Using Heuristics Tools to Improve Critical Thinking in a Problem Based Learning Curriculum

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This presentation reviews the creation of instructional tools to aid learning in a problem-based learning (PBL) curriculum about child traumatic stress. The tool creation was a part of a larger curriculum improvement project using instructional design principles to improve the use and dissemination of the curriculum. In order to improve the support of complex-problem solving related to child trauma cases, we created a number of heuristic graphic organizers to incorporate into our PBL structure. This presentation will describe the curriculum, explain our steps in tool development, outline our theoretical approach, and discuss the results of the process as seen through the lenses of our PBL facilitators.

The Core Curriculum on Childhood Traumatic Stress

The Core Curriculum on Childhood Traumatic Stress is a national curriculum used to educate mental health practitioners in different academic and field-based environments about child traumatic stress. The curriculum is being developed by the UCLA/Duke University National Center for Child Traumatic Stress in collaboration with its partners in the National Child Traumatic Stress Network (NCTSN). The aim of the curriculum is to support the mission of the NCTSN to improve the quality of trauma-informed care for children and families by raising the standard of education and training for their care providers in foundational principles of childhood traumatic stress.

When the program improvement project began, the curriculum consisted of five detailed case studies written by a panel of experts in childhood traumatic stress. Each case focused on a fictionalized child and their family who had experienced a traumatic event or events. The cases were divided into sections, each ranging from one to two pages in length. Each section revealed new information about the child, the traumatic situation, and the context of the experience. These cases were conducted using traditional variations of a problem-based learning (PBL) model: Learners worked in groups of 6-12 students, reasoning section by section through the case. The cases were specifically designed to build complex problem-solving skills by intermixing both meaningful and less relevant information, thereby forcing learners to identify and piece together the relevant factors as they work their way through the case (Barrows, 1986; Hmelo-Silver, 2004). The curriculum used a medical variation of PBL, including a basic four-step PBL cycle. With each section, the participants work their way through the problem by (a) identifying facts, (b) creating hypotheses about the case, (c) determining next steps that align with the hypotheses, and (d) identifying learning issues where more information is necessary. This process is guided by an expert facilitator who helps to consolidate conceptual understandings and support the group process. (Layne et al., 2014).

At the beginning of our project, we conducted a qualitative analysis to determine the aspects of the curriculum that were serving their purposes and the aspects that could be improved. This work revealed that PBL was an essential aspect of the curriculum that needed to be retained. Not only was PBL known in the literature for building evidence-based reasoning and prioritization skills (Savery & Duffy, 1995), but a survey of our facilitators

showed that it was well liked and considered a strength of the program. However, the survey also revealed that facilitators felt that the PBL cycle did not easily support all of the learning objectives, especially objectives that centered on solving complex problems involving multiple interrelated factors.

Accordingly, one of the primary purposes of our program improvement project was to create ways to make this complex decision-making more accessible in the PBL framework. Our solution was to create graphic organizing tools that supported learners as they were working through these complex problems. The tool creation was guided by applied cognitive science, and the collaborative design process was guided by design-based research. After creating these tools, we invited the curriculum's current facilitators to field-test them. We then conducted an interview study to explore the tool use and how it influenced learning from the curriculum.

Design-Based Research Approach

The curriculum improvement project began with a critical needs and constraints analysis to determine which goals the current curriculum was meeting and to identify foundational aspects of the curriculum that should be retained. More about this analysis is being shared at this conference in a presentation about conducting a collaborative program improvement project (Grossman & Layne, 2018). After concluding the analysis, we reviewed the results to determine our improvement goals. Our primary aims were to improve support for PBL facilitators, improve program implementation fidelity, create tools that could be used to improve clinical reasoning and other learning objectives using the established PBL framework, and create ways to assess learning outcomes.

