively, and were revised several times throughout their creation. Additional information about theme development, as well as all theme definitions is provided in Appendix B. Examples of the generation and categorization of codes can be found in Appendix C For this WIP paper, we will focus on the theme of "values": a principle or standard cited or described by the participant. 4) Iteration/Confirmation: The researcher went back and revised/re-coded, reflecting on each instance to ensure codes, themes, and categories accurately represented interviews.

Preliminary Results:
Initial coding revealed categories and themes. Categories helped the researchers understand the main topics of conversation, while themes revealed the different aspects of each category. An initial codebook sorted by category and theme can be found in Appendix D. For this paper, the researchers focused on one theme: values.

Values are particularly interesting because they underlie the culture of any figured world. Table 1 shows research and teaching values by participant. Note: these values were discussed or demonstrated by faculty, but do not represent a comprehensive set of values for each faculty member. If a faculty member does not have a value checked; it does not mean they do not hold it, only that they did not express it during the interview.

Table 1: Research- and Teaching- Values Coded in Participant Interviews

Research: Value	Ari	Blair	Cori
Researcher Persistence	✓	✓	✓
Societal Contribution	✓	✓	✓
Comfort Not Knowing	✓	✓	
Researcher Integrity	✓		✓
Finding Truth		✓	✓
Attention to Detail		✓	
Innovation		✓	
Modeling		✓	
Researcher Passion			✓
Researcher Creativity			✓
Researcher Ambition			✓

Classroom: Value	Ari	Blair	Cori
Student Effort	✓	✓	✓
Conceptual Understanding	✓	✓	✓
Student Excitement/ Enjoyment	✓		✓
Grade Differentiability	✓		✓
Student Collaboration	✓		
Systematic Approach	✓		
Modeling		✓	
Diverse Learning Experiences			✓
Student Individualism			✓
Student Persistence			✓

In the larger study, we outline how faculty values align with practices to form a self-consistent Research World. On the classroom side, this is not the case. Faculty expressed misaligned values both within themselves and between each other, creating a potentially confusing foundation for students as they negotiate expectations in School World. In the following paragraphs, we investigate examples of these misalignments and their possible impact on the classroom environment.

One example of misalignment between instructors is the conflict between the value of "student individualism" as expressed by Cori and "student collaboration" as expressed by Ari. Cori states that *"there's no guarantee that the homeworks are testing their individual abilities because I know that they talk to one another- and they use online resources and stuff like that. So I think the successful students, really- I think they, you know, they look for the multiple perspectives on it from the lecture, from the textbook and then they-they work to independently understand those before working with others."* Cori values *"individual abilities"* and believes students should get content knowledge from lectures and the textbook, rather than each other. They believe that individually working through problems is the best way to learn and build problem-solving skills. When asked how students should approach problem solving in their class, Cori replied *"independently"* before explaining that collaboration short-circuits learning: *"I think you have to struggle to learn."*

Cori's view is in stark contrast to Ari, who states, *"I think that [students] overcome points where they're stuck faster when they are solving problems together. So, what I have heard from some students is that when they're working on it alone they'll get stuck, and they'll just be sort of stuck for like, a long time…It seems like feelings, feelings of frustration, and for some students being overwhelmed build up. And I think when they're working on it together, they can overcome that a lot faster and get around points where they're stuck…For the students who do feel frustrated and feeling overwhelmed, I think that working with peers makes them realize, like-or like remove some of those feelings of, like, loneliness or like, "is it just me?""* Ari values collaboration as a way of learning. They worry that for some students, individually struggling through problems can lead to unproductive emotions, while working together can dispel them. Ari does not appear concerned that collaboration could inhibit learning, but instead indicates it as an accelerant, helping students *"overcome points where they're stuck faster."*

When entering a classroom, students may have no way of knowing if the professor is a Cori or an Ari. This can be confusing to students, possibly leading them to conceal their learning strategies. Having misaligned School World values across classes builds an unsteady foundation on which the rest of the culture is built.

