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Variation in students' propensities for managing uncertainty

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ABSTRACT

The purpose of this qualitative study was to explore how students vary in their propensities for managing uncertainty they experience during academic tasks. Naturalistic observation and interviews were conducted with students collaborating on robotics engineering projects in a regular fifth-grade class. Techniques of grounded theory and microanalysis of discourse revealed five propensities for managing uncertainty. In particular, students varied in the size and composition of the set of tactics from which they drew and in their willingness to acknowledge uncertainty. Results contribute to theoretical understandings of uncertainty orientations as multi-dimensional and well represented by categories. They also contribute to the science of instruction by indicating that students with different propensities might benefit from differential teacher scaffolding. Suggestions are made for how teachers can shape students' management of uncertainty to facilitate learning.

1. Introduction

Uncertainty is a common experience in academic settings where students struggle to learn new knowledge and skills, adopt new practices, and come to new understandings (Jordan, 2010). Understanding how students manage uncertainty is important because uncertainty is endemic to learning. As Barnes (1992) noted, "Most learning does not happen suddenly: we do not one moment fail to understand something and the next moment grasp it entirely" (p. 123). Piaget (1972) described learning as resulting from disequilibration processes in which a learner moves from one state of clarity to a new state of clarity. This experience of uncertainty pushes us toward scheme reorganization, prompting learning. Although learning is frequently conceptualized as a process of reducing uncertainty, learning may also entail cultivation of uncertainty. Intentionally generating uncertainty can help students appropriate new beliefs, values, and conceptions (Chan, Burtis, & Bereiter, 1997; Jonassen & Land, 2012) and facilitate creative problem-solving (Audia & Goncalo, 2007; Cropley, 2006).

The purpose of this qualitative study was to explore how students vary in their propensities for managing uncertainty they experience during academic tasks. Previous research has found that students and teachers often struggle to manage uncertainty, students pressing for reduced ambiguity and risk, and teachers acquiescing through instructional practices (Baker-Sennett, Matusov, & Rogoff, 2008; Doyle & Carter, 1984). This is problematic because it limits opportunities that can be productive for learning (Doyle & Carter, 1984). Yet, few researchers have systematically observed students' behaviors as they attempt to manage uncertainty while engaged in learning activities (but see Doyle & Carter, 1984; Huber, 2003; Jordan, 2010; Jordan & Babrow, 2013; Jordan & McDaniel, 2014a), and little is understood about variation in how students manage uncertainty.

Furthering a program of inquiry on the role of uncertainty in learning, in this study I consider how individuals in one fifth-grade class managed uncertainty during collaborative projects associated with engineering instruction. My aim was to characterize differentiable propensities for managing uncertainty by systematically examining students' collaborative interactions and their reflections on those experiences. The analysis I present constitutes evidence for how variation in the ways students tend to manage uncertainty shapes how they experience and learn from academic tasks. Thus, this study extends previous research on individual orientations to uncertainty and on the role of uncertainty in learning.

1.1. Defining uncertainty and uncertainty management

Uncertainty is an individual's subjective experience of wondering, doubting, or being unsure about how the future will unfold, what the present means, or how to interpret the past. Uncertainty can pertain to one's self, other individuals, or aspects of the environment (Jordan et al., 2012). It applies to probabilistic and evaluative judgments (Babrow, 2001; Jordan & Babrow, 2013). As subjective consciousness of one's lack of knowledge, uncertainty is a form of metacognitive awareness, what Smithson (1989) called *secondary ignorance*.

Uncertainty management is behavior individuals engage in to facilitate action in the face of uncertainty. Although common conceptions are limited to tactics aimed at reducing uncertainty, uncertainty management also pertains to efforts to ignore, maintain, or even increase uncertainty (Babrow & Matthias, 2009). Which strategies are appropriate in a given situation depends on multiple factors such as

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the source and form of uncertainty (Han, Klein, & Arora, 2011) and cultural norms (Goldsmith, 2001; Hofstede, 2001; Young & Morris, 2004).

Efforts to identify between-person differences in responding to uncertainty extend from the mid-20th century (e.g., Budner, 1962; Ely, 1995; Norton, 1975; Rokeach, 1960; Weary & Edwards, 1996). Research focusing on individual differences in how students manage uncertainty in academic contexts – and why it matters – have primarily been framed around three prevailing frameworks: *tolerance for ambiguity* (Kazamia, 1999), *uncertainty orientation* (Sorrentino et al., 2008), and *need for closure* (Kruglanski & Webster, 1996). Empirical studies based on these frameworks establish that variation in elementary students' orientations to uncertainty is associated with cognitions and behaviors needed for academic learning (e.g., Levitt, 1953; Maw & Maroon, 1971; Smock, 1957; Wang, Chen, Sorrentino, & Szeto, 2008), early adolescents' performance in collaborative tasks (Huber, 2003; Huber, Sorrentino, Davidson, Eppler, & Roth, 1992), and college and high school students' achievement goals and cognitive engagement (DeBacker & Crowson, 2008; Harlow, Debacker, & Crowson, 2011).