In order to create tools to support the identified goals of the curriculum, we needed to have a shared understanding of the curriculum's learning objectives. Our needs and constraints analysis provided some of the most basic constraints of what should be incorporated within the curriculum. The curriculum was created to share foundational principles about child traumatic stress; these needed to be incorporated. Additionally, the PBL process had been selected because skills that it helped develop, such as case conceptualization and critical reasoning skills, were seen as necessary for this work. These learning objectives were easy to identify. To identify other relevant learning objectives that were not as apparent, we reviewed trauma competencies from different professional literatures, such as social work, psychology, and psychiatry. These were used to identify overlapping goals and prioritize the skills seen as necessary for trauma-informed practice with professionals. This information was summarized and used to create a prototype of the general learning objectives. Once they had been negotiated on an organizational level, the design team went to work making sure there were tools to support those learning objectives. To build these tools we used a design-based research approach with iterative collaborative design and product development, followed by a comparative product analysis to determine utility (Sandoval & Bell, 2004). We identified the gaps in the curriculum through surveying learning facilitators, trauma experts, and learners. We then designed a tool to bridge those gaps in our learning contexts. These tools were prototyped and then evaluated by facilitators as compared to the curriculum without the tools.

Applied Cognitive Load and the Cognitive Refraction Model

Cognitive load theory approaches improving learning through balancing the cognitive work associated with a learning task. If the load is manageable, the material can be accessed by the learners. However, if the load too large (or not large enough), learning will be diminished (Chandler & Sweller, 1991). The instructional design used in this project was an applied cognitive load model specifically created to support this work. We used the model, which we call the cognitive refraction model, to identify tools that might aid learning during specific learning tasks. It organizes learning objectives into categories of similar types of work to prescribe what type of tools would support learners in the learning task. The model can be seen in Figure 1 and is also being presented at this conference in a separate paper (Grossman, 2018)

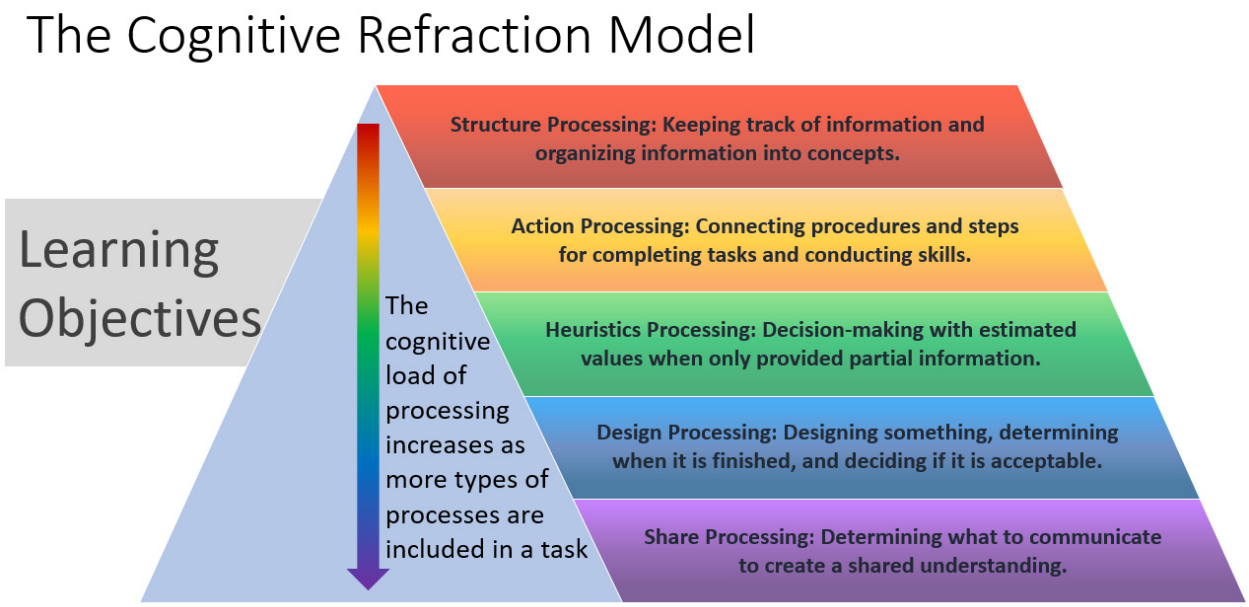

Figure 1. The cognitive refraction model categorizes learning objectives based upon the cognitive work associated with completing the task accurately (Grossman, 2018).

