# WIP: Instances of Dynamic Pedagogical Decision Making in the Uptake of a Technology Tool

## Introduction

In this work-in-progress paper, we continue investigation into the propagation of the Concept Warehouse within mechanical engineering (Friedrichsen et al., 2017; Koretsky et al., 2019a). Even before the pandemic forced most instruction online, educational technology was a growing element in classroom culture (Koretsky & Magana, 2019b). However, adoption of technology tools for widespread use is often conceived from a turn-key lens, with professional development focused on procedural competencies and fidelity of implementation as the goal (Mills & Ragan, 2000; O'Donnell, 2008). Educators are given the tool with initial operating instructions, then left on their own to implement it in particular instructional contexts. There is little emphasis on the inevitable instructional decisions around incorporating the tool (Hodge, 2019) or on sustainable incorporation of technologies into existing instructional practice (Forkosh-Baruch et al., 2021). We consider the take-up of a technology tool as an emergent, rather than a prescribed process (Henderson et al., 2011). In this WIP paper, we examine how two instructors who we call Al and Joe reason through their adoption of a technology tool, focusing on interactions among instructors, tool, and students within and across contexts.

The Concept Warehouse (CW) is a widely-available, web-based, open educational technology tool used to facilitate concept-based active learning in different contexts (Friedrichsen et al., 2017; Koretsky et al., 2014). Development of the CW is ongoing and collaboration-driven, where user-instructors from different institutions and disciplines can develop conceptual questions (called ConcepTests) and other learning and assessment tools that can be shared with other users. Currently there are around 3,500 ConcepTests, 1,500 faculty users, and 36,000 student users. About 700 ConcepTests have been developed for mechanics (statics and dynamics). The tool's spectrum of affordances allows different entry points for instructor engagement, but also allows their use to grow and change as they become familiar with the tool and take up ideas from the contexts around them.

Part of a larger study of propagation and use across five diverse institutions (Nolen & Koretsky, 2020), instructors were introduced to the tool, offered an introductory workshop and opportunity to participate in a community of practice (CoP), then interviewed early and later in their adoption. For this paper, we explore a bounded case study of the two instructors, Al and Joe, who took up the CW to teach Introductory Statics. Al and Joe were experienced instructors, committed to active learning, who presented examples from their ongoing adaptation of the tool for discussion in the community of practice. However, their decisions about *how* to integrate the tool fundamentally differed, including the aspects of the tool they took up and the ways they made sense of their use. In analyzing these two cases, we begin to uncover how these instructors navigated the dynamic nature of pedagogical decision making in and across contexts.

## Conceptual Framework

Adoption of an instructional tool or practice occurs along a trajectory of practice (Kinser-Traut & Turner, 2020; Nolen et al., 2011; Thompson et al., 2013), within a complex instructional context.

In undergraduate instruction, entry points for adoption depend on understanding of the tool's affordances and the instructor's goals. From initial implementation, instructors use data (e.g., student feedback and performance, time required, the kind of information provided) to make decisions about continued use, adaptation, or abandonment of the tool. These trajectories depend, in part, on how tool use fits within the context of an instructor's existing teaching practice. As in our larger study, we take a sociocultural perspective and use an ecosystems model to describe how people interact with their environments as active agents (Nolen & Koretsky, 2020). The ecosystems model allows inquiry into the role of instructor histories and multiple aspects of educational context in the uptake of the CW.

We ground the analysis in the Pedagogical Reasoning and Dynamic Decision-Making in Digital Environments (PR3D) framework developed by Stefaniak et al. (2021) which details the reciprocal relationship between pedagogical reasoning and decision-making processes. Stefaniak and colleagues' evaluation describes pedagogical reasoning and decision-making as occurring within a bounded rationality which includes the instructional context (class size, lecture style, collaborative learning, conceptions of assessment) and the instructor's experiences. Such bounded rationality allows instructors to identify emerging value and feasibility of digital environments which promotes ongoing transformation of their teaching practice using a technological tool like the CW.

**Methods**

This case study focuses on Al and Joe, two white male instructors teaching in undergraduate engineering programs. Al and Joe started using the Concept Warehouse in their statics classes as part of this project. We conducted two virtual interviews with each instructor. The first focused on personal history, context, and current instructional and assessment practice, early in or just prior to adoption for in-class instruction. The second interview, after one or two terms of CW use, focused on current practice, including pandemic-related shifts. Each shared an example from their course, demonstrating how they used the CW. Interviews were video recorded, transcribed, and then coded collaboratively by the four authors. Data analysis involved iteratively refining codes to describe instructors' ongoing trajectories of practice with the CW within specific contexts.

