Combining Cognitive Flexibility Theory and Case Method: A novel idea for addressing novel ideas in teacher education

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Introduction

Teachers encounter novel situations and problems characterized by unpredictability (Palincsar et al., 2007). These challenges cannot be addressed by pre-packed solutions and routine practice, rather they require teachers to recognize situational complexities (Jordan, Kleinsasser, & Roe, 2013) and adaptively construct solutions tailored for the task at-hand (Spiro, 2015). Teacher education has historically been categorized as being complacent in its approaches to teach prospective teachers (McCall, 2017), and that there is a pervasive "gap" between theory and practice in professions, including teaching, where education is overly theoretical or not practice focused enough (Barbour, Kinsella, Wicks, & Toker, 2009). There is also increased recognition that these programs must improve how they prepare students to face the numerous, unpredictable scenarios that come with teaching (Spiro et al., 2019; French & Kennedy, 2017).

Despite proponents for teacher education becoming more complexity-oriented (e.g. Spiro, Feltovich, Coulson, & Anderson, 1988; Feltovich, Spiro, & Coulson, 1993), reductionist approaches to learning, or approaches that intentionally reduce the complexity, are still prevalent (Valentine & Kopcha, 2016). Previous work has identified that a major deficiency in teaching educational psychology is that many teacher education psychology courses are too focused on teaching concepts and theories in abstract ways (Asay & Orgil, 2010), and as a result, teachers have difficulty transferring concepts learned in courses to practice. Research has also demonstrated that in-service teachers and pre-service student teachers (e.g. Jonassen, 1992; Franz, Hopper, & Kritsonis, 2007) are often presented problems that are well-structured and find themselves struggling to cope with the ill-structured problems they encounter in the classroom.

Related, there is a dearth of work that has investigated how early experiences in teacher education psychology courses can provide opportunities for prospective teachers to encounter ill-structured classroom situations that represent the challenges they can expect in-practice. *Case*

method learning (CM) is a constructivist pedagogy in which students read hypothetical accounts of real world situations and consider how they would respond if facing similar challenges (Shulman and Bird, 1992; Shulman, 1996). *The purpose of this piece is to briefly synthesize previous work in CFT and work related to the use of CM in teacher education and synthesize CFT and CM to develop suggestions for instructional design, practice, and research that will encourage the development of adaptive readiness and response to novelty in teacher education.*

This piece will draw from principles and work of CFT (Spiro et al., 1988) and CM in teacher education (Shulman, 1992) to examine how the use of cases can be informed by the CFT framework to help teacher education students' prepare for adapting to and dealing with novelty in ill-structured domains-a skill that is increasingly demanded in today's teaching skill set. First, I will provide a brief overview of the CFT framework and establish how case method will be operationalized in this piece. Next, the literature review work in both CFT and CM that exemplify the two areas' relatedness. Next, I will discuss points of overlap in the literature between CFT and CM, specifically, the CFT tenants of *dealing with novelty*, *developing an adaptive worldview*. Lastly, implications for research and practice will be discussed.

*For this piece, the terms *case* and *context* are operationalized similarly.

Conceptual Framework

Cognitive Flexibility Theory

Cognitive Flexibility Theory (CFT) is a constructivist framework which outlines features of advanced knowledge construction by which learners obtain deep meaning of content material and learn to flexibly apply knowledge in diverse contexts (Spiro et al., 1988). Specifically, CFT outlines how to learn in *ill-structured domains* (ISD's)- knowledge area that varies substantially across contexts and does not have consistent operationalization of terminology across contexts

(Spiro & DeSchryver, 2009). In other words, CFT emphasizes knowledge assembly that is adaptive to utilize existing knowledge, specific to unique contexts. Spiro and Jehng (1990) describe cognitive flexibility in terms of one's ability to restructure knowledge in order to meet the demands of changing situations. The constructivist approach of which CFT takes influence is in contrast with essentialist approaches (i.e. Kirschner, Sweller, & Clark, 2006) where it is argued that learning requires predetermined, guided instruction of "essential" information. The principles of CFT map well onto teaching because of the framework's application to learning about concepts whose operationalizations and relationships to other concepts may hold inconsistent patterns of pertinence and function (Spiro, Vispoel, Schmitz, & Boerger, 1987).