The model aligns these cognitive loads with tools that have been evidenced to support learning from the different tasks. We reviewed and categorized the cognitive load literature about tools and techniques that improved learning to align the tools with the model's categories. Further, we organized methods that simplified learning in a situation, or improved the learner's accuracy, according to the learning tasks where they could be applied. This allowed the model to be a prescriptive lesson planning tool: Specify your learning objectives, then use the model to categorize them and prescribe specific instructional tools to help learners achieve those objectives.

The cognitive refraction model classifies the complex problem-solving we wanted to support as heuristic processing. Table 1 provides some of the techniques for simplifying the work of heuristic processing and for improving the accuracy of heuristic processing.

Table 1: Examples of Techniques for Heuristic Processing

Simplifying the work of Heuristic Processing
• Providing guides to direct attention to important factors in the decision-making process
• Sharing an expert's guiding rules for decision-making before practicing the decision-making
• Providing tools that represent the information visually to reduce the work of multiple elements
• Practicing the decision-making to make the factor identification and weighing-out more automated thus requiring less attention
Improving Heuristic Processing
• Providing tools to allow more factors to be compared simultaneously
• Teaching self-evaluating skills to improve accuracy in decision-making
• Incorporating feedback about the accuracy of the decision-making methods during future decision-making
• Increasing contextualization of information into larger systems and frameworks.

The cognitive loads associated with heuristic processing include the work related to identifying relevant factors for decision-making, estimating the importance of these factors, determining interactions between factors, predicting what possible outcomes might be, and selecting the best outcome out of the options. To design the tools to support these processes, we needed to know which tools might help with each type of work. The cognitive

refraction model's facilitator tools classification chart laid out our options for us in this practice (Grossman, 2018). We identified how we could support the skills specific to our learning objectives. We decided to create a classification chart to help learners identify important factors in a case. Other tools provided conceptual bins for classifying factual evidence to help learners integrate case information and form hypotheses about how various case factors interrelate.

Our heuristic processing was being conducted in a collaborative setting, and cognitive loads associated with collaboration would also influence learning from our PBL cases. The cognitive load literature most influential to this aspect of our work was the literature about collaborative load. Collaborative load is defined as the sum of the cognitive loads associated with collaboration on both the individual and the group level. Individual factors include the load of verbalizing thoughts and the load of maintaining an internal representation of the process. Group-level factors include both the load of creating a shared understanding, and the load of creating a representation of the group model of the problem-state (Kirschner, Paas, & Kirschner, 2009). We needed to keep these loads manageable for collaborative work to be successful. We decided to use graphic organizing tools to support these processes. Graphic organizers are helpful for collaborative heuristic processing in a number of ways:

1) For internal representations: Graphic organizers help keep multiple concepts in the mind concurrently. We can only hold a limited number of factors in our minds at one time (Cowan, 2010); when this work is offloaded into a visual-spatial format, this load is reduced.
2) For representations of the problem state: They organize information so that it can be processed more efficiently. By grouping information into meaningful conceptual bins, those categories can be processed together.
3) For reducing the load of verbalization and the load of creating a shared understanding: It concretizes definitions to create a shared understanding. As collaborative processes create agreed-upon definitions and categorizations, it becomes more clear when a shared understanding has been achieved.
4) For group representation of the problem-state: The visual representation supports the creation of a shared problem representation. Graphic tools can simplify defining and relating models in a collaborative process by predefining the factors in the model being applied.

The Tool Development Process

Our decision to guide learning with instructional tools was made after some tool construction had already taken place. One of the primary tools already existed (CHECKS/Double Checks Heuristic), and another had already been outlined (Seesaw Model). For the other tools, we used a collaborative design-based research approach to tool development, in which products were designed through iterative improvement cycles. This particular collaborative model included critical pedagogy, which allowed content knowledge to be guided by trauma-informed care experts while the overall improvement process was guided by an instructional design expert. The steps of the tool design process can be seen in Table 1.

