Examining Instructor Decision-Making Using Two Frameworks in the Context of Inquiry-Based Learning

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In this paper, I use two frameworks—Schoenfeld's theory of teaching in context (2010) and Herbst and Chazan's practical rationality theory (2012)—to make sense of an undergraduate mathematics instructor's decision-making when teaching with inquiry-based learning (IBL) methods. After providing a brief review of the relevant literature and the frameworks, I illustrate the analysis of one decision-making situation. I then discuss the affordances and challenges of the theories. The goal is to better understand what each framework offers in relation to the context and the nature of the analyzed data, and how findings from each framework can contribute to research on decision-making in the context of undergraduate teaching and IBL.

Keywords: teacher decision-making, university mathematics teaching, inquiry-based learning

Explaining why teachers do what they do has been a fundamental research problem on teaching, built on the central assumption that teachers are professionals who make reasonable decisions (Herbst & Chazan, 2017; Shulman, 1986a). Investigating teacher decision-making has mainly taken place in K-12 mathematics education settings. In a review of 60 articles on mathematics teachers' decision-making, perception, and interpretation, Stahnke, Schueler, and Roesken-Winter (2016) found only two articles assessing teacher decision-making in higher education. Given that postsecondary settings are distinctly different (e.g., faculty in general have more autonomy), I conjecture that faculty decision-making is different from that of K-12 teachers, thus, an important area of research in its own right.

In this study, I deliberately focus on teacher decision-making when implementing inquiry-based learning (IBL) methods in university mathematics courses[1]. While IBL has been appraised as a promising alternative to lecturing (Kogan & Laursen, 2014; Yoshinobu & Jones, 2012), the studies on the effects of IBL have not been entirely consistent in showing positive student outcomes (e.g., Freeman et al., 2014; Johnson, Keller, & Fukawa-Connelly, 2018; Laursen Hassi, Kogan, & Weston, 2014; Sonnert, Sadler, Sadler, & Bressoud, 2015). Moreover, because IBL has emerged from mathematicians' teaching practices rather than research findings, conceptualizations of IBL are still under development (e.g., Laursen & Rasmussen, 2019; Mesa, Shultz, & Jackson, 2020). Although these conceptualizations provide useful building blocks for practitioners, it is not obvious how instructors operationalize them. I propose that one way to explain the inconsistent student outcomes associated with IBL is to understand the source of differences in IBL implementation: teacher decision-making. This paper is a step in that direction.

I used two theoretical frameworks—Schoenfeld's theory of teaching in context (2010) and Herbst and Chazan's practical rationality theory (2012)—to illustrate the process of analyzing decision-making situations (for more, see Gerami, 2020). My goal through these preliminary analyses is to gain insights regarding how studying undergraduate mathematics instructors' decision-making can be approached theoretically in the context of IBL.

[1] See Ernst, Hodge, & Yoshinobu (2017), Laursen & Rasmussen (2019), and Yoshinobu & Jones (2013) for descriptions of IBL methods in undergraduate mathematics education within the U.S. context.

Background on Research on Teacher Decision-Making

Research on teacher decision-making has two main strands: cognitive and sociocultural. The cognitive strand started during the cognitive evolution in psychology in the 1960s and gained more traction as a result of Shulman's (1986b) call for using cognitive psychology in research with teachers. This approach assumes that individuals make decisions based on personal and idiosyncratic schemas (e.g., what has worked in the past) and as such, focuses on individual teachers rather than on teachers as a group (e.g., Bishop, 1976; Borko & Shavelson, 1990; Shulman & Elstein, 1975). Because of "theoretical and methodological limitations that keep the research at the scale of case studies of individual teachers" (Herbst & Chazan, 2017, p. 110), this strand has continued without acceleration in its growth. To address these shortcomings, a sociocultural orientation, that assumes teaching as a social activity, has emerged. This strand situates decision-making within ecological considerations, allowing researchers to investigate teacher decision-making in specific situations, and across teachers, as members of professional communities.