When Al first used CW ConcepTests in class in Fall 2019, he was a tenured associate professor with a master's degree in mechanical engineering and 20 years of experience teaching at 2-year colleges. He was introduced to the CW at an NSF - IUSE project kickoff workshop in January 2019 and used the CW in a single section of Statics, ranging from 15 to 20 students during Fall 2019 and Winter 2020 quarters. Following his first interview in August 2020, he continued use of the CW in his instruction during Fall 2020 and Winter 2021. The second interview was conducted in January, 2021.

Joe was in his third year as a tenure-track assistant professor with a Ph.D. in engineering education at a large public teaching university when he began using ConcepTests in class. Introduced to the CW at the Learning Lab project kickoff in September 2019, he participated in the first phase of the larger study, using CW only to deliver the pre- and post-course Concept Inventory in Winter 2020. His first interview was in March 2020. He first used ConcepTests the following Fall term, while teaching three 35-student sections of Statics. The second interview

was conducted in January 2021. Both instructors participated in the CoP, meeting six times in the 2020-21 academic year.

## Findings

Both Al and Joe recounted pedagogical reasoning and dynamic decision-making along a trajectory of practice induced by the tool's initial perceived affordances in relation to their existing practice and instructional goals. Practice, and thus the instructional context, changed along the trajectory, responding to the ongoing interactions among students, instructors, and tool. Multilayered contexts included institution, enrollment, and the global COVID-19 pandemic. In the findings below, the text in quotations is from the instructor interviews.

### Pandemic as an Aspect of Instructional Context.

The onset of the COVID-19 pandemic was a change in the instructional context that made it necessary for both Al and Joe to alter their instructional practices, with impacts on course structures, student collaboration, and classroom activities. *Inflection points* -- the state of their instructional practice when the pandemic forced instructional change -- are important in understanding the impact on trajectories of practice and the use of the tool. Prior to the pandemic, Al's course was "flipped," with in-class time devoted to problem-solving activity, which "positioned [him] pretty well for the online transition." Weekly 90-minute synchronous sessions replaced class time. Prior to the pandemic, Joe reported giving "relatively active" lectures twice a week and conducting hands-on "active learning modules" that were "semi-structured…to generate discussion" on a third day. After moving online, Joe's students viewed recorded lectures and completed assigned ConcepTests asynchronously, then completed active learning modules in breakout rooms during a weekly synchronous class period.

### Adopting the CW in the Context of Existing Trajectories of Practice.

Both Al and Joe had promoted active learning in their pre-pandemic, pre-CW practice. Their adoption of the CW was part of their trajectories of instructional practice, taken up to serve specific goals. Al used simulation activities and assigned one or two multiple choice concept questions during class, polling using "ABCD cards" and using a form of peer instruction (Mazur, 1997). His goal was to uncover and support students' conceptual thinking. This practice provided an easy entry point for Al's use of the CW; he simply substituted the tool's ConcepTests and polling features for his previous method. The tool's affordance for adding and using student written explanations then prompted Al to expand his practice, getting a broader sense of student thinking by scanning written responses in real time during class.

Joe's interest in adopting the CW was primarily as a formative assessment tool. He was already using "concept questions" and collecting student explanations as part of out-of-class work, but finding it unwieldy. In his first interview, prior to adoption of the CW, he identified an affordance of the CW towards organized data collection. He stated, "I wish I would have had the time to put [my concept] questions into the CW… because collecting that data would have been much simpler." In his first term using the tool, Joe assigned 6-9 ConcepTests as homework, also collecting written explanations in response to the tool's affordances. This decision led to a flood of data on student thinking (over 600 responses per week). Unable to process this volume, this use of the tool did not support Joe's assessment goals.

Trajectories: Pedagogical Reasoning about the CW

Although both Al and Joe required their students to submit written explanations for each CW question they answered, their reasoning about the data generated was grounded in their different trajectories of practice.