Table 1: Steps of the Tool Design Process

1. Define the goal of the end product.
2. Determine necessary content and scope
3. Engage in collaborative decision-making about content of prototype
4. Create draft of prototype
5. As a design team, continue to create iterative drafts of the prototype until an acceptable draft is created
6. Field test prototype with expert facilitators
7. Collect feedback about the draft
8. Incorporate corrections and refinements derived from the feedback
9. Formalize final product
10. Evaluate the final product in relation to its use as a tool and its usability
11. Effect wide dissemination of final product

The Tools for the Core Curriculum

The needs and constraints assessment identified three of the curriculum's learning objectives as being particularly difficult to support: case factor identification, case conceptualization, and critical reasoning. These three learning tasks are all classified as heuristic processing in the cognitive refraction model. To support learning in these areas, we wanted graphic tools that could model the problem organization and simplify the work of creating shared understandings. We determined that we needed tools to serve three purposes: first, to help identify important ecological factors in a child's ecocultural context; second, to aid in conceptualizing about the case and how identified factors play a role in a child's traumatic experience and recovery; and third, to support critical reasoning around treatment prioritization and interventions related to a child's case. For these purposes, we created four graphic organizing tools to be incorporated into the PBL curriculum: (1) Ecological Dimensions Categorizing Chart, (2) Protective Shields Factor Map, (3) Seesaw Model, and (4) CHECKS/Double Checks Heuristic.

Ecological Dimensions Categorizing Chart (EDCC): The EDCC is our most basic tool. It helps novices learn to identify important case factors and classify them in meaningful conceptual bins. The tool presents learners with worked examples of ecological factors in a child trauma case. Learners are then asked to identify ecological factors in the problem case. Theoretically, it helps learners achieve a basic level of mastery in identifying and classifying case factors.

Protective Shields Factor Map (Protective Shields): The Protective Shields is a more advanced tool to aid in identifying case factors, as it requires a basic working knowledge of ecological theory. Using this tool, learners identify case factors and classify them into ecological dimensions based upon whether they are theorized to serve as causal risk factors or as supportive factors. In a cognitive load theoretical framework, the diagram reduces the work of holding case information in the mind, categorizing case factors, and communicating about the interactions between factors. We hypothesized that this tool will serve as a learning tool, communication aid, assessment tool, and supervisorial tool.

Seesaw Model: The Seesaw model takes a dichotomous (either-or) decision-making event and forces the learners to use evidence to support their decision-making. Using this tool, learners identify relevant case factors, weight each relevant factor according to its credibility, and then align the factors for versus against the decision. The seesaw model is hypothesized to be a good learning tool, communication aid, and assessment tool. Theoretically, this activity slows down thinking and requires explication of logic in a collaborative process.

CHECKS/Double Checks Heuristics: The CHECKS and the Double Checks Heuristics are tools to organize case information for case conceptualization. These tools organize the information based on the role each factor is hypothesized to play in influencing the child's experience and post-traumatic recovery. Using these tools, learners take identified relevant case factors and determine the role the factors play in the child's case and how they relate to the possible case outcomes. The CHECKS Heuristic invites learners to sort case factors into four conceptual bins consisting of: causal risk factor, protective factor, vulnerability factor, and negative outcomes. The Double Checks Heuristic is a more advanced version of the same tool that includes four additional conceptual bins: positive outcomes, promotive factors, inhibitory factors, and facilitative factors. The CHECKS and Double Checks are hypothesized to be learning tools, communication aids, assessment tools, and supervisorial tools. We theorize that these tools categorize information into meaningful chunks and help retain multiple factors simultaneously. We thus hypothesize that the CHECKS and Double Checks serve as learning tools, communication aids, assessment tools, and supervisorial tools.

Tool Evaluation Methodology

To examine how the tools were perceived to influence learning, we turned to our advanced facilitators for feedback. Our advanced facilitators (N = 26) were trained in the original curriculum between 1-3 years prior to the tools introduction. These advanced facilitators were professionals in fields of mental health, such as psychology, psychiatry, and social work. The group contained clinic directors, university instructors, and community center representatives. They held a great deal of expertise in child trauma, but were not professional educators. Since their original training, these facilitators had using the curriculum at their work sites and occasionally at affiliated sites. This gave them experience in conducting the curriculum without the new tools. In June 2017, these facilitators went to our advanced college, where they were introduced to the new learning tools.