I chose two teacher decision-making frameworks—Schoenfeld's (2010) theory of teaching in context and Herbst and Chazan's (2012) practical rationality theory—for three reasons: (1) both frameworks, while situated within K-12 mathematics education research, have been empirically tested and found fitting in investigating mathematics instruction; (2) these theories have been increasingly appearing in empirical research in postsecondary settings (e.g., Lande & Mesa, 2016; Mesa & Herbst, 2011; Paterson, Thomas, & Taylor, 2011; Herbst & Shultz, 2019); and (3) each represents a different strand: Schoenfeld's theory is an individual-centered perspective of teacher decision-making, whereas practical rationality takes an ecological perspective and has been used to study decision-making across teachers. This allowed me to investigate IBL instructor decision-making from two complementary perspectives and reflect on the benefits of each framework in the given context.

Two Theoretical Frameworks to Study Teacher Decision-Making

Theory of Teaching in Context

The central claim of the theory of teaching in context is that people's in-the-moment decision-making in well-practiced, goal-oriented and knowledge-intensive domains, such as teaching, "can be fully characterized as a function of their orientations, resources, and goals" (Schoenfeld, 2010, p. 182). Three constructs—goals, orientations, and resources—are used to *model*, and even *predict*, teachers' in-the-moment decision-making in the classroom. By modeling, Schoenfeld means that the theory provides explanations of how and why teachers make decisions as they teach, with decision defined as the selection of goals and actions that are consistent with one's orientations and resources. The modeling is done with fine-grained analyses paired with subjective calculations for each teacher (see Schoenfeld, 2010).

In Schoenfeld's (2010) theory, teachers' decisions are always consistent with a set of goals of varying degrees. These goals are not always conscious; the teacher may make decisions that serve unconscious goals. When a goal is achieved, the goal with the next highest priority takes its place. Orientations, as an inclusive term that "encompass[es] beliefs, dispositions, values, tastes, and preferences" (p. 15), shape how teachers perceive different situations, establish their goals, and use their resources to achieve those goals. Similar to goals, orientations can be unconscious. As the third construct of the theory, resources are brought into a decision-making situation and are subjective to the specific teacher. Knowledge is a significant resource; once a piece of knowledge is activated, related knowledge and actions are also accessed and activated, resulting in established patterns of behavior such as routines and scripts. Resources can also be non-intellectual, such as material (e.g., curriculum, learning manipulatives), institutional (e.g., computer labs, online teaching platforms), or social (e.g., colleagues' support) resources. The theory assumes that in a contextualized situation, the teacher as an individual with a pre-existing set of goals, orientations, and resources, reevaluates their goals and makes decisions that are consistent with them. When a situation is familiar, existing routines and scripts are accessed, making the process more automated to reduce cognitive load. In unfamiliar situations, the subjective expected value of each available option is calculated and the option with maximum expected value is picked. Next, the teacher enacts the plan and monitors its effectiveness. Decision-making starts again when a goal is achieved or a plan is interrupted.

Theory of Practical Rationality

The theory of practical rationality of mathematics teaching uses two main constructs—norms and obligations—to unpack mathematics teacher's justifications behind their actions (Herbst & Chazan, 2012.). When teachers are asked to explain the rationality behind their instructional actions, norms and obligations are two sources they use. Norms are tacit expectations in teachers' and students' patterns of behaviors and responsibilities (Chazan, Herbst, & Clark., 2016); as cultural behaviors, they can go unnoticed, without the need to justify them, because they are implicit and typical (Moore-Russo & Weiss, 2011; Webel & Platt, 2015). Nonetheless, teachers may make different decisions under the same set of norms. Professional obligations, as types of social norms, are a set of resources that teachers, as professionals belonging to professional communities, use to justify deviating from the norms. The environments (e.g., department, institution) that an individual in the position of a mathematics teacher is placed in impose these social norms and values that "constrain and condition the position of mathematics teacher" (Chazan et al., 2016, p. 1066). Herbst and Chazan identify four stakeholders that a mathematics teacher has obligations to: the discipline of mathematics, including the knowledge and its applications, the valid representations of the knowledge, and the disciplinary practices (*disciplinary obligation*); the students and their individual needs (*individual obligation*); the society, including the appropriateness of patterns of interpersonal and social interactions, and acceptable societal dynamics (*interpersonal obligation*); and the institution and its regimes, such as policies and scheduling (*institutional or schooling obligation*). The four sets of obligations are, however, not exhaustive, as obligation to other professional groups are possible. The framework is considered situative rather than individualistic because it sees "teaching as an activity system involving positions, roles, and relationships" (Herbst & Chazan, 2012, p. 601). In other words, while teachers can and do make individual choices, these choices have some costs, because teaching is a cultural act with environmental constraints on their position as teachers.