Case Method

Case method (CM) is an instructional approach in which students encounter narratives that convey the complexity of "real life" situations (i.e. Shulman, 2000; Bentz, 2014). Cases in case method instruction are rich in detail. Shulman (1992) describes cases as a type of narrative that helps one appreciate more than the particularities of the case itself (p.17). In other words, learning from cases helps to emphasize the context-dependency of individual contexts within a single subject domain, which, consequently, prepares learners to approach past, present, and future situations in a context-dependent manner versus abstractly (Bransford and Schwartz, 1995). CM is one of the current approaches utilized in different subject areas of education to fill the gap between theory and practice. CM provides students with the opportunity of participatory education by facilitating active and reflective learning (Tomey, 2003).

Connected to CM is *case based instruction* (CBI)-teaching, discussing, and guiding students through classroom discussion of cases (Welty, 1989). In CBI, realistic cases/problems are posed to prospective teachers which increases appreciation for contextual knowledge and

understanding that problem solving processes are context-dependent. It is also important to separate case method from *case study*, where the former is the practice of using cases as pedagogical tools and the latter is the methodological approach to researching consisting of intensive analysis of an event or person (Stake, 2005; Levin, 1995). For the purposes of this paper, CBI is considered as an instructional method within CM. CM is a compatible pedagogical approach for guiding teacher preparation because it encourages students to develop adaptive expertise and the ability to deal with novelty, qualities necessary to be an effective teacher, and both of which are also tenants of CFT.

Literature Review

The following section will outline works prominent works in CFT and relevant works that have explored CM in teacher education (or related field). The literature review is categorized into CFT and CM sections, but I argue that CFT and CM are complementary in their emphasis on developing adaptive worldviews and complex knowledge structures, and many studies do not fall into either CM or CFT, rather many studies employ aspects of both CM and CFT.

Cognitive Flexibility Theory

Spiro, Coulson, Feltovich, and Anderson (1988) studied how the use of cases, in the form of excerpts from a medical textbook arranged as a hypertext, can be selectively highlighted and rearranged based on pertinence to specific situations to heighten awareness of context-dependency and combat what they call *content representation errors*-a set of cognitive errors that oversimplify complex knowledge structures inappropriately prompt top-down knowledge processing and content-independent conceptual representation. They found that use of the hypertext encouraged students to develop increased awareness of context-dependency in how concepts and conceptual relationships are applied across different medical contexts.

Spiro et al., (1990) is another early work in CFT that exemplifies using cases to support adaptive problem solving. In this study, researchers used a hypermedia program to teach the film *Citizen Kane* in which clips from the movie served as "cases". Students were able to navigate through these cases in a nonlinear fashion as they compared cases with each other and to film theories. Results showed that this type of nonlinear hypermedia comprised of cases was effective in helping students apply knowledge to problem-solving situations.

A study by Lowrey and Kim (2009) explored how CFT-guided web pages can influence efficiency, recall, and elaboration of information when students read news websites. Results showed that compared to the traditional linear and nonlinear website structures, the CFT structure showed no loss in recall despite less time being spent when reading the CFT structure, indicating that the CFT structure may be more efficient than other formats. The study also echoes previous work that states that prior level of expertise plays a role in how students are able to utilize the CFT structure to elaborate upon complex ideas; students who had experience using news web pages and prior understanding of the news topic were more likely to benefit from the CFT structure than those who were not familiar with the news topic.

Results from Lowrey and Kim (2009) resonate with other works like Shapiro and Niederhauser (2004) who state that the learning effects of nonlinear learning environments such as hypertexts on students is moderated by prior level of expertise, and that for low prior knowledge students, it is important for learning environments to present a cognitively manageable quantity of information in a structure that is also cognitively manageable. Shapiro and Niederhauser (2006) and Spiro and Jacobson (1995) state that the high cognitive demands of a CFT-like learning environments are manageable for students with high prior expertise, and that these environments afford exploration of complex knowledge domains in an efficient manner.

Butler, Black, Raley, & Marsh (2017) investigated differences in levels of transfer among students who were subject to different levels of variability in practice problems. Results showed that there was superior transfer to novel contexts in students who were subject to high variability compared to those who were given a single example to practice. These results are in-line with principles of CFT that state prior experiences that emphasize conceptual variability help develop adaptive performance in future situations (Bransford & Schwartz, 1995)

CFT has been a framework of application in other fields such as business. Laureiro-Martinez and Brusoni (2016) used CFT to examine how business executives engage in well-structured and ill-structured decision making tasks by examining types of cognitive processes used when switching between tasks. Results indicate that the higher the level of cognitive flexibility, the more likely the participant was to switch between well-structured and ill-structured tasks while implementing appropriate cognitive processes (i.e. the participant would not implement routinized decision making for ill-structured tasks).