In order to gain advanced certification, participants were required to train in a case using at least one new tool. Advanced facilitators who had used one of these learning tools in their training were then candidates for participation in the study. If a facilitator was willing to participate, an appointment was set up for a semi-structured telephone interview about their tool use and their perceptions of its utility. These participants were part of our program and invested in the project of program improvement. They were considered collaborators more than study participants.

Ten of these advanced facilitators agreed to contribute to evaluating their use of the tools. We interviewed them regarding the ways in which they were incorporating the new tools into PBL cases and the roles they might play in educating mental health professionals in foundational competencies. The interview included questions about their training particulars, the tools they used, details regarding how they incorporated the tools into their training, and how the tools were contributing to the quality of learning. We used this feedback for a number of purposes: to improve the tools themselves, to evaluate whether the tools were contributing to our learning goals, and to broaden the range of the tools potential applications.

Feedback from Facilitators

When we introduced the tools at the advanced facilitator training, the trainees appeared to be very circumspect, some even openly skeptical, in their reactions. We had groups of facilitators work through two of the new tools (the Protective Shields and Seesaw Model) in participatory exercises. We also introduced other two tools with the assurance that we would cover them later in a webinar. These instructional tools were only one part of a larger training, and the quantity of material they received during that two-day intensive training proved to be overwhelming for them. It was hard for the design team to tell if they considered the tools useful or enjoyable. Observing the training did inform us that we needed to clarify some of the tool instructions and to provide a terminology glossary for the language used in the tools. We analyzed and used this training feedback to refine the tools before formally distributing them. Whether or not they enjoyed the new tools, using at least one of the new tools was necessary for certification, so they were motivated to try.

The phone interviews with the 10 facilitators revealed a good deal about the tools' perceived utility. Everyone interviewed had used at least one tool in their training. Eight had co-facilitated the curriculum with another facilitator. This suggested that the early adopters were the ones who had the support of a partner. The tools were used in a variety of settings, including schools of social work, integrated health organizations, a special education collaborative, and for intern and clinical trainings. These trainings included shorter trainings (from 3-6 hours), extended classroom settings (a 7-day intensive and course-work broken between 20 hours across a semester), and regular clinical work incorporating aspects of the program (for example, attending 2, 3-hour blocks for all interns).

All five of our cases were used with the different tools, though more facilitators used the James case, a pre-teen case of domestic violence and child physical abuse, than any other case. All four of the tools were tried by at least one facilitator; EDDC, n=3; Protective Shields, n=7; Seesaw Model, n=3; CHECKS/Double Checks, n=4. The tools were appreciated by the facilitators who incorporated them. A primary appreciation of the tools was that facilitators valued how they changed the pace of the traditional PBL cycle, which could become repetitive. The tools were seen as giving facilitators more options in how they used their training time. Another common theme facilitator observed was the tools enriched group conversations about case factors, including deeper consideration about the specific roles each factor played, and the credibility of each piece of evidence. The tools also invited collaborative perspective sharing, leading to more contributed perspectives and pooled information. Many facilitators also remarked about the visual nature of the tools and how that was helpful for organizing information and comparing groups of information. The feedback about specific tools follow in Table 2.

Table 2: Summary of Feedback about Specific Tools

EDCC: Valued for giving novices structure to support conceptual understanding. It embedded the traumatic situation within the surrounding ecology in which it was happening. This tool was seen as very easy to incorporate.
Protective Shields: Valued as a tool for helping hold and organize multiple perspectives. Facilitators particularly liked how it helped learners communicate about factors and identify areas where they needed more information. Dividing information into risk versus supportive factors allowed learners to focus more on supporting the child than

they normally would. It was seen as an intuitive way of organizing the information. Two of the facilitators organized the fact collecting in PBL using this tool throughout the whole case.

Seesaw Model: Valued because it slowed down the learning process, forced learners to support their perspectives with evidence, and revealed personal biases. They particularly liked the conversations that came with trying to resolve differences of opinion related to case factors. This tool received some negative feedback, suggesting that time management was difficult with this too. Users reported that many professional decisions cannot be distilled down to dichotomous either/or options, and even seasoned professionals can reach very different conclusions about the same set of factors.