Methods

This analysis is part of a larger study exploring 20 mathematics instructors' decision-making in IBL lower division courses via a survey and a follow-up interview. The decision-making situations section of the survey (the main data source for this paper) asked instructors to choose a lower-division course that they have taught with IBL methods and to describe five situations where they made a decision: about the content, about the course materials, about the assignments and assessments, about methods of teaching, and while teaching. For each situation, participants were asked to (1) list all options available to them when making the decision, (2) the desirable and undesirable outcomes of each option, (3) explain what they chose and why, and (4) identify the use and frequency of various teaching methods (e.g., lecturing, whole class discussion) and their learning objectives for their students. The survey also inquired about instructors' background and demographic information, their definition of IBL, reasons for using IBL, and personal gains and concerns about IBL. I followed up their survey's responses via a semi-structured hour-long interview.

Here, I use data from Leah—a full-time untenured lecturer at a PhD-granting public university, teaching pre-calculus for the first time, with 13 years of teaching experience—who described herself as knowledgeable of IBL and comfortable with implementing it. When asked to explain the situation where Leah made a decision about the mathematics content covered in the course, she wrote: "[W]hen we were studying trig[onometry] functions, I had to basically skip tan[gent] all together so that we could better cover cos[ine] and sin[e]. I showed one single example of a graph of the tan[gent] function." Leah listed four available options she could choose from: (1) cover Tangent graphs with some book example in class via short lecture, (2) skip Tangent graphs altogether, (3) ask students to read about Tangent graphs on their own, and (4) cover Tangent graphs in class like any other topic covered in class. In reflecting on the desirable and undesirable outcomes of each option (see Table 1), Leah chose option (1): "I gave a short lecture/example and didn't include it in any of their assessments ... I did this so that we could spend the extra time on graphs of sin[e] and cos[ine] instead. We needed more time on this."

Table 1. Leah's options and the desirable and undesirable outcomes of each option

Options	Desirable Outcomes	Undesirable Outcomes
(1) Cover Tan graphs via mini lecture	students see some new examples, allows more time on Cos and Sin	short lecture likely results in the students not learning
(2) Skip Tan graphs altogether	more time to spend on Cos and Sin graphs	students do not see examples of the Tan graph, problematic for calculus series
(3) Ask students to learn Tan graphs on their own	more time to spend on Cos and Sin graphs	have to follow up (only a couple students would read the book), students not learning
(4) Cover Tan graphs in class	reinforce ideas from the Cos and Sin graphs	No more time to spend on to better learn Cos and Sin graphs

Illustration of Analyses

Using Theory of Teaching in Context

To use the theory of teaching in context to explain why an instructor chose a specific option in a situation, I attended to each participant as an individual instructor by: (1) going through a process of "getting to know the instructor" before analyzing the decision-making situations, (2) analyzing all the decision-making situations for each instructor at a time, and (3) triangulating the findings with other available data. To get to know the instructor and triangulate the findings, I listened to the interview, read responses to other parts of the survey, and took notes when I found the information relevant to the situation. Analyzing the decision-making situations consisted of: (a) deciding whether the situation was familiar or unfamiliar; (b) identifying the dimensions that the instructor used to evaluate the options for unfamiliar situations; (c) identifying goals, orientations, and resources essential in the situation at hand; and (d) triangulating them with other data, describing how the option was chosen in the light of the findings from Step (a)-(c).