Lima, Koehler, and Spiro (2004) drew inspiration from Harvard's century-old use of case study in its business school (Bhatti, 1985; Gragg, 1954) to develop a web-based system for diagnosing complex business cases called *Panteon*. Panteon's design and features were based upon Jonassen, Peck, and Wilson's (1999) *meaningful learning* model and Iowa's *integrated thinking model* (1989) and guided by principles of CFT (Sprio et al., 1988). Their findings suggest that compared to the Harvard method of case study, Panteon was preferred by students and business experts for its affordances to stimulate higher order cognitive skills. This study is an example of how integrating technological affordances of information communication technologies with case methods can yield promising outcomes in learning in ill-structured domains.

Cooper Stein, Miness, & Kintz (2018) used CFT as a framework to investigate how teacher's beliefs about student engagement are related to how students perceive them as engaging. Their findings suggest that teachers whom students found more engaging illustrated more CFT-like beliefs about engagement. Conversely, teachers whom students rated as less engaging tended to illustrate more simplistic thoughts and beliefs about engagement. The authors call for better understanding of factors that promote teacher's development of cognitive flexibility. This study will address this call for research by investigating how implementing a CFT-based case study activity in a teacher education psychology course can foster cognitive flexibility.

Case Method

Lee Shulman, a prominent figure in integrating case method into teacher education, researched how case method has been and can be utilized in the classroom and in preparing prospective teachers. Shulman (1992) states that a limitation of education for prospective teachers is a lack of authentic classroom experiences which can promote overgeneralized conceptualizations about a situation. Even through CM, Shulman notes that there are some limitations in how students can adapt to a variety of classroom situations. I propose that with the guidance of CFT, CM can be refined to offer authentic learning experiences that provide opportunities for students to practice using their prior experiences with cases to adapt to novel situations.

An affordance voiced by researchers interested in CM is that CM provides students with opportunities to engage in "real world" situations that allow them to make connections between what is learned in the classroom and the unpredictability of the reality of their profession (Shulman, 1986). Teacher education programs typically don't introduce students into classroom

situations until the end of their program, and it is important for these programs to bridge the gap between the content learned in the early stages of the program and the experiences of which they engage later in the program and once they begin their professional career (Lundeberg & Scheurman, 1997; Shulman, 2002).

Doyle (1990) provided insight into how cases in teacher education emulate a distinction between a focusing on performance and being concerned with complex cognitive processes that underlie successful performance in classroom settings (p.8). Doyle's third framework, *Knowledge and Understanding*, posits that teachers have propositional knowledge that enables them to recognize and interpret situations, and that these situations are usually complex and context-dependent. Thinking and decision making are influenced by cognitive patterns developed during teacher education and prior teaching experiences. Doyle's framework set the stage for others interested in CM to investigate how cases can be utilized as complex representations that encourage students to develop cognitive patterns that are conducive to recognizing and interpreting complex situations they will encounter in practice.

Sykes and Byrd (1992) were another pioneering voice in developing case method for teacher education. They articulated the need to develop constructing "rich and interesting case materials in a variety of settings for a variety of purposes while simultaneously studying those uses" (p. 509). Shulman (1988) builds upon this sentiment by stating that combining cases and theory, cases can become a powerful vehicle for education. Along a similar vein, Darling-Hammond (2006) articulates that cases serve as narratives, and that students in teacher education can use these narratives to promote thinking that combines theory (what is learned in the classroom) and practice (what students can expect to encounter in real situations).

Yadav (2008) explored preservice teachers' perceptions of using video cases in a literacy course. The study found that preservice teachers felt positively towards using video cases to aid their learning. An important result is that participants felt that scaffolding while using video cases was more helpful than using them unscaffolded. The author also notes that preference for scaffolded video cases may stem from participants' pre-existing beliefs about teaching and learning, meaning that preservice teachers' worldview of education is shaped by their own experiences as students. This point reinforces the notion that it is important for teachers to develop adaptive worldviews early and often to combat potential preference for practices that could encourage non-adaptive worldviews in their students.

