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An Exploratory Constructivist Grounded Theory Study: Science Teachers' Binary Thought Processes

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Abstract

Using constructivist grounded theory, this study explores science teachers' binary thought processes when interpreting students' scientific models that are comprised of drawings. Using theoretical and inductive data, the study highlights the role of Western culture in shaping science teachers' binary interpretation of scientific drawings. In addition, the study points out science disciplinary cultural practices that perpetuate the dominant ideologies on science assessments.

Keywords: science teachers' binary thought processes, science disciplinary culture theory, science assessment practices, scientific drawings

Purpose of the Study

This proposal comes from a larger study that developed a constructivist grounded theory —science disciplinary culture theory (SDCT)—that explains secondary school science teachers' thought processes in interpreting students' scientific models that are comprised of drawing activities (Redway, 2023). Selecting a slice from the larger project, this proposal focuses solely on the science teachers' binary thought processes (STBTPs). In the study, I explored STBTPs as a secondary school science teacher but also as a constructivist grounded theorist.

Theoretical Framework

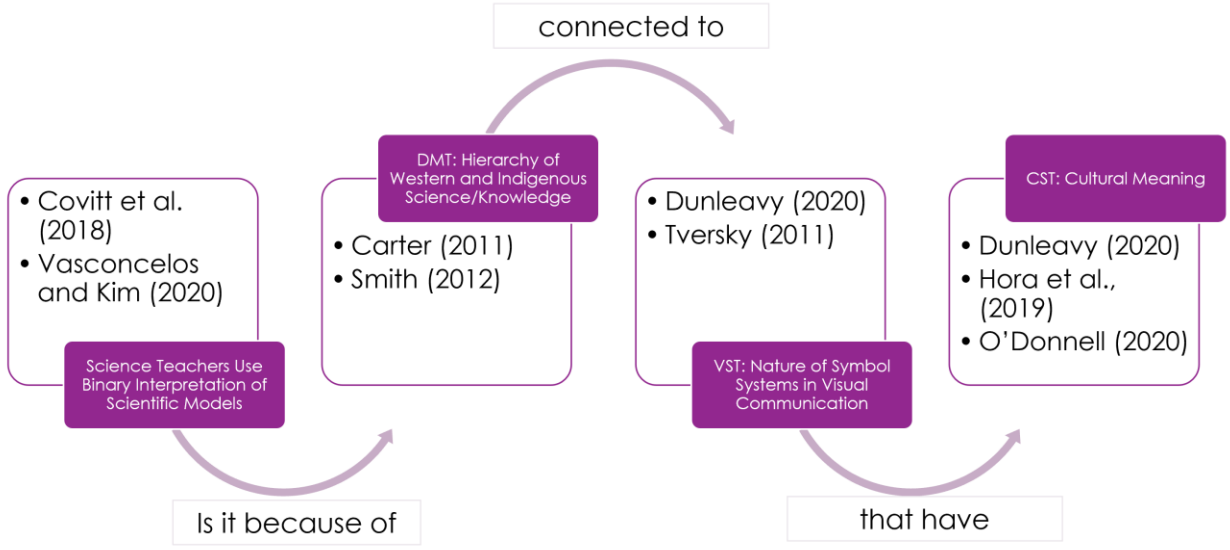
Science disciplinary scholars (Covitt et al., 2018; Vasconcelos & Kim, 2020) expose relevant assessment issues associated with STBTPs used to interpret students' scientific drawing activities. In the larger project, I chose the a priori classification "binary" to describe the value-laden thoughts of science teachers in the context of scientific model assessments since Covitt et al. (2018) claim that science teachers interpret students' scientific models as right or wrong despite training. In a later study making a similar axiological assertion, Vasconcelos and Kim (2020) underscored that "[a] common misconception among teachers is that models from textbooks are the only correct answer rather than an alternative form of representation" (Science teachers and scientific modeling section, para. 1). Surprisingly, the cause of the misconception is unknown (Wang et al., 2014).

At the onset of my study, to gain a handle on this critical science assessment issue within the context of scientific drawings, selected interdisciplinary theories—decolonizing methodologies theory (DMT), visual semiotic theory (VST), and cultural studies theory (CST)—collectively were brought to bear as an epistemological lens for initially examining the invisible STBTPs when interpreting students' scientific drawings. See Figure 1. According to DMT,

STBTPs stem from scientific research valuing Western cultural knowledge over Indigenous cultural knowledge (Smith, 2012). Situated within this politics of epistemology issue (Alcoff & Potter, 1993), DMT brings to light that throughout history, scientific research favoring Western hegemonic practices can be traced to semiotics originating from colonialism (Carter, 2011). Expounding on the semiotic organization of scientific drawings, VST clarifies that scientific drawings are composed of signs with multiple meanings (Tversky, 2011). These meanings, though implicit and arbitrary, are developed and shared in cultures (Dunleavy, 2020). In the field of anthropology, CST stresses the advantage of shared cultural knowledge in interpreting sign systems (O'Donnell, 2020) such as scientific drawings. Adding nuance to this conversation, Hora et al. (2019), in studying oral communication in STEM professions, show that science disciplines have cultural communicative practices that influence how members interpret meaning.