Getting to know the instructor. To teach her pre-calculus course for the first time, Leah heavily depended on her colleagues for advice and course materials. As her priority was to make the course inquiry-oriented, she adjusted the curriculum, the examination, and the grading structure for the course, which she referred to as good learning opportunities for herself. While Leah oriented herself towards promoting inquiry into mathematics for her students, she also oriented herself towards inquiry into student thinking about mathematics. This is also manifested in her beliefs about lecturing; she equates lecturing with “feeding the materials to the students” without them “really learning” the materials or her learning about student thinking. Therefore, she avoids lecturing unless absolutely necessary. Based on three of the five decision-making situations, it became apparent that Leah prefers covering content in class with students because she believes that students learn better in class with her support.

Step (a). The decision-making situation was captured as: whether and how to cover graph of Tangent functions. The situation was coded as unfamiliar because it is Leah’s first time making this decision as it is her first time teaching pre-calculus.

Step (b). The desirable and undesirable outcomes were used to determine two dimensions on which she assessed each option: (D1) students learning Sine and Cosine graphs deeply, with Leah’s support; and (D2) students learning Tangent graphs deeply, with Leah’s support.

Step (c). I identified three goals for Leah: (G1) covering content efficiently in terms of time, (G2) assuring that students learn the concepts deeply, and (G3) preparing students for the next course. I identified both material and intellectual resources. The course textbook, as a material resource, is discussed when Leah talks about students learning about Tangent graphs by themselves using their textbook, or showing them some examples from the textbook via a mini lecture. In terms of intellectual resources, Leah had access to a script for teaching graphs of Tangents in the form of a short lecture. Moreover, her decision-making was navigated by her knowledge of her students’ level of understanding of the graphs of Sine and Cosine functions and her knowledge of the future courses. In terms of orientations, Leah believes that spending more time on graphs of Sine and Cosine functions in class would allow students to engage with the content more “deeply” and learn the materials better. She believes that covering graphs of Tangent functions could be an opportunity for students to better understand graphs of Sine and Cosine functions. She finds graphs of Sine and Cosine functions as more fundamental and necessary to learn. While shying away from lecturing, Leah orients towards covering new content in class; this is evident from option (3)’s desirable outcomes, when she says that if she asks students to learn Tangent graphs at home, then she would still need to follow up with them to make sure that they have learned them.

Step (d). Because the decision-making situation was unfamiliar, Leah’s decision-making is modeled by calculating subjective expected value of each option, where the option with highest value is chosen. Instead of assigning numeric values to each dimension for each option like Schoenfeld (2010) did, I attributed a satisfaction score (none, low, medium, high) based on the degree to which Leah described the options satisfying the dimensions (see Figure 1). Given that Leah values both dimensions and her goals, we can predict that she would not choose option (2) because it would not satisfy D2. Next, because Leah finds graphs of Sine and Cosine function fundamental, we can also predict than she values D1 more than D2, meaning that she would choose an option that would satisfy D1 more than D2. This eliminates option (4). So Leah is left with options (1) and (3). At this point, I reached a bypass where I could not explain which option Leah would choose based on her orientations, resources, and goals. Yet, knowing that Leah chose option (1) with both dimensions scored for medium satisfaction instead of option (3), where D1 has a high satisfaction score and D2 has a low satisfaction score, I wondered if the "Medium/Medium" combination subjectively sounded better to Leah, than the "High/Low" combination. Looking across her other decision-making situations, I found that Leah also chose "Medium/Medium" combinations over others. However, because only five decision-making situations were elicited from Leah, I cannot confirm that she mostly orients towards options that satisfy more dimensions moderately, rather than options that satisfy some dimensions more than others.

	D1: students learning Sine and Cosine graphs deeply, with Leah's support	D2: students learning Tangent graphs deeply, with Leah's support
(1) Cover Tangent via mini lecture	Medium	Medium
(2) Skip Tangent graphs altogether	High	None
(3) Ask students to learn on their own	High	Low
(4) Cover Tangent graphs in class	Low	High

Figure 1. Satisfaction score attributed to each option on the dimensions. The satisfaction scores are associated with colors: None = red; Low = light pink; Medium = light green; High = dark green.

