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Refining Conjecture Mapping for Design-based Research

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Abstract: In this paper, we examine the original conjecture mapping by Sandoval (2004, 2014) and discuss two issues with its current design. Based on the analysis, we further refine conjecture mapping and use a real-case example for elaboration. Through the reconceptualization of conjecture mapping, we hope to further advance current discussion of conjecture mapping to inform the formation and review of design-based research in practice.

Keywords: Conjecture mapping, design-based research

1. Introduction

Conjecture mapping by Sandoval (2004, 2014) is a recent advancement in design-based research. In this paper, we first review the original conjecture mapping by Sandoval (2004, 2014). Based on the analysis, we propose a reconceived conjecture mapping and use an example to illustrate how it can be used to inform the design of research. Through the reconceptualization of conjecture mapping, we hope to further advance the current discussion of conjecture mapping to inform the formation and the review of design-based research in practice.

2. The Original Conjecture Mapping

Sandoval (2004, 2014) described conjecturing mapping as a way to complement design-based research (DBR). By design-based research, we refer to approaches that design and enact educational interventions to refine designs in practice and to advance theories in a particular domain (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Design-based Research Collective, 2003; Plomp, 2013). Sandoval suggested that conjecture mapping spells out essential features of learning environment in the design-based research (in a form of a map). The map projects how elements of learning environments work together to bring about the desired outcomes of the research. Conjecture mapping makes the design of intervention in design-based research more concrete in a tangible form of a map. It also helps visually explain the changes of intervention across cycles and contributes to practice refinement and theory building in design-based research.

As is shown in Figure 1, a conjecture map comprises components of *high level conjecture, embodiment, mediating process, outcomes, design conjectures, and theoretical conjectures.* A typical conjecture map starts with *high-level conjecture* (Sandoval, 2014, p. 22). They are ideas that are often expressed in general and vague terms. High-level conjectures can be further reified into *embodiment* in the learning environment as shown by the arrows between high-level conjecture and embodiment. Sandoval (2014) suggested that examples of embodiments might include tools and materials (e.g., ICT tools and resources), task structures (e.g., goals and standards of tasks), participant structures (e.g., roles and responsibilities of participants), and discursive practices (the way that participants communicate and talk). Sandoval (2014) argued that respective embodiments of high-level conjecture are first linked to *mediating process* (instead of outcomes) through *design conjectures* shown in the arrows under design conjectures (see Figure 3.2). By design conjectures, Sandoval referred to such hypothesis as placing embodiments in place in the learning environment may lead to the emergence of the certain mediating learning process. This mediating process, according to Sandoval (2014), is the projected activities or interaction that are brought about by

design and intended to produce outcomes. He suggested two ways to examine the process: the observable interactions and participant artifacts. In other words, mediating processes may be manifested by these two types of process evidence. Mediating processes are then linked to the *outcomes* through *theoretical conjectures* as shown in the arrows under theoretical conjectures (see Figure 3.2). Such outcomes, according to Sandoval (2014) may be learning outcomes, interest/motivation, and other outcomes. Sandoval suggested that theoretical conjecture may explain how mediating process leads to desired outcomes in the study. An example of promoting scientific argumentation in an elementary science classroom is cited to explain conjecture mapping and can be further referred to in Sandoval (2014). We now further examine the conjecture mapping and discuss some issues that may be further addressed.
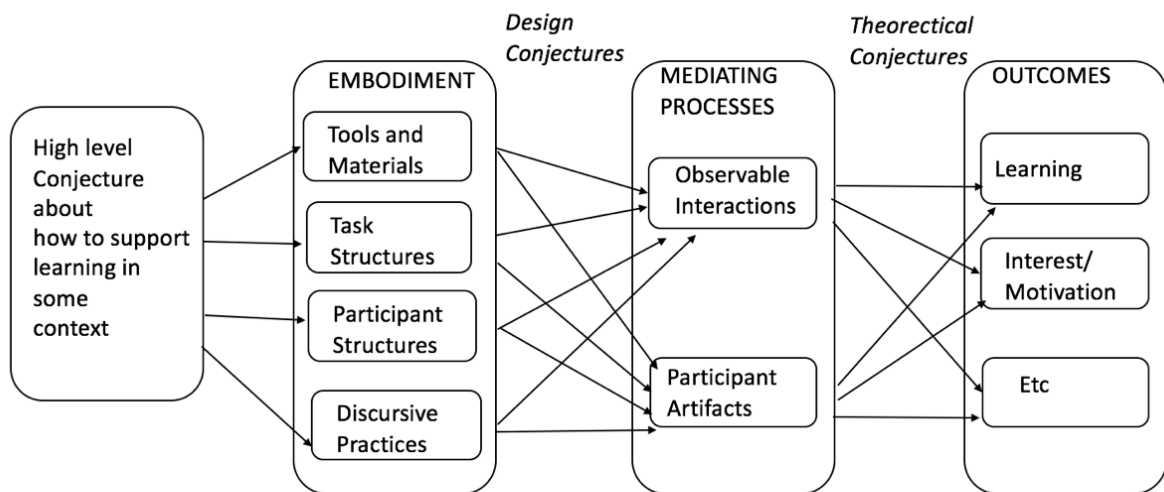

