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Cognitive Load Measurement, Worked-Out Modeling, and Simulation

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1   **Cognitive Load Measurement, Worked-Out Modeling, and Simulation**

2   **Background**

3   Nursing was founded in an apprenticeship educational model, in which a student was

4   paired with an expert nurse who provided supervision, support, and instruction. In this model, the

5   student learned through demonstration, observation, and imitation, while engaging in dialogue

6   and coaching with the expert nurse concerning skills, interventions and critical thinking

7   processes (Baltzersen, 2014, Ch. 3). The complex simulation environment often does not provide

8   this benefit of the "expert" nurse exemplar that is seen in the historical apprenticeship and

9   current clinical model of nursing education.

10   Multiple concepts are presented in simulation, requiring the student to analyze and filter

11   relevant information, while engaging in critical reasoning to guide interventions in a complex

12   setting. Cognitive load theory (CLT) aptly applies to complex learning situations like simulation,

13   providing a range of interventions that positively affect student learning. Clark, Nguyen, &

14   Sweller (2006) identify one such intervention as the worked-out example, which provides task

15   completion demonstration prior to task performance. Effectively, reducing cognitive load,

16   increasing learning, and assisting critical reasoning development. This study's aim was to

17   evaluate the application of worked out modeling (WOM), developed by the author, based upon

18   the CLT worked-out example and applied to simulation. WOM is defined as "The modeling of a

19   skill or procedure by a nurse paired with verbal and gestural description of critical thinking

20   processes and pathophysiological connections to the content to be used for imitation,

21   comparison, or as a representation of a standard of practice." (Josephsen, 2015, p.16).

22   **Theoretical Framework**

23   CLT focuses upon understanding how a student's cognitive architecture affects learning.

24   Cognitive architecture is composed of a variety of information processing components including

25   working memory, long-term memory, schema, and cognitive load. Working memory is finite,

26   used during initial learning, and is affected by cognitive load. Working memory is generally

27   thought to be limited to processing up to seven elements or pieces of information at one time.

28   This amount decreases as the need for analysis and problem solving increases. Long term

29   memory stores knowledge that can be situationally retrieved, enhancing working memory

30   function (Plass, Moreno, & Brunken, 2010). Integral to long term memory is the development

31   and use of schema (a framework or model, much like a clinical algorithm) that assists in

32   organizing information and guiding solutions related to specific content.

33   Cognitive load consists of three distinct types, extraneous, intrinsic, and germane.

34   Extraneous load involves instructional aspects that are not related to learning outcomes and taxes

35   working memory and learning ability. Intrinsic load consists of materials or activities essential to

36   learning. Content that is complex or has multiple conceptual elements contains higher intrinsic

37   load, impacting working memory and learning capacity. Lastly, germane load relates to the

38   ability to integrate new knowledge into schemas that are used in future practice. These types of

39   load have an additive effect, and once the working memory is exceeded, learning is negatively

40   impacted. Simulation generally contains many elements/concepts and dynamic conceptual

41   interactivity that contributes to high extraneous and intrinsic load, limiting working memory,

42   decreasing germane load, and potentially diminishing learning (Fraser, et al., 2012, p. 1056).

43   Using WOM as a pre-simulation intervention may alleviate inherent cognitive load

44   issues. WOM provides guidelines for addressing the scenario, identification of visual cues and

45   verbal representations of problem areas, and highlights relevancy of identified concepts/elements

46   to the final scenario solution. Renkle and Atkinson (2003, p. 17) suggest novice learners often

47   have insufficient domain specific knowledge when presented with new problem situations,

48   causing reliance upon general problem solving tactics. This can increase intrinsic load, tax

49   working memory, and affect learning. If pre-simulation the student is provided with an example

50   solution, explanation of how to approach the scenario, and the critical thinking processes utilized

51   by an expert nurse, concepts can be connected and germane load enhanced. This assists in

52   meeting learning outcomes and enables schema creation for transfer to future practice (Van

53   Merrienboer, Kirschner, & Kester, 2003, pp. 6-7).

54   WOM use supports simulation outcomes related to clinical judgment and reasoning,

55   critical thinking, and psychomotor skill development. Providing WOM pre-simulation ideally

56   assists the student to focus on important simulation elements, identify critical thinking processes,

57   distinguish data relevancy, select appropriate interventions, and assist in analyzing patient

58   outcomes. Additionally, use of WOM provides the student with a proficient example of

59   application of psychomotor skills and allows for the expert nurse to discuss examples of how to

60   contextually adapt skills if needed (Josephsen, 2015).

61   **Sample**

62   A quasi-experimental quantitative research design was used with a convenience sample

63   of 61 senior nursing students with previous simulation experience. Students were divided into 8

64   groups of 7-8 students each, with four treatment groups receiving WOM and 4 control groups not

65   receiving WOM. There were 27 students (21 female, 6 male) in the treatment group and 34

66   students in the control group (30 female, 4 male).

67   **Methods**

68   A multi patient simulation focusing on delegation and decision making was selected for

69 the study. This simulation was felt to be appropriate as it involved clinical reasoning and

70 prioritization skills, which require development and use of schema. Both treatment and control

71 groups performed the usual pre-simulation reading assignment. The control group went through

72 the usual prebriefing, orientation, and question/answer time prior to simulation participation. The

73 treatment group also had a prebriefing, orientation, and question/answer time but it was

74 shortened so that a 10 minute WOM video could be shown. The video contained an example of

75 an expert nurse performing the simulation, providing verbal description of thinking processes

76 and pathophysiology as interventions were implemented throughout the scenario.