There is also misalignment within each faculty member. Faculty appear to incentivize School World practices and demonstrate an understanding that School World is distinct from Research World. However, they express frustration when students exhibit School World practices. Ari articulates the differences between the figured worlds while describing the value of comfort in ambiguity in research, *"[it's] a willingness to sit with not knowing things… like, it's… I don't know how to say it. It's not like-it's not like I'm solving, like a problem for class where there's a-a right way and a right solution."* For Ari, school- and research- problems are distinct, and have different levels of expected ambiguity. In class, Ari values development of conceptual knowledge, but they also value a systematic problem-solving approach that may create algorithmic problem-solvers rather than building conceptual fluency. *"We use, like, a known, given, find, assume, solve approach. So they need to sort of work through the whole approach to earn full credit."* Ari believes this is beneficial to students. However, they also *"think the students who, like, really engage with [problems] and try to understand the reasoning more than just, "can I look at a solution for a similar problem and do something similar?" I think, are the most successful."* Grading based on an algorithmic solution path incentivizes students to problem-match and stick to a problem-solving script rather than creatively explore problems/concepts. Ari demonstrates both a willingness to collaborate with students in School World practices and a hesitancy to fully buy into School World culture, leading to an internal misalignment in Ari's School World values.

Cori also expresses these sentiments. They say their goal for students is, *"not memorize [a topic], but understand it conceptually."* However, Cori also describes that in recitations, they *"went through example problems that were kind of similar to the homework"* as a way to help students. Despite wanting students to gain conceptual understanding, Cori understands that students engage in problem matching and takes steps to support it. Additionally, Cori describes the discussion problem as *"a problem that, like, might not match one of the problems in the homework exactly. It's a little- It's a little bit of a reach."* Cori contextualizes the problem's difficulty based on how similar it is to examples, demonstrating fluency with this aspect of School World culture.

Blair has a more contentious relationship with School World problem-solving strategies. Although Blair uses primarily well-defined, single solution problems in their classroom and grades based on correct solutions, they explain that *"Many students ask like, "are we supposed to" or "allowed to" and that tends to mean that they are seeing things from a particular perspective. So like, maybe the instructor assessing them and, and having to do something that the instructor wants. So then I try to tell them, "you know, it doesn't matter what the instructor wants, the real system will do what it does. As engineers, our job is to model it the best that we can.""* The "perspective" Blair describes is School World. Despite the incentive structure of the class pushing students to behave in accordance with the role "student," Blair sees their students as engineers, and wants them to engage in engineering practices. Blair appears to empathize, but not sympathize, with students as they navigate School World.

These moments reveal value misalignments within faculty that likely lead to perplexing moments of friction in the classroom both between students and faculty and between students. Knowingly or unknowingly, faculty struggle as they navigate and contribute to School World, influencing the experience for both students and themselves.

Instructors are not exempt from School World practices normally attributed to students, and may even engage them when problem-solving. When talking through possible solution paths to the discussion problem, Cori describes their thought process: *"I don't think that this is part of the problem, but if one is more full of all this liquid, then it's probably harder to change its temperature, because there's like-it has a higher heat capacity."* [request for elaboration] "*Well, I guess that this particular problem looks like something that you would get in a thermodynamics class. And in thermodynamics you usually think about everything being in equilibrium. So whereas, like, heat transfer is a non-equilibrium process…. So I-I guess, like, it just looks more like a thermodynamics problem to me."* Cori identifies, and then disregards, the physical phenomenon at play in the problem. Like a student problem matching to get a correct answer on a homework or exam problem, Cori classifies the problem as *"something that you would get in a thermodynamics class"* and neglects the heat transfer elements.

This example does not illustrate a careless instructor, but rather an instructor who is culturally embedded within School World and its practices. Like their students, Cori is attempting to navigate a culture with confusing and sometimes misaligned values that lead to specific practices. Beginning to see how faculty fit into and co-create School World cultures is an important step towards realigning it with productive engineering practices.

Conclusion:
Professors participate in two distinct cultural worlds: School World and Research World. In each of these worlds, faculty must play different roles, follow different rules, and may abide by different values. In the larger study, we detail a self-consistent Research World. However, the three faculty disused here exhibit misalignments in their School World values, both across and within faculty members. These misalignments have the potential to lead to confusion and negative outcomes for students trying to succeed in a variety of classroom environments. As we build on this WIP as part of the larger investigation, we hope to further illuminate faculty experiences in, and influences on School and Research World.

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Appendices:

Appendix A: Interview Protocol w/Progression Notes and Discussion Problem

The interview protocol was as follows:

The first half of the interview focused on the participants' research practices.

- What is your official title?
- In a couple of sentences, how did you get to this position- what was your path?
- If you had about a minute to explain your research and research laboratory to the president of your university, what would you say?
- For this study, I'm interested in a project where you use fundamental thermodynamics, heat transfer, or fluids principles to make progress in your research. Can you tell me a little bit about a project like that in your lab?