Florez (2011) was driven by the question "case-based instruction (CBI) in early childhood teacher preparation: does it work?". In their study, undergraduate pre service teachers were taught using both CBI and traditional didactic instruction and learning outcomes were analyzed across both instructional methods. Results showed that students with high prior knowledge outperformed peers, regardless of instructional method and that students with low prior knowledge gained the most knowledge from CBI. This is an interesting result in that it resonates with previous research that suggests those with high prior knowledge benefit from CM but also that students with low prior knowledge may benefit the most from CM instruction. Previous research has suggested that level of prior knowledge is a mediator for effects CM has on learning (i.e. Mostert, 2007; Yadav & Koehler, 2007; Frommelt, Hugener, & Krammer, 2019), often going hand in hand with the notion that students with low prior knowledge will not benefit to the same degree. This indicates that more research must be done to better understand how the contexts in which CM is used and levels of student prior knowledge interact to influence learning.

Takala and Wickman (2019) studied the use of cases in special education students to provide artificial experiences that could help bridge the gap between theory and practice. Their results showed that students thought using cases was a new and inspiring model, and that alternatives to the traditional lecture should continue to be tested in the context of teacher education.

Gravett, de Beer, Odendaal--Kroon, and Merseth (2017) explored the affordances of case-based teaching for the professional learning of student teachers in large classes. Data collected from interviews with pre service teachers and teacher educators, video footage of classroom interactions, student-student discussions on a LMS, and reflective essays by students revealed that case-based teaching encouraged engaged learning, understanding of the complexities associated with teaching, and application of course ideas to practice. Another important finding is that case-based teaching can help reveal students' preexisting worldviews, more specifically, preconceptions about the nature of teaching. This is an important contribution to the field in that it provides evidence that CM is worth pursuing as an instructional position for large classrooms (in this case, two-350 student classes) where teacher-student interaction may not be intimate.

Frommelt, Hugener, and Krammer (2019) investigated the use of classroom video cases on student teachers' abilities to critically analyze cases for pertinent information. Their findings showed that participants in the video case groups were better at identifying teaching situations that are relevant to learning than the control group. The study also found that although there was significant difference in the instances of students identifying relevant information, participants had difficulty articulating why these instances were relevant, indicating that more novice level learners interact with cases differently than experts and those with higher prior knowledge.

Zydney and Grincewicz (2011) joined the worlds of video cases and CFT. The authors explored how the use of video cases paired with CFT-design principles influences high school students to consider multiple perspectives. Using the CFT tenants of multiple representations of knowledge and context-dependent knowledge application, the researchers designed mini "case" videos that either conveyed single or multiple perspectives to a pollution problem. Results indicate a correlation between viewing the CFT videos and students considering multiple perspectives.

Connections between Case Method and Cognitive Flexibility Theory

Spiro et al. (2019) outlines how tenants of CFT are used to address adaptive readiness and adaptive response to novelty. Using the the two features of CFT that address dealing with novelty as an outline-*oversimplification of complex concepts* and *developing an adaptive worldview/expertise*-this section will synthesize CFT into the context of CM to both demonstrate how CM can be supported by CFT and how CFT-type learning can benefit from using CM.

Oversimplification of complex concepts

The previously discussed Spiro et al. (1989) study demonstrated how students' analogical errors led to oversimplification of complex concepts in anatomy. Spiro et al. (2019) states that oversimplification is both caused by and drives future reductive tendencies and may eventually result in reductive worldviews-the opposite of adaptive worldviews. Spiro also describes how patterns of oversimplification can serve as and contribute to the future development of *knowledge shields*-cognitive barriers constructed to protect one from having to do the hard work of developing more appropriately complex understanding (Feltovich, Coulson, & Spiro, 2001).

This tenant of CFT is important to consider in the contexts of teacher education and using CM. There is no doubt that teaching presents ill-structured situations each day, and in the context

of teacher education, pre service teachers undergo the challenge of translating their teacher education experiences from the college classroom to their own classrooms, where their problems are often more messy and unpredictable than they had practiced for in training. It is imperative that teacher education programs emphasize developing *adaptive* cognitive tendencies in prospective teachers' so they avoid developing knowledge shields than can cause future oversimplification of classroom situations.

Jordan, Kleinsasser, & Roe (2013) explored teacher's reasonings and reflections upon decisions of practice, judgement, and thinking as simple, complicated, and complex. Through narrative inquiry (Loughran & Russell, 1997), they conclude that ultimately, these narratives are complex and suggest that this complexity cannot be ignored, rather embraced so as to become more honest about the complex nature of problems that accompany teaching and better equip existing teachers with strategies to reflect upon their practice and inform teacher educators how to prepare future teachers for the ill-structured nature of novel contexts they will experience.