CHECKS/Double Checks: Valued as a framework for formulating a working clinical theory, this tool was used for organizing information and structuring learners' thinking about the roles factors play in traumatic situations. Facilitators who liked this tool applied it regularly and in multiple settings. It became a way of framing the reasoning around a case conceptualization and treatment planning. Users first used it as a communication aid and training tool, and then some expanded their application of the model itself by using it as a clinical supervision tool with their interns. The negative feedback about this tool was that the terminology of the tool needed pre-training, and that the Double Checks Heuristic (which contains 4 more factors) was too complex for beginning audiences.

Tool adoption, dissemination, and implementation

After facilitators had used the tools, they continued to use them. The tools were seen as engaging and especially valued for how they encouraged and facilitated perspective-sharing. They said they got more positive feedback from stakeholders as well. Each facilitator modified the tool use slightly to fit their situations; for example, some made hand-outs of the models for each learner, whereas others used the models with real-life case material in addition to Core Curriculum case studies. They became integrated into our facilitator's professional practice. These facilitators share aspects of their work with each other during our regularly held consultation calls, which is helping to slowly broaden tool use in the advanced facilitator cohort. Based on this feedback, we created a number of new tools to support reasoning in other learning objectives.

We also used facilitator feedback in another cycle of refining the curriculum. Because advanced facilitators judged the EDCC and the Protective Shields to be beneficial for all Core Curriculum learners, we chose to incorporate those two tools into the base curriculum and introduced them at our basic training for new facilitators. In this basic-level training, we were more intentional and direct in clarifying the flexibility that these new options created for facilitators. Introducing these tools at the basic training helped novice facilitators to conceptualize the tools as an integral and foundational part of the curriculum. Consequently, we observed that the novice facilitator cohort had an easier time incorporating the tools into their PBL facilitation than did the advanced facilitators.

The feedback also helped us identify that the Seesaw Model could not be classified as a tool. The Seesaw Model was seen as a useful activity to help learners slow down their thinking, identify biases, and find evidence for beliefs. However, it didn't flow well with the PBL cycle and wasn't something that would be regularly incorporated in a section-by-section case analysis. Instead, we recognized that the Seesaw model falls into a new category of instructional materials: Activities. We have thus started to develop a Core Curriculum activity kit to support our learning objectives. We will design the activities in this toolkit to deepen thinking about case factors outside of the regular 4-step PBL cycle, thereby allowing learners to practice the skill once or twice during the case (such as at critical decision-making junctures as the case unfolds) instead of incorporating the tool into regular section-by-section case processing. The Seesaw Model will become part of the activity kit once it is completed.

Discussion

At the beginning of our work, our needs and constraints analysis revealed a need for better support for learning objectives associated with factor identification, case conceptualization, and critical reasoning. We hypothesized that we could support this learning with heuristic tools to balance cognitive loads during the PBL cycle. The tools we designed would theoretically support this learning by aiding communication about the case, organizing information into conceptual bins, making the information easier to retain, and simplifying the creation of a shared understanding. The feedback from our facilitators supported these hypotheses. Facilitators spoke of

improvements in organization of information, sharing perspectives, and combining information. The tools functioned as hypothesized and in doing so, improved learning outcomes from the curriculum.

In the larger picture, this work supports using an applied cognitive load lens in instructional design. As anticipated, the practice of balancing the cognitive load of the learning task in PBL did improve learning from the curriculum. Facilitators spoke of holding deeper and richer conversations than they had previously had, and of building a deeper shared understanding of the material, than what was previously possible. We propose that mental health professionals require these diverse reasoning skills to handle the complex child trauma cases they encounter in their work. This curriculum invites them to practice that reasoning in a supported situation with low-risk decision making, given the obvious fact that making poor decisions with a fictional child carries far lower risks than making erroneous decisions in real-world cases. The use of the tools during learning aligns with and supports the classification skills and conceptual understandings that are necessary for performing this work in the field.

In terms of increasing the applications of PBL in complex learning, this study supported the methodology, showing that heuristic tools could be used to scaffold learning of complex-problems in a collaborative manner that allowed for perspective sharing and improved reasoning skills. This was engaging curriculum that learners felt was easily applicable to the everyday practices of their professional work.

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