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Cognitive Load Measurement, Worked-Out Modeling, and Simulation

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Background

Nursing was founded in an apprenticeship educational model, in which a student was paired with an expert nurse who provided supervision, support, and instruction. In this model, the student learned through demonstration, observation, and imitation, while engaging in dialogue and coaching with the expert nurse concerning skills, interventions and critical thinking processes (Baltzersen, 2014, Ch. 3). The complex simulation environment often does not provide this benefit of the “expert” nurse exemplar that is seen in the historical apprenticeship and current clinical model of nursing education.

Multiple concepts are presented in simulation, requiring the student to analyze and filter relevant information, while engaging in critical reasoning to guide interventions in a complex setting. Cognitive load theory (CLT) aptly applies to complex learning situations like simulation, providing a range of interventions that positively affect student learning. Clark, Nguyen, & Sweller (2006) identify one such intervention as the worked-out example, which provides task completion demonstration prior to task performance. Effectively, reducing cognitive load, increasing learning, and assisting critical reasoning development. This study’s aim was to evaluate the application of worked out modeling (WOM), developed by the author, based upon the CLT worked-out example and applied to simulation. WOM is defined as “The modeling of a skill or procedure by a nurse paired with verbal and gestural description of critical thinking processes and pathophysiological connections to the content to be used for imitation, comparison, or as a representation of a standard of practice.” (Josephsen, 2015, p.16).

Theoretical Framework

CLT focuses upon understanding how a student's cognitive architecture affects learning. Cognitive architecture is composed of a variety of information processing components including working memory, long-term memory, schema, and cognitive load. Working memory is finite, used during initial learning, and is affected by cognitive load. Working memory is generally thought to be limited to processing up to seven elements or pieces of information at one time. This amount decreases as the need for analysis and problem solving increases. Long term memory stores knowledge that can be situationally retrieved, enhancing working memory function (Plass, Moreno, & Brunken, 2010). Integral to long term memory is the development and use of schema (a framework or model, much like a clinical algorithm) that assists in organizing information and guiding solutions related to specific content.

Cognitive load consists of three distinct types, extraneous, intrinsic, and germane. Extraneous load involves instructional aspects that are not related to learning outcomes and taxes working memory and learning ability. Intrinsic load consists of materials or activities essential to learning. Content that is complex or has multiple conceptual elements contains higher intrinsic load, impacting working memory and learning capacity. Lastly, germane load relates to the ability to integrate new knowledge into schemas that are used in future practice. These types of load have an additive effect, and once the working memory is exceeded, learning is negatively impacted. Simulation generally contains many elements/concepts and dynamic conceptual interactivity that contributes to high extraneous and intrinsic load, limiting working memory, decreasing germane load, and potentially diminishing learning (Fraser, et al., 2012, p. 1056).

Using WOM as a pre-simulation intervention may alleviate inherent cognitive load issues. WOM provides guidelines for addressing the scenario, identification of visual cues and verbal representations of problem areas, and highlights relevancy of identified concepts/elements to the final scenario solution. Renkle and Atkinson (2003, p. 17) suggest novice learners often have insufficient domain specific knowledge when presented with new problem situations, causing reliance upon general problem solving tactics. This can increase intrinsic load, tax working memory, and affect learning. If pre-simulation the student is provided with an example solution, explanation of how to approach the scenario, and the critical thinking processes utilized by an expert nurse, concepts can be connected and germane load enhanced. This assists in meeting learning outcomes and enables schema creation for transfer to future practice (Van Merrienboer, Kirschner, & Kester, 2003, pp. 6-7).

WOM use supports simulation outcomes related to clinical judgment and reasoning, critical thinking, and psychomotor skill development. Providing WOM pre-simulation ideally assists the student to focus on important simulation elements, identify critical thinking processes, distinguish data relevancy, select appropriate interventions, and assist in analyzing patient outcomes. Additionally, use of WOM provides the student with a proficient example of application of psychomotor skills and allows for the expert nurse to discuss examples of how to contextually adapt skills if needed (Josephsen, 2015).

Sample

A quasi-experimental quantitative research design was used with a convenience sample of 61 senior nursing students with previous simulation experience. Students were divided into 8 groups of 7-8 students each, with four treatment groups receiving WOM and 4 control groups not receiving WOM. There were 27 students (21 female, 6 male) in the treatment group and 34 students in the control group (30 female, 4 male).

Methods

A multi patient simulation focusing on delegation and decision making was selected for the study. This simulation was felt to be appropriate as it involved clinical reasoning and prioritization skills, which require development and use of schema. Both treatment and control groups performed the usual pre-simulation reading assignment. The control group went through the usual prebriefing, orientation, and question/answer time prior to simulation participation. The treatment group also had a prebriefing, orientation, and question/answer time but it was shortened so that a 10 minute WOM video could be shown. The video contained an example of an expert nurse performing the simulation, providing verbal description of thinking processes and pathophysiology as interventions were implemented throughout the scenario.