The interviewer then navigated the conversation to different research and modeling practices, investigating how the participants understand their decision making process and the arc of a research project. Conversations included when and why back-of-the-envelope style calculations may be used, verification and validation of simulations, what constitutes building new knowledge in that project, and what happens when the researcher gets stuck. Because much research consists of modeling practices (as defined in the introductory sections), conversation generally centered around an exploration of how the researcher engages in these modeling practices. The research section concluded with the question *What makes a particularly successful researcher?*

The second half of the interview focused on the participants' teaching practices. Like the research portion, it began with some shorter questions before going in-depth about a specific class. These questions included:

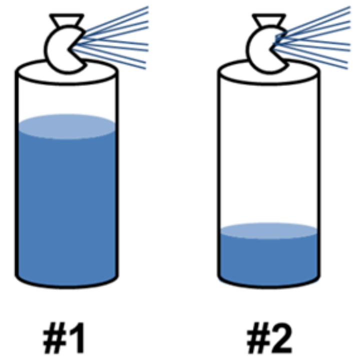
- About how many years have you been teaching university classes?
- What courses do you teach?
- Let's focus on [pick relevant undergraduate class]. What is the size of that class?
- How much autonomy do you have over what and how you teach?
- What is the format of the class?
- What knowledge and skills do you want students to leave this class with?
- What makes a particularly successful student?
- Ideally, how would students approach problem solving in your class?

Lastly, the interviewer showed the participant one of two short problems. Problem choice was determined by the class of focus. The problem used in the interviews analyzed for this WIP paper is adapted below:

Two containers that use a gas spray to clean computer keyboards each contain difluoroethane at 22°C. Container 1 is 75% full with liquid difluoroethane and container 2 is 25% full. They are each used for 15 s.

Which do you expect to be correct about the final temperatures? Why?

A. $T_1 < T_2 < 22°C$
B. $T_2 < T_1 < 22°C$
C. $T_1 = T_2 < 22°C$
D. $T_1 > T_2 > 22°C$
E. $T_1 = T_2 = 22°C$



The interviewer gave the participant about a minute to read through the problem and provide initial reactions before asking how the participant would solve the problem and how they would expect their students to approach it. Follow-up questions were asked when appropriate for each section. This portion of the interview concluded with the question *Do you think students would develop modeling skills through this problem?*

The interview concluded with the interviewer asking if the participant had anything else to add to either section, and thanking the participant for their time.

Appendix B: Additional Information on Theme Creation and Revision

Theme Revision Example: Within the category "modeling" the theme "contribution" initially emerged. However, as the theme of "influence" developed within "classroom" and "research," many of the codes within the theme of "contribution" were re-characterized as "influence."

The theme "values" initially centered on responses to the questions, *What makes a particularly successful researcher?* And *What makes a particularly successful student?* However, as other codes were sorted into themes, it became clear that interviewees referenced their values across the entire interview, sometimes within conversations about research and teaching limitations, sometimes while discussing aspects of successful projects or collaborations, and sometimes while discussing skill development or tool use. Codes within these other themes were analysed and codes were split, combined, and added to better represent the interviews.

There were some codes that could not be grouped into themes and some themes that were not spread across different categories. One example of an isolated code is the discussion of "timescales" within the category of "research." The timescale of research came up unprompted in each of the three interviews, indicating that it is important to how these professors understand their world. However, as the participants discuss it, it could not be placed within any of the current themes, leaving it isolated for the purposes of this WIP report. An example of a theme that exists in only one category is "approaches" in the category of "problem discussion." This theme is distinct from others because it marks a strategy that the professor uses/discusses using to problem-solve. "Approaches" may reveal skills, values, limitations etc, but in a more nuanced way.

Current themes are as follows:

<u>Tools:</u> something one *uses*. A *thing* such as a physical object, software package, or step-by-step problem-solving methodology.

<u>Skills:</u> something one *does.* Skills relate to *actions* such as communication, problem-matching, model-selection, or simplification.

<u>Influences:</u> something *affecting* a practice. This includes limitations, which specifically restrict.

<u>Goals:</u> the *objective* or *aim* of a practice

<u>Values:</u> a *principal* or *standard* cited or described by the interviewee

<u>Approaches:</u> a strategy the interviewee *demonstrates* or *discusses* as part of the problem-solving section of the interview. Could relate to any of the above themes.