77   A practicing registered nurse with 7 years bedside medical surgical and charge nurse

78 experience provided the modeling of nursing skills and judgment in the simulation. While a

79 certified nursing assistant with 10 years of experience provided modeling of accepting delegation

80 and performing delegated activities throughout the simulation. The WOM video was reviewed

81 by a Certified Healthcare Simulation Educator faculty member prior to being shown to assess for

82 content appropriateness. The simulation took place in the school's simulation center and was

83 facilitated by faculty trained in Tanner's Clinical Judgement Model of debriefing (Tanner, 2006).

84   **Cognitive load and knowledge survey development.**

85   Since a tool specific to cognitive load and nursing simulation was not found, the Leppink,

86 Paas, Van der Vlueten, Van Gog, and Van Merrienboer (2013) tool was adapted by adjusting the

87 questions to fit the simulation environment. Research supports using a measurement model that

88 examines all three aspects of cognitive load. The tool used for adaptation was selected as it met

89 this model, offering integration of extraneous, intrinsic, germane, and overall cognitive load

90 measures. See Table 1.1 for the Simulation Self-Report Cognitive Load Measurement Tool 1.0.

91   Part of the Leppink, et al. (2013) tool included examination of pre/post knowledge via

92   word problems. This technique was not easily applied to the simulation, so a pre/post knowledge

93   survey was developed. The pre/post knowledge survey used a multiple-choice format, addressing

94   simulation content and learning outcomes, such as use of delegation or fall prevention. Baseline

95   knowledge data was collected during the associated didactic course one week pre-simulation to

96   assess differences in knowledge attainment in the control and treatment groups. Post simulation

97   both treatment and control groups were given the cognitive load measurement tool and the post

98   knowledge survey to complete.

99   **Results**

100   **Baseline and knowledge acquisition differences.**

101   No significant differences were found between the treatment and control groups related to

102   pre-knowledge. No significant differences were found between the groups related to

103   demographics, completion of pre-reading, or simulation role (observer vs. participant) per a χ^2

104   analysis. Examination of the post simulation knowledge survey showed the treatment group had

105   greater knowledge related to patient falls, F (1,43) =6.91, p=.012, η^2=.139. Additionally, the

106   amount of intrinsic load was found to be significant related to falls post knowledge, F (1,43)

107   =5.955, p=.019, η^2=.119. This suggests the concept of falls had many elements and the WOM

108   intervention assisted in germane load transference and knowledge attainment. Other areas of

109   significance found, included an association between germane load and post simulation

110   knowledge concerning Situation, Background, Assessment, Recommendation (SBAR), F (1,43)

111   =4.477, p=.040, η^2=.092, suggesting that use of WOM assisted in schema development

112   associated with SBAR concepts.

113   **Cognitive load survey findings and interpretation.**

114   Aggregate scores were calculated for each type of cognitive load post survey. Extraneous

115   load aggregate showed poor internal consistency reliability, α=.384. Intrinsic load aggregate had

116   acceptable internal consistency reliability, α=.775. Germane load aggregate had good internal

117   consistency reliability, α=.841. Overall cognitive load measurement had acceptable internal

118   consistency reliability, α=.736. These reliability scores indicate the tool has overall acceptable

119   reliability, but caution should be used when interpreting extraneous load data. Due to this, the

120   tool has been revised. See Table 1.2 for the Simulation Self Report Cognitive Load

121   Measurement Tool 2.0.

122   Significant relationships were found between overall intrinsic and germane load and

123   overall extraneous and germane load, F (1,56) =10.569, p=.002, η^2=.159 and F (1,55) =8.332,

124   p=.006, η^2=.132, respectively. This data supports known information concerning interaction

125   between cognitive load types. Results indicated students completing pre-reading experienced

126   greater germane load, F (1,59) =5.97, p=.018, η^2=.095. No significant differences were found in

127   cognitive load reported between observer and participant roles. No significant differences in

128   cognitive load were found between the treatment and control groups.

129   Although not significant, data suggested that the treatment group experienced more

130   intrinsic and germane load and less extraneous load, indicating use of WOM pre-simulation can

131   enhance learning outcomes and address issues related to cognitive load experienced. These

132   results direct simulation educators to examine simulation practices, as data confirmed students

133   are experiencing cognitive load during simulation and that pre-simulation interventions such as

134   WOM can positively affect simulation outcomes.

135   **Conclusion**

136   This study investigated WOM as a pre-simulation intervention and its effect on cognitive

137   load and learning outcomes. Results suggest that WOM successfully impacts learning and

138   cognitive load experienced. Moreover, this study piloted a cognitive load measurement tool

139   which was shown to have overall adequate reliability. The independent measure of extraneous

140   load was found to have poor reliability, leading to development of version 2.0 of the tool.

141   Analysis of common simulation practices of pre-reading and participant vs. observer role,

142   support current simulation best practices in the context of CLT. Additionally, data supported

143   what is known about the relationships between extraneous, intrinsic, and germane load. Findings

144   have limited generalizability due to the pilot nature of the intervention and measurement tool,

145   although a framework for additional research is presented. Considerable CLT research

146   opportunities exist, including continued research on cognitive load measurement, best practices

147   for WOM, and how to address and manage cognitive load in simulation design and

148   implementation.

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