Enter CM. Carter (1999) states that the purpose of cases in teacher education is to depict the complexity of teaching environments (p. 166). The use of cases in the form of *mini cases* is already a topic discussion in CFT when considering how to combat oversimplification of complex concepts. Mini cases are cognitively manageable cases that illustrate multiple perspectives of a topic, show variation in levels of pertinence of concepts, and exemplify context-dependent operationalization of concepts. Researchers have outlined CM instruction that resembles the use of CFT mini cases such as suggesting that cases be constructed to encourage students to consider multiple perspectives and experience conceptual variability from case-to-case. In sum,CFT provides the guidelines for design and instruction for CM to adopt to combat oversimplification and foster recognition of conceptual complexity.

Developing an Adaptive Worldivew/Expertise

Another tenant of addressing novelty in CFT is developing an adaptive worldview and expertise. In many ways, processes of building an adaptive worldview and expertise are antitheses of developing a reductive worldview and patterns of oversimplification. Sprio outlines the *cognitive values* of an adaptive worldview as: paying attention to the variegation of concepts in multiple cases; using multiple representations of concepts; building understanding of concepts through engagement with individual cases (*bottom-up processing*) as opposed to applying abstract definitions to all cases (*top-down processing*); encouraging recognition of differences and decreasing emphases on similarities; expecting unpredictability, particularly in conceptual function and pertinence from case-to-case and when addressing a novel situation; embracing flexibility of knowledge over rigidity; emphasizing context-dependency over context-independency; and relying on constructing a *schema of the moment*-situational understanding of a problem informed by previous experiences with multiple, unique cases-as opposed to prepackaged solutions.

As previously mentioned, teacher education benefits from fostering the development of an adaptive worldview in prospective teachers. The aforementioned cognitive values aid in teachers' abilities to address ill-structured problems faced in the classroom each day. It is also worth developing this type of worldview and expertise because it combats the formation of knowledge shields and routinized expertise-expertise that relies on prepackaged solutions to problems and rigid knowledge structures. Shulman (2004) posits that uncertainty and unpredictability are essential features of teaching. Floden and Clark (1988) echo this sentiment, arguing that teaching is inevitably uncertain. Sato and Rogers suggest that instruction and preparation for teaching should include training that represents the complexity of the ill-

structured domain by creating webs of information, multiple perspectives, and embedding course knowledge within multiple contexts. Briefly put, the goal is not to prepare students for every situation they might face-this is a futile effort, given the ill-structured nature of teaching. Instead, the goal should be to develop worldviews that equip them with the skills to adaptively construct schema of the moment solutions, which allows them to address novelty consisting of an endless combination of conceptual variability.

Now to connect the development of an adaptive worldview to CM. Becoming proficient in assembling schema of the moment is a skill outlined in CFT related to dealing with novelty in that novelty is, by definition, unfamiliar, unpredictable, and at times, changing from case-to-case. A quality of case methods that utilize multiple cases is providing students with several "mini cases" throughout a course where contextual differences are emphasized. Mini-cases, afford students opportunities to practice developing schema of the moment by equipping them with several perspectives of a set of concepts of which they can draw from when encountering a novel situation.

A quality of mini cases in the context of CFT is that they encourage *bottom-up* processing (Spiro, 2015), where context/case-specific particularities are used to build understanding of complex subjects versus *top-down* processing, where abstract, universal rules and definitions dictate how one understands all cases. CM facilitates bottom-up processing by accentuating the complex intricacies of a single case (Doyle, 1990) and by providing experiences where the class reflects upon the unique ways in which concepts are operationalized through discussion. Bottom-up processing is a critical component of developing an adaptive worldview. As previously noted, engaging with a diverse array of cases helps to practice building schema of the moment, but one must also practice bottom-up processing to develop an adaptive worldview

in which dealing with novelty happens. In the context of teacher education, the difference between top-down processing and bottom-up processing is a teacher employing a one-size fits all solution to all student problems and a teacher who uses the specific parameters of a classroom situation to determine how they will use their prior knowledge to construct a schema of the moment solution.