Al had a developed formative assessment practice focused on in-the-moment instruction and peer instruction suited to his relatively small single section, and he adapted the CW to support this existing practice. In class, he assigned one or two questions to be answered individually with written explanations, then small groups discussed their responses in virtual breakout rooms. During breakouts, Al skimmed written explanations in the tool for potentially productive discussion in the larger group. Al then repolled individually. Students often changed their minds as their understanding shifted. If groups converged on the correct answer, he would invite one of them to explain while he acted as a scribe for the rest of the class to see how their peers thought about the problem. When students disagreed on an answer, he moderated a class discussion of their explanations. Focused on just a few questions analyzed in real time, Al was able to gather initial data about student understanding of a concept and then measure growth in understanding of that concept to inform his instruction in the moment. For Al, the CW's explanation feature provided perceived value for the students, as well: "Even though it takes more time, when I have students write explanations, that helps them think deeper about those questions."

Joe's formative assessment practice had included instructor-led discussions and listening in to students working on modules in class. Like Al, Joe adapted this practice to online instruction using breakout rooms. His use of the CW, however, was restricted to asynchronous individual work. Joe hoped to use the written explanations as a source of data about student thinking that could inform his instruction, as well as to provide students with conceptual practice. Problems arose through the interaction of the specific approach, his institutional context, the tools he had available for analysis, and the structure of the tool. His choice to assign 6-9 conceptual questions with written explanations to over 100 students across three sections generated a flood of student data. Using analytical tools from his research practice to make sense of student explanations outside of class, rather than skimming responses in class, quickly became overwhelming. "It was too many questions, I'm realizing. I pared it down after a while but this was…still too many." His institutional context (3 sections) played a role in his reasoning about the utility of the tool. "What changes am I realistically going to be able to make based on what I'm seeing here? To an asynchronous class that meets once a week that I already have the activities planned out for?" Unlike Al, Joe considered the student production of written explanations "frustrating." His use of that feature in the context of independent homework, rather than in class, coupled with the CW's lack of correct-answer feedback prompted student complaints. Joe could see the CW's explanation feature as theoretically valuable for the instructor, but limited.

Role of CW Community of Practice in Trajectories of Adoption

Al and Joe participated in 6 monthly community of practice (CoP) meetings during 2020-21, presenting examples of student explanations from their courses to provide attendees the opportunity to discuss ways of building on student responses in the first term. In the following term, activity focused on instructors sharing different ways to deploy the CW, including making sense of written responses on the fly during instruction. Although Al felt he needed more advanced discussion, Joe found the CoP more useful, reporting that he planned to implement in-

class use of one or two questions at a time (similar to Al's practice) the following year. Joe expressed that he learned from other instructors in the CoP that "less is more," because it gave those other instructors the opportunity to "unpack one response… and do more with them."

Summary.
Instructor adoption of the CW into existing practice depended upon their pedagogical reasoning about how and where to deploy its features given their goals and contexts. Joe's struggles were a function of his choice of strategy, within the context of larger classes and the pandemic, while trying to preserve his existing classroom structure. His ability to reason pedagogically about student explanations was limited, in part, by the volume of data and the timescale and nature of his formative assessment cycles. However, by interacting with a community of instructors, Joe was able to develop ideas about different ways to incorporate the tool into his practice. Al's more successful implementation built on the affordances of the CW for the kind of instruction he was already doing. His on the fly reasoning practices were well-adapted to the smaller volume of data he elicited and the timescale of formative assessment cycles.

## Discussion and Future Directions

The Concept Warehouse was designed as a flexible tool to support conceptual learning, and participants in this study were encouraged to use the tool in ways that made sense to them, given their own courses and contexts. We conceptualize shifts in instructor practice as a *conversation* with the tool, data, contexts, and tool users over time as each instructor moved along their trajectory of practice. Understanding elements of that conversation can provide insight into the timescale of adoption, how given starting points might influence the success with which a tool is adapted, and how external contexts like the CoP might support professional development.

This case study suggests that such framing may be useful in designing supports for growth on longer timescales, potentially helping instructors develop ways to participate more meaningfully in that conversation, diversifying their use of the tool to better fit the needs of their students. We argue that this form for professional development contrasts with the traditional workshop-based model by allowing instructors to engage in the following:

- **Multiple Sources of Information**: expertise is not solely located with the workshop designer/presenter but across contexts with focus on reflection/sensemaking on practice.
- **Longer Timescale**: allows for ongoing development and new problems/ideas to emerge which allows for gradual development of dynamic decision-making practices.
- **Adaptation:** promotes the idea that implementation is not application but adaptation to dynamic and multilayered contexts.

We will continue to investigate how this instructor, tool, student dynamic impacts an instructor's trajectory-of-practice as we analyze the remaining ten cases in our larger study.

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