Most studies using these approaches measure individual differences using self-report questionnaires or projective techniques, focusing primarily on cognitive or affective responses. They provide little information about what students do – actions they take as they respond to uncertainty during learning tasks (but see Huber, 2003) – that might provide guidance for teachers in designing instruction to purposefully utilize and shape students' diverse responses to uncertainty. Also, these theories conceptualize propensities as existing on a continuum (e.g., between ambiguity tolerance–intolerance) and share a normative approach to uncertainty orientations. This may not reflect the multifaceted nature of uncertainty management as observed by teachers or experienced by students. My intention in this qualitative study was to contribute to existing understanding of these issues using direct observations and interviews to address the question: How do students vary in their propensities for managing uncertainty during collaborative tasks?

2. Materials and methods

This investigation was part of a larger program of naturalistic inquiry exploring how students in a regular fifth-grade class managed uncertainty during collaborative engineering projects across one school-year (see Jordan, 2010, 2014; Jordan & Babrow, 2013; Jordan & McDaniel, 2014a). My approach is guided by theoretical views of learning as a complex dynamic process influenced by interdependencies among culture (e.g., Gutiérrez & Rogoff, 2003), cognition (e.g., Greeno & van de Sande, 2007), identity (e.g. Wortham, 2006), and pedagogy (e.g., Clark, Kjorholt & Moss, 2005). I see individual propensities not as fixed traits or invariable reactions, but as "responses to past experiences that are simultaneously committed to future experiences" (Eisenhart, 2001, p. 217). Dispositions toward uncertainty, then, evolve from participation in past groups and are shaped by ongoing social relations. Thus, I followed students over time to observe both patterns and variation in their uncertainty management.

2.1. Context and participants

A collaborative engineering learning context was selected as a site for this research because uncertainty permeates engineering design activity (Glanville, 2007; Hjalmarson, Cardella, & Adams, 2007). Also, because creative problem-solving entails reducing *and* generating uncertainty (Cropley, 2006), engineering design projects may engender students' use of multiple management strategies. Furthermore, because robotics was new to most students,[1] uncertainty was induced by novelty and unfamiliarity (Doyle & Carter, 1984; Herbst, 2003). Because uncertainty stems from social as well as task issues, uncertainty may be particularly prevalent when learning tasks entail collaboration (Jordan & McDaniel, 2014a, 2014b).

Robotics engineering, a regular part of the year-long curriculum in this class, consisted of designing, building and programming structures using LEGO Mindstorms robotics kits containing building pieces, motors, sensors, an NXT Intelligent Brick, and graphical software that uses an intuitive drag-and-drop environment. Robotics took place at least once a week and proceeded through completion of three projects (see Table 1). Students were assigned to three-to-four-member teams, changing membership for each project. Although participation was graded,[2] the teacher's instruction focused on preparing for authentic culminating events.

The 24 fifth-graders in the class (15 boys, 9 girls) were demographically representative of the diversity in their suburban district.[3] Ten were African American, seven White, five Hispanic, and two Asian. Thirty-three percent of students at this school were economically disadvantaged. Five students' primary home language was other-than-English. Five students received special education services, one received English as a Second Language services, and three were identified gifted-and-talented. Their teacher, a white female with more than 20 years of experience, was well-versed in project-based instruction and robotics engineering.

Although the study utilized data from all class members, I concentrated on 15 diverse focal students (see Table 2). Because gender and cultural differences can influence how individuals approach and communicate uncertainty (e.g. Bernstein, 1962; Lakoff, 1973b), purposefully selecting focal students on these dimensions maximized range (Weiss, 1994) and reduced the possibility of failing to capture a range of propensities. Data for most focal students were drawn from at least two projects to ascertain the consistency of their uncertainty management across groups and projects.[4]

2.2. Data collection and analysis

The study relied on extensive naturalistic observation of students working in collaborative groups (51 days, August–May, 1 1/2–4 h each). Expanded field notes and audio/video recordings documented events and captured students' interactions with teacher, peers, objects, and tools. Transcription commenced during data collection.

Semi-structured interviews enriched understanding of students' mental processes (Bogdan & Biklen, 2007) and built a picture of uncertainty management informed by students' points of view. I developed an initial set of open-ended questions to elicit students' descriptions of their experiences. I tried to avoid explicitly asking about uncertainty, instead, listening carefully for how I could direct a student to describe his or her response to incidents from the immediately prior group-work session. However, if no such opening ensued, I directly asked, "Was there ever a time you felt uncertain or unsure about something while you were working with your group today?" Each focal student was interviewed at least twice (range 6–20 min).

Analysis was inductive and interpretive (Merriam, 2009), an appropriate choice given that uncertainty is an internal experience, the meanings of which are only partly manifested in discursive interactions (Gill & Babrow, 2007). Member checking with the teacher and

[1] Two students had participated in a summer robotics workshop. Neither was selected as a focal participant.

[2] The teacher occasionally referred to criteria on which students would be graded individually (e.g., engaged participation), and as a group (e.g., collaborative interaction, meeting assignment parameters), but these references were rare. Grading criteria were never established in written materials.

[3] Consent was sought and obtained from all parents and all students assented to be in the study, as did the teacher. All names are pseudonyms.

[4] Exceptions were two students for whom I had data from only a single project, Nathan (Project 1) and Trevor (Project 3). Nonetheless, their propensities for managing uncertainty were sufficiently interpretable in the single projects during which I observed their groups daily that I felt their inclusion was warranted and helped further the study's aims.