Related, Flyvbjerg (2006) articulates that the case study method of teaching provides opportunities to develop context-dependent knowledge that is critical in developing expertise, particularly, expertise guided by an adaptive worldview (p. 222). In the same piece, Flyvbjerg states that "context-dependent knowledge and experience are at the heart of expert activity", indicating that one's ability to recognize context-dependency and construct meaning of concepts in novel situations in a non-abstract manner is important in developing proficiency in a field. As Shulman (1986) states, the use of cases in teacher education should provide strategic understanding the wise application of knowledge to situations where principles conflict and no simple solution is possible-a statement that resonates well with the tenants of CFT.

Implications for Instructional Design and Future Research

So far, I have introduced the CFT framework and provided a focused scope of the case method approach to teaching and learning; reviewed relevant literature where the overlap between CFT and the use of cases is demonstrated; and discussed the theoretical compatibility between CFT and CM. The following section provides suggestions for instructional design and research, with consideration of the previous sections. I contend that it is important for both practice and research to work in-tandem, as the design, experiences, and outcomes of CFT-guided CM are explored.

Implications for Instructional Design

Many of the previously discussed works outlining CFT-based instruction can help illustrate what CFT-guided CM looks like, when it is appropriate, and where it should be implemented in the context of a teacher preparation program. Spiro et al. (2019) outlines guidelines for deliberate practice of CFT-based learning environments. To construct CFT systems, the authors suggest starting with 10-20 *crossroads cases*, or mini cases that are densely packed with conceptual features crucial to the knowledge domain at-hand. Next, students "unpack", or use them to help construct understanding in new contexts, these crossroads cases which, because of their conceptual complexity and variability, lead learners to view their pertinence and meaning differently each time they apply them to a new situation. Quickly, students "overlearn" these crossroads cases which leads them to develop an adaptive performance skill of constructing a schema of the moments when faced with novel situations. Spiro and colleagues state that this is another aspect of deliberate practice in CFT learning environments that creates accelerated expertise. It is important to note that the goal, here, is not to increase the speed in which students can recognize similarities in new situations relative to their past experiences, rather the goal is to equip students with a set of cognitively manageable, complex and diverse array of cases that represent the knowledge domain so that they can use different combinations of cases and different pieces from each case to help inform their understanding of novel situations.

A prominent fit for marrying CFT and CM in teacher education is implementing *hypertexts*-a network of texts, images, and other media organized in a nonlinear manner based on a programming structure-into the curriculum. Spiro et al. (2019) elaborates upon the differences between two types of hypertext: *link-based* and *cognitive flexibility hypertexts* (CFH's). The design of a link-based hypertext is pre-programed and links are pre-compiled, leading to an

intentionally structured network that is relatively stable in how resources are explored. The most obvious example of a link-based hypertext is the *World Wide Web*. The programming of CFH's, on the other hand, assigns tags to resources which allows the hypertext to adaptively *highlight* and suggest resources that are most pertinent to a specific situation. For example, in Spiro et al.'s (1989) study of medical students' reductive biases, the CFH used *contet-sensitive selective highlighting* (CSSH) to "light up" text the most pertinent excerpts from different chapters in the textbook. The feature of CSSH allows CFH's to rearrange which resources are connected in a context-dependent manner and has been found to both fight against the formation of reductive biases but also encourage adaptive ways of thinking in future novel situations (also called *preparation for future learning*; Bransford & Schwartz, 1999).

Another CFT-based instructional tool is video cases. In recent years, teacher preparation programs have increasingly made use of case-based learning with classroom videos for fostering analytical skills (Gaudin & Chaliès, 2015). Video cases, themself, are not CFT-inspired, but they can be vehicles for developing adaptive worldviews/expertise and combating reductive biases related to oversimplification. Yadav and Koehler (2007) describe video cases as being able to provide preservice teachers with authentic classroom experiences that better represent the complexity of classroom events than written cases. In other words, video cases allow students to "enter" multiple classroom situations and practice application of concepts in ways that would otherwise only be available via actual classroom experience. It has also been shown that the use of video cases has a positive impact on pre service teachers' learning (Yadav, 2008).

In a CFT-guided implementation of video cases, students may be exposed to a variety of videos that exemplify teaching situations that represent a wide array of practices, student behaviors, and classroom contexts. The goal is to demonstrate how one-size-fits-all solutions to

classroom problems fail to address the complexities of each unique classroom situation while simultaneously allowing students to practice building schema of the moment solutions to novel situations using their repertoire of knowledge from the video cases.