Within themes, there are codes that have the same name but exist in multiple themes. Two examples of this are "collaboration" and "literature." For this type of code, the theme is dictated by how the participant operationalizes the idea. Something may be coded "Research: Tools: Collaboration" if the participant *uses* collaborators or collaborative relationships as a tool towards achieving research goals. Something may be coded "Research: Influence: Collaboration" if the participant describes the collaboration as changing the path of the research or *affecting* what is possible in a particular project. Distinguishing between these themes helps show the different ways codes manifest in the participants' work.

Appendix C: Code Examples

<table>
<tr><th>Category</th><th>Theme</th><th>Code (s)</th><th>Example</th></tr>
<tr><td>Research</td><td>Value</td><td>Comfort in Unknown</td><td>“a willingness to sit with not knowing things” … “an ability to like, sit with that, and not let it overwhelm you or frustrate you is an important part of being a successful researcher.</td></tr>
<tr><td colspan="4">Explanation: the participant is referring to research and specifically cites the ability to “sit with” the unknown and “not let it overwhelm or frustrate”, both suggestions of comfort with the unknown (“not knowing things”). This is a value because it describes a principal or standard the participant believes is “an important part of being a successful researcher.”</td></tr>
<tr><td>Research</td><td>Value</td><td>Integrity</td><td>” I'm not like the most productive faculty member, but I feel like I wanna make sure that, like, what we're doing is right before we move on to the next step.”</td></tr>
<tr><td colspan="4">Explanation: In the first part, the participant expresses that they make research choices based on interest. In the second part, they add in that funding requirements also affect their decisions.</td></tr>
<tr><td>Research</td><td>Influence</td><td>*Researcher personal interest, **Funding</td><td>“in this particular case, it's more of, I would say more *driven by a combination of, what seems very intriguing*. Of course, **what aligns with the scope of the funding**…”</td></tr>
<tr><td colspan="4">Explanation: In the first part, the participant expresses that they make research choices based on interest. In the second part, they add in that funding requirements also affect their decisions.</td></tr>
<tr><td>Classroom</td><td>Influence</td><td>Instructor interest, Student emotion</td><td>“It's kind of fun, because it's like their first exposure to how heat transfer works, and, and that's something that I like, right? So I want them to like it.”</td></tr>
<tr><td colspan="4">Explanation: the participant’s interest in the subject affects the ways they approach teaching it. Additionally, they “want [the students] to like it,” demonstrating that they care about how students receive/feel about the subject matter.</td></tr>
<tr><td>Classroom</td><td>Skills</td><td>Model Selection</td><td>“So basically that means identifying the main right model” … “sometimes that's 2 or 3 different ways to model it and then figuring out which models might be applicable.”</td></tr>
<tr><td colspan="4">Explanation: the participant is discussing how students should approach problem solving. They highlight model selection as an important aspect of problem solving, a skill students should develop.</td></tr>
<tr><td>Modeling</td><td>Goal</td><td>Predict</td><td>“in other situations, we might want to predict how a certain system will behave as realistically as possible”</td></tr>
<tr><td colspan="4">Explanation: this is discussion of creating a model in pursuit of the aim of predicting the behavior of a system, an engineering aim.</td></tr>
<tr><td>Problem Discussion</td><td>Influence</td><td>Past Experience</td><td>“this relates to a real world situation, and I happen to have used that before.”</td></tr>
<tr><td colspan="4">Explanation: the participant recognizes the problem as something they have experienced before, and that experience affects how they move forward in the problem.</td></tr>
</table>

Appendix D: Codes within Themes and Categories.

	Research	**Classroom**
Tools	Collaboration, Literature, Lab equipment Software package	Lecture format, example problems, algorithmic solution path Point awarding as behavioral incentive
Skills	Troubleshooting, engineering judgment, communication	Conceptual understanding, problem matching, equation-concept link, abstraction, model selection
Influences	Technology limitations, Researcher's personal interest, funding, Collaboration literature External Institutions	Perceptions of difficulty, instructor interest, student emotions, colleagues, grades/grade distributions, tradition
Goals	Explain, Design, Impact, Citations, Fill Knowledge Gap, Commercialization, Publication	Content knowledge, Conceptual knowledge
Values	Persistence, Attention to Detail, Passion, Integrity, Ambition, Comfort in the Unknown Societal Contribution Finding Truth	Individualism, Persistence, Collaboration, Effort/Engagement Meritocracy (Rankings) Conceptual Understanding Systematic Problem- Solving Approach Grade differentiability