Takeaways. The main challenge I encountered using this theory was differentiating between goals, orientations, and dimensions, as they overlap or inform one another. Schoenfeld (2010) neither defines dimensions, nor describes how he draws them, nor explains the relationship between these constructs. To carry out my analysis, I conceptualized: 1) goals as what teachers want to be achieved; 2) dimensions as the criterion that teachers think about when weighing different options; and 3) orientations as how teachers perceive everything associated with teaching and learning, including the goals and dimensions. Although the framework has been used to model in-the-moment decision-making, I expanded the framework to include outside-class situations. It seems that to harness the modeling power of the theory for both types of situations, multiple instances of similar decision-making situations are needed; this would allow the researcher to unpack automatic teacher decision-making in familiar situations and find more accurate satisfaction scores in unfamiliar situations.

Using Theory of Practical Rationality

Analyzing the decision-making situations with this framework consisted of three main steps. First, I identified the situation's normative behavior(s) and whether the normative behavior was breached by the instructor choosing the option they chose. Second, I determined whether the instructor's choice breached the norms. Third, I identified all instructor's *considerations* (why the instructor would or would not choose an option) when asked to provide the desirable and undesirable outcomes of their available options and explain their reasoning for choosing one of the options. Although the theory has been used to examine teachers' justifications for their *actions*, analyzing instructor's justifications for considering other options added nuance to the findings by showing that instructors may consider a more diverse set of professional obligations. Fourth, I coded considerations for types of resources that instructors used to justify breaching or not breaching the normative behaviors (norm, the four professional obligations) and open coded the ones that did not fit the norms and the four professional obligations. Some considerations were coded for multiple justification resources because they did not solely align with one.

Analyzing the situation. I identified two norms governing the situation: Leah was obliged to teach Tangent graphs because of her position as the instructor (obligation to institution) and she was supposed to teach new content in class so that students learn the materials deeply (instructional norm and an obligation to students). I identified four considerations from Leah's descriptions of her options' desirable and undesirable outcomes: students learning graphs of Sine and Cosine better (individual obligation); more time should be spent on the graphs of Sine and Cosine because they are fundamental materials (disciplinary obligation), covering content that prepares students for the next course (disciplinary and individual obligation), and saving class time (institutional obligation). Choosing option (1), giving a mini lecture, breached the second norm. This was justified by all four considerations. In other words, Leah justified not covering Tangent graphs in depth using professional obligations to the students, to the institution, and to the discipline of mathematics.

Takeaways. A major challenge in using Herbst and Chazan's (2012) theory was identifying norms in teaching lower division IBL mathematics courses, as these have not yet been documented at the level of detail as in K-12 settings. The framework assumes that teachers who teach the same content in similar context (e.g., high school geometry) make decisions under the same set of norms within similar didactical situations. I identified the norms underlying each situation based on the instructor's responses, which made it salient that instructors make decisions under different sets of norms than those found in K-12 settings, and that these norms may not be similar even across the same lower-division undergraduate course (Gerami, 2020).

Discussion

Much was revealed about Leah as an individual decision-maker because of Schoenfeld's (2010) framework's exclusive attention to her goals, orientations, and resources. The theory's attention to individual instructors can be useful in this context because it may help explain the diverse implementation of IBL by showing the variety of goals, orientations, and resources. I hypothesize that this theory can be used across instructors by positioning them in the same situation and investigating their goals, resources, orientations, and dimensions. Nonetheless, the way the theory binds these constructs is idiosyncratic to each teacher, making the theory in its whole inadequate for studying decision-making across IBL instructors.

Using Herbst and Chazan's (2012) theory allowed me to identify the actions that Leah found to be normative and the justifications she relied on for diverging from such norms. My preliminary findings show that these obligations look different across instructors, possibly because of institutional differences or instructors' diverse perceptions and implementation of IBL, and that IBL instructors may be obligated to novel stakeholders, such as the IBL community (Gerami, 2020). More research is needed to understand these norms and the sources of their differences.

Given the importance of cultural and social forces in university mathematics teaching (McDuffie & Graeber, 2003), Schoenfeld's (2010) theory will not paint a comprehensive picture of college mathematics teacher's decision-making. On the other hand, Herbst and Chazan's (2012) theory highlights such societal influences. Paying attention to both cognitive and sociocultural influences via complementary frameworks appears to be the best way forward; as Sfard (1998) puts it, "it seems that the most powerful research is the one that stands on more than one metaphorical leg" (p. 10).

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