Figure 1

Theoretical Frameworks



Therefore, in interpreting students' scientific drawings, a written form of science disciplinary communicative practice (hereafter practice), these theories suggest that secondary school science teachers value and expect to see these practices. However, what are these practices that science teachers prioritize over others? By identifying these practices that perpetuate STBTPs, my study aimed to bridge this gap.

Methodology

For four reasons, grounded theory (GT) was a well-suited methodology for identifying the practices associated with the STBTPs. One, given that the phenomenon—STBTPs—is an unexplored area of research (Chun Tie et al., 2019), GT would shed light on this overlooked area in scientific model research. Two, as a process that I tentatively theorized would occur in stages over time (Creswell & Poth, 2018), GT was apt for visualization. Three, since the STBTPs are unobservable processes (Charmaz, 2020) that occur in the heads of science teachers (Clark & Peterson, 1986), GT was also appropriate for connecting meanings to these invisible processes (Charmaz, 2020). Four, the practices can be densified (Urquhart, 2023) to produce themes representing the STBTPs.

Since the themes that shape the STBTPs when interpreting students' scientific drawings were unknown, qualitative data collection and analysis tools were brought to bear (Creswell & Creswell Báez, 2021). Using purposeful, snowball, and theoretical sampling techniques, I collected data from five culturally diverse secondary school science teachers from lower New York State who used model-based instruction. Data were collected using surveys, observations, interviews, and documents, and analyzed using open, focused, and theoretical coding techniques (Urquhart, 2023).

Research Questions

Using GT as the methodology incited two research questions:

1. What are themes of STBTPs used in interpreting students' scientific drawing activities?
2. In what way does culture play a role in the STBTPs when interpreting students' scientific drawing activities?

Results

To answer the first research question, 731 codes were generated. Four themes indicating STBTPs emerged. They included: (1) directions or rules, (2) forms of communication, (3) creations, and (4) interpretations or understandings. To creatively answer the second research question, a found poetry was constructed to reveal the role of Western culture in contributing to STBTPs. See Box 1. For an in-depth look at the comprehensive SDCT—as expressed in the found poetry, see Redway (2023).

Conclusions

In the literature, to my knowledge, the field of science education has not explained the cause of STBTPs when interpreting students' scientific drawings. As emphasized in the theoretical framework conversations and the found poetry, STBTPs are shaped by Western cultural communicative practices. In the four emerging themes and found poetry, the study highlights the shared "thinking, values, and forms of expression" (New York State Education Department, 2019, p. 11) that reproduce and perpetuate STBTPs.

Box 1

Found Poetry: The Role of Western Culture in STBTPs

In interpreting students' scientific models that are comprised of drawings, science teachers in the lower New York State expressing Western cultural thought processes expect students to

FOLLOW DIRECTIONS OR RULES,

So that they can have COMMON FORMS OF COMMUNICATION,

Such as COMMUNICATING A SHARED DISCIPLINARY LANGUAGE, LOGIC, and SYMBOLS,

To CREATE AN IDENTICAL OR SIMILAR MODEL WITH A PEER, THEMSELVES, TEACHER, TEXTBOOK, OR REFERENCE,

And also HAVE A COMMON INTERPRETATION OR UNDERSTANDING WITH A PEER, THEMSELVES, TEACHER, TEXTBOOK, OR REFERENCE,

If students DEVIATE FROM DIRECTIONS OR RULES,

Then the COMMUNICATION IS perceived as UNCOMMON and they are STRUGGLING,

Which can be identified by students MISSING OR CONFUSING THE DISCIPLINARY LANGUAGE, LOGIC, and SYMBOLS,

Which results in students DEVIATING FROM IDENTICAL OR SIMILAR CREATIONS,

Or CONFUSING OR SIMPLIFYING THE INTERPRETATION OR UNDERSTANDING…

Educational Implications

For secondary school science teachers and science assessment writers, this study offers the SDCT for understanding their assessment practices. The SDCT provides science teachers with an "effective, equitable, and efficient" (Brown, 2017, p. 37) metric to inform their thinking about the practices that are valued and assessed in science classrooms using evidence-based research instead of relying on intuition (Brown, 2017). These privileged practices include communicating the shared science disciplinary symbols, language, and logic.

In addition, the SDCT provides science assessment writers with guidance for decentering Western dominant ideologies on local and state exams (New York State Education Department, 2019). In the context of scientific drawing assessments, such decentering assessment practices should include giving students the choice and freedom to show their multiple ways of expressing (CAST, 2018) scientific models.

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