Figure 1. A generic conjecture map (Sandoval, 2014)

3. Two Issues

Although the original idea of conjecture mapping contributes to DBR in making the investigation of design and theoretical conjectures more systematic, in our attempt trying to apply to our projects, we identified at two issues.

The first issue is a need to link design principles and embodiment. As can be seen, this link is missing in the current design of conjecture mapping. Design principles are guidelines generated from previous empirical studies and adopted to inform designs in new contexts (Bell, Hoadley, & Linn, 2004). Sandoval (2004), in his original map (2014), differentiated *embodiment* (or embodied conjectures) from design principles. Embodied conjectures, according to him, are specific and empirically examinable, while design principles are general and empirically untestable. While it remains true that design principles, as general design guidelines, can be abstract and fluid, we find it necessary to position design principles in the conjecture mapping. Such changes will inform how these embodiments (or embodied conjectures) are related to the proposed principles. They may also further tighten the relationship between conjecture mapping and design principles and facilitate the research process both conceptually and practically.

The second issue of conjecture mapping is the need to locate mediating evidence to the original map. Sandoval suggested that observable interactions and participant artifacts could be used as ways to examine *mediating process*, namely the projected activities or interactions brought about by design. He, however, did not highlight their function as providing evidence of the mediating process. Without this emphasis on this function, Sandoval's claim on mediating process may be weakened and become less tenable. We thus argue that it is necessary to emphasize their role as

mediating evidence. By highlighting their roles as mediating evidence for better coherence and attentions to the mediating evidences.

We now turn to the reconceived conceptual mapping and further explain how the examination of the original design of conceptual map leads us to the reconceived conjecture mapping.

4. The Refined Conceptual Mapping: Two adjustments

In reply to the identified two issues, we recommend two adjustments to the original CP. First of all, the refined conjecture mapping integrates design principles by refining the concept *of embodiment* to *DP instantiation* (see Figure 2). This adjustment addresses the first issue of a missing link between design principles and embodiment in the original mapping. The changes of terms foregrounds design principles and explains the instantiation of design principles in the conjecture map for the current study.

The second adjustment is rephrasing the original term of mediating process to *mediating evidence* (see Figure 2). The adjustment addresses the second issue of locating mediating evidence in the original mapping. This new term of mediating evidence foregrounds the function of these data. Rephrasing this term may also align conjecture map with research questions in a study. Mediating evidence informs the collection of process data and point researchers to a deeper understanding of how the designed process leads to outcomes of the design research.

We also change the term outcomes to *latent outcomes* in the refined conceptual mapping to capture its implicit and often un-observable nature. This change also helps to inform researchers and calls their attention to the close examination of outcomes in the study. By making these adjustment, the refined conjecture mapping demonstrates a tightened relationship between conjecture mapping and design-based research. This is mainly realized by reflecting design principles and process evidence in the conjecture mapping itself.

5. An Illustrative Case

We now introduce a case below to illustrate reconceived conjecture mapping in practice. This study explores practices of digital storytelling (DS) in literature and proposes a Knowledge Forensics Digital Storytelling approach (KFDS) to develop critical thinking in the Character and Citizenship Education (CCE) context (see Chen & Wu, 2018). By knowledge forensics, it refers to engaging the storytellers in co-critiquing plausible views in life (e.g. a technopoly view that technology is an answer to all problems in life).

The study adopts a design-based research approach. It follows the model by McKenney and Reeves (2014) and suggests a four-cycle study to systematically examine the approach. Five design principles are distilled from literature. They are DP-pre: skill training, DP-core: story production, DP1 – learner options (choices by storytellers), DP2- personal reflections, and DP3 – group knowledge forensics. Through the systematic study of the proposed approach, the study hopes to advance the theoretical understanding of critical thinking in school practice and shed lights on design deliberations of promoting critical thinking in the CCE context.