A practicing registered nurse with 7 years bedside medical surgical and charge nurse experience provided the modeling of nursing skills and judgment in the simulation. While a certified nursing assistant with 10 years of experience provided modeling of accepting delegation and performing delegated activities throughout the simulation. The WOM video was reviewed by a Certified Healthcare Simulation Educator faculty member prior to being shown to assess for content appropriateness. The simulation took place in the school's simulation center and was facilitated by faculty trained in Tanner's Clinical Judgement Model of debriefing (Tanner, 2006).

Cognitive load and knowledge survey development.

Since a tool specific to cognitive load and nursing simulation was not found, the Leppink, Paas, Van der Vlueten, Van Gog, and Van Merrienboer (2013) tool was adapted by adjusting the questions to fit the simulation environment. Research supports using a measurement model that examines all three aspects of cognitive load. The tool used for adaptation was selected as it met this model, offering integration of extraneous, intrinsic, germane, and overall cognitive load measures. See Table 1.1 for the Simulation Self-Report Cognitive Load Measurement Tool 1.0.

Part of the Leppink, et al. (2013) tool included examination of pre/post knowledge via word problems. This technique was not easily applied to the simulation, so a pre/post knowledge survey was developed. The pre/post knowledge survey used a multiple-choice format, addressing simulation content and learning outcomes, such as use of delegation or fall prevention. Baseline knowledge data was collected during the associated didactic course one week pre-simulation to assess differences in knowledge attainment in the control and treatment groups. Post simulation both treatment and control groups were given the cognitive load measurement tool and the post knowledge survey to complete.

Results

Baseline and knowledge acquisition differences.

No significant differences were found between the treatment and control groups related to pre-knowledge. No significant differences were found between the groups related to demographics, completion of pre-reading, or simulation role (observer vs. participant) per a χ^2 analysis. Examination of the post simulation knowledge survey showed the treatment group had greater knowledge related to patient falls, F (1,43) =6.91, p=.012, η^2=.139. Additionally, the amount of intrinsic load was found to be significant related to falls post knowledge, F (1,43) =5.955, p=.019, η^2=.119. This suggests the concept of falls had many elements and the WOM intervention assisted in germane load transference and knowledge attainment. Other areas of significance found, included an association between germane load and post simulation knowledge concerning Situation, Background, Assessment, Recommendation (SBAR), F (1,43) =4.477, p=.040, η^2=.092, suggesting that use of WOM assisted in schema development associated with SBAR concepts.

Cognitive load survey findings and interpretation.

Aggregate scores were calculated for each type of cognitive load post survey. Extraneous load aggregate showed poor internal consistency reliability, α=.384. Intrinsic load aggregate had acceptable internal consistency reliability, α=.775. Germane load aggregate had good internal consistency reliability, α=.841. Overall cognitive load measurement had acceptable internal consistency reliability, α=.736. These reliability scores indicate the tool has overall acceptable reliability, but caution should be used when interpreting extraneous load data. Due to this, the tool has been revised. See Table 1.2 for the Simulation Self Report Cognitive Load Measurement Tool 2.0.

Significant relationships were found between overall intrinsic and germane load and overall extraneous and germane load, F (1,56) =10.569, p=.002, η^2=.159 and F (1,55) =8.332, p=.006, η^2=.132, respectively. This data supports known information concerning interaction between cognitive load types. Results indicated students completing pre-reading experienced greater germane load, F (1,59) =5.97, p=.018, η^2=.095. No significant differences were found in cognitive load reported between observer and participant roles. No significant differences in cognitive load were found between the treatment and control groups.

Although not significant, data suggested that the treatment group experienced more intrinsic and germane load and less extraneous load, indicating use of WOM pre-simulation can enhance learning outcomes and address issues related to cognitive load experienced. These results direct simulation educators to examine simulation practices, as data confirmed students are experiencing cognitive load during simulation and that pre-simulation interventions such as WOM can positively affect simulation outcomes.

Conclusion

This study investigated WOM as a pre-simulation intervention and its effect on cognitive load and learning outcomes. Results suggest that WOM successfully impacts learning and cognitive load experienced. Moreover, this study piloted a cognitive load measurement tool which was shown to have overall adequate reliability. The independent measure of extraneous load was found to have poor reliability, leading to development of version 2.0 of the tool. Analysis of common simulation practices of pre-reading and participant vs. observer role, support current simulation best practices in the context of CLT. Additionally, data supported what is known about the relationships between extraneous, intrinsic, and germane load. Findings have limited generalizability due to the pilot nature of the intervention and measurement tool, although a framework for additional research is presented. Considerable CLT research opportunities exist, including continued research on cognitive load measurement, best practices for WOM, and how to address and manage cognitive load in simulation design and implementation.

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