Another potential space for CFT-based learning environments is *concept maps*. Concept maps are tools that visualize how concepts are organized and interact with each other in a knowledge domain and assist individuals in visualizing the journeying nature of a concept's development (Novak, 1984; Butler-Kisber & Poldma, 2010). Much like CFH's, concept maps guided by CFT could integrate CSSH to help preservice teachers visualize the conceptual variability of concepts. For example, a traditional concept map is static, meaning the relationships among the nodes (concepts) and links (connections among concepts) is unchanging from context-to-context. A CSSH concept map would *adapt* its configuration for each unique situation. Say concepts A and B are pertinent in situation 1 and concepts B and C are pertinent in situation 2. A CSSH concept map would represent this by "highlighting" different concepts when applying the concept map to different situations. In addition to highlighting concepts, the links among concepts could be highlighted or "dimmed" to represent the variability of conceptual relationships from context-to-context. Used in-tandem with the aforementioned cross-roads cases, CFT-guided concept maps have the potential to even further accelerate the development of adaptive performance in preservice teachers, among other professions where ill-structured domains are encountered.

CFT also informs a rapidly changing educational landscape, characterized by a refocus on 21st-century skills (Dede, 2010). Spiro et al. (2017) note that teacher evaluations based on teacher or student performance on assessments that test simple retrieval of information can retard the development of adaptive readiness and performance. The authors advocate for the

implementation and continued development of new kinds of tests of complex understanding and transfer (e.g. Hoffman et al., 2014).

Implications for instruction

Previous research provides designers of CFT-learning environments insights into how to appropriately implement the use of CFT-guided CM into teacher education and, at times, when educators should opt for a more well-structured approach.

It is important to provide students with cases that provide a cognitive challenge in terms of unpacking conceptual complexity and variability. With that said, there is evidence that scaffolding measures should be put in place, especially with novices, when using this instructional approach. Jacobson and Spiro (1995) found that students with higher prior knowledge were able to think more deeply about the concepts in a CFH than novice students. Additionally, the flexible and complex organization of the CFH was found to be an obstacle to novices' learning. Several other works have echoed this sentiment in work addressing the use of complex learning environments (Jonassen, 1984; Shapiro and Neiderhauser, 2004; Lowrey & Kim, 2009), noting that the less structured nature of hypertexts may be more beneficial to students with prior knowledge. This presents instructors with a dilemma: as we have discussed, it is important to develop adaptive ways of thinking *early* to combat the development of knowledge shields and other reductive biases, but if novices struggle using CFT-guided learning environments, how can we teach these ways of thinking? It may be tempting to assume that a hierarchical structure is the only way to structure information in a way that is accessible to novice students, but previous research in hypertext structure has shown that it is not the structure itself that scaffolds novice learners' understandings, rather it is instruction that makes the structure of information explicit (regardless of if the information is in a hierarchy or heterarchy)

that supports novice learners. Work in CFT provides some suggestions as to how to address using CFT-guided learning environments effectively..

First, instructors and designers should make sure that the cases being used in CFT-guided learning environments are cognitively manageable; in the context of CFT, cases are *dense* in the sense that they exemplify concepts' complexity and variability in a small-package. These cases should be challenging, but not overwhelm students' cognitive load. Others have noted that learning environments designed to convey complexity require greater attention to learner disorientation due to the wealth of information in the environment (Strobel et al. 2008)

Second, it is important to minimize the cognitive load resulting from trying to make sense of how to use a technology/learning environment (Jacobson & Spiro, 1995). Before asking students to use CFT-guided learning environments, instructors should provide explicit instruction that explains how to navigate environments like hypertexts, video cases, concept maps, and other information systems. I should note that the term "navigate" does not mean instructing students paths of which to take when exploring these learning environments, rather it refers to developing students' technological competencies so that they have the ability to explore these environments freely, in nonlinear, context-dependent manners.

Third, instructors should provide explicit instruction that equips students with a general understanding of CFT. The goal is not to make students experts in the field of CFT, rather it is to provide cognitive preparation for interacting with complex systems of concepts. By providing a baseline understanding of CFT to novices, they are better equipped to make sense of the structure of CFT-guided learning environments and more likely to recognize conceptual complexity and variability of concepts housed in the learning environments.