As is shown in Figure 2, the high-level conjecture of the current study is that KFDS may be adopted for critical thinking in the CCE context. As discussed above, there is a total of five design principles embedded this approach. DP- pre and DP-core are essential to design principles used in DS studies in general and are not included in the conjecture map. In the following paragraph, we use DP1 learner options as an example to explain how the refined conjecture mapping is constructed.

DP1 learner options are instantiated into options such as selecting a topic of interest, group members, construction paths, and voices (e.g., 1st person, or 3rd person voice) in the story (DP1-I). As Figure 2 shows, this study conjectures that providing learners with these options (DP1-I) may lead to identity outcomes (LO1) (TC4 and TC6) and value-based choices outcome (LO3) (TC5) through their DS artifacts (e.g., sketches, drafts and final version of the digital story) (ME3) (DC1) and presentation before showing the story (ME4) (DC2). This conjecture is built on current review on DS studies. The review suggests that providing storyteller with options to develop the digital

story in their ways contributes to their self-expression and positioning as agentive self (LO1) as the options allow them to create and present stories relevant to themselves (ME3 & ME4). In this study, learner options in self-authorship, when properly facilitated, may go beyond the personal identity and lead to value-based choices (LO3).
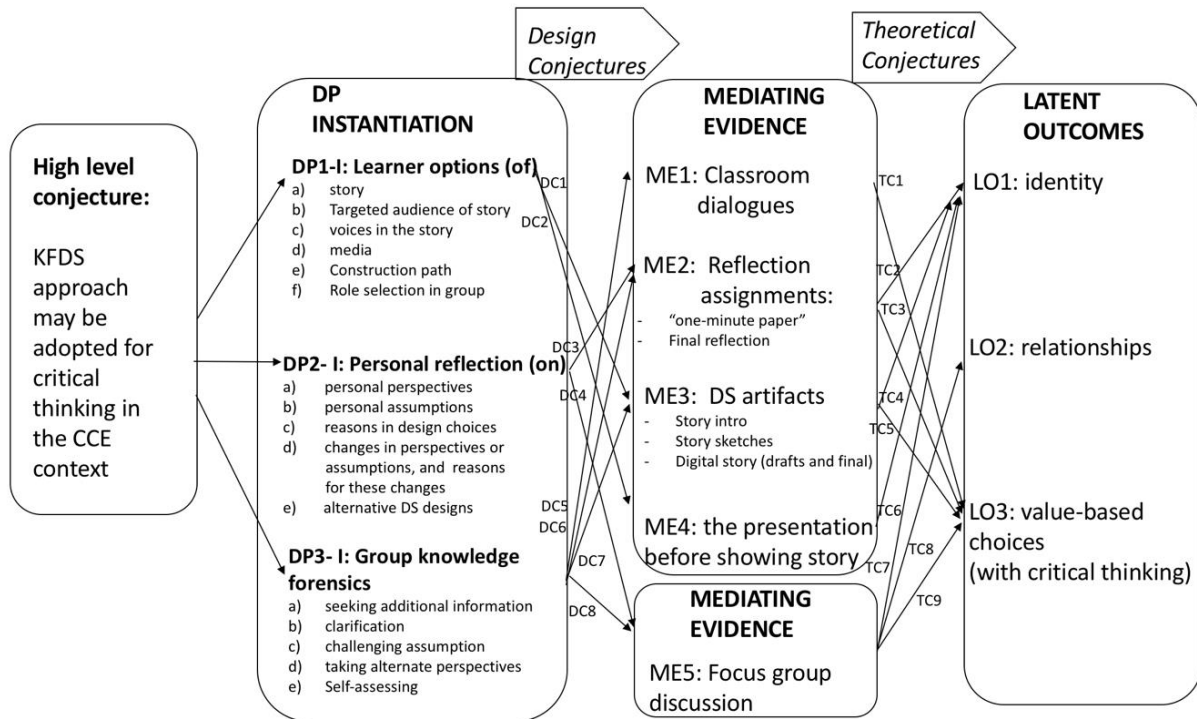

Figure 2. An illustrated reconceived conjecture mapping

6. Conclusion

With this refined conjecture mapping, researchers may better utilize the use of conjecture mapping in their design-based research. Its alignment between DBR and conjecture mapping provides a clearer guidance of the design and implementation of the intervention; the alignment also better informs the researchers in the collection and interpretation of research data, particularly the process data. Such refinement may facilitate both the design and the data collection process. By reconceiving the conjecture mapping, it is our hope to advance the current understanding and practices of conjecture mapping.

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