Lastly, the beauty of CFT-guided learning environments is that they support learning for all levels of expertise. The aforementioned considerations can help novices utilize these environments to develop adaptive worldviews and complex understandings of ill-structured domains. Intermediate and experts benefit from these environments by exploring and reconceptualizing the conceptual variability of concepts and conceptual relationships from case-to-case.

Implications for Research

Researchers interested in marrying CM, CFT, and teacher education should continue to explore the design of CFT-guided CM tools and instruction, further consider outcomes that represent adaptive worldviews and complex understandings, and better understand the processes involved in the development of a CFT-like way of thinking through the use of cases in teacher education.

In terms of designing learning environments and constructing cases to encourage CFT-ways of thinking, researchers should explore the usability and utility of such learning environments and technological tools. For example, research could explore whether or not students find CFT-guided learning environments that use cases too cognitively challenging to use. Related, it would be useful to better understand students' affect towards such learning environments, and the CM approach in general. That is, do they feel optimistic or skeptical about the utility of this approach and related learning environments as helpful to their learning? Why or why not? Lastly, researchers should continue to develop CFT-guided learning environments that can be implemented into curriculum with consideration to teacher training, school resources, and adherence to standards. In other words, questions like "how much/what kind of training do teacher education instructors need to effectively use these tools/environments?"; "how can these

environments be developed so they are useful to schools with diverse arrays of technological and human resources?"; and "how can these environments and goals of CFT benefit existing school standards/does the use of these environments and goals of CFT conflict with existing school standards?".

Spiro et al. (2017) outline the need for new kinds of assessment that better gauge students' 21st-century skills. The 21st-century skills framework overlaps with tenants of CFT in in many ways. Generally speaking, learning in the 21st century often consists of addressing phenomena that are context-dependent, concepts that are dynamic and ever-changing, an adaptation to understand and address (Davis and Sumara, 2006). Researchers interested in the development of CFT-guided CM in teacher education should continue development of assessments that represent complex, context-dependent, adaptive ways of thinking. By developing these types of assessments, researchers can simultaneously provide insight into the design of curriculum and instructional tools to match this type of assessment.

Lastly, research should continue to explore how features of CFT can be integrated into CM and how cases can continue to be used in CFT-guided learning environments, particularly in the context of teacher education to encourage the development of complex conceptual understanding and an adaptive worldview. Researchers may explore questions such as: what kinds of deliberate practice are most effective in helping students use CFT-guided CM to build complex understandings in ill-structured domains?; how do studies concerning transfer inform how we measure students' adaptive performance?; in which knowledge domains do CFT-guided CM help/hinder students' development of adaptive expertise?; what differences concerning accelerated knowledge construction and expertise emerge when comparing CFT-guided CM and other pedagogical methods guided more traditional approaches (i.e. the essentialist approach;

Kirschner, Sweller, & Clark, 2006); what features of emerging media, both existing and yet to be developed, can be leveraged to further increase the development of adaptive worldviews and complex conceptual understandings in CFT-guided CM.

Conclusion

In this paper, I have provided *brief* accounts of CFT and CM and why and how both areas of research should compliment each other to support the development of teacher education. CFT addresses learning in ill-structured domains, of which is often the case with teaching. Specifically, teachers must deal with novelty in the classroom which requires an adaptive worldview, ability to construct schemas-of-the-moments, and the development of complex knowledge structures to understand complex concepts and conceptual relationships. CM is an instructional approach that can be guided by tenants of CFT to create instructional methods and learning environments that use cases to help students experience authentic, complex, and cognitively manageable classroom situations.

The merging of CFT and CM provide several implications for instructional design, instruction, and research in teacher education. In terms of design, learning environments should convey the context-dependent nature of concepts' operationalizations through features such as CSSH. The structure and function of learning environments should use cases to help students build a repertoire of cognitively manageable cases that represent diverse conceptual application, pertinence, and organization. In terms of instruction, it is important for teacher educator instructors to provide necessary scaffolding so that students can utilize CFT-guided CM learning environments. Providing cognitively manageable mini cases provides students with an array of complex conceptual representations of which to draw from when constructing schema of the moment to address novelty. Providing explicit instruction about CFT itself can help students,

particularly novices, make sense of what can be a confusing structure of information in CFT-guided learning environments. In terms of research, there is a broad spectrum of outcomes to explore. This paper covers literature from CM and CFT that has shown application in teacher education, but there is a dearth of empirical research that has married CM and CFT in the context of teacher education, and the work that has addressed it, suggests further investigation.

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