Developing critical thinking and problem-solving skills learning progressions in dental hygiene programs

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Abstract

Subject Matter Experts (SME's) evaluated teaching strategies that help promote critical thinking and problem-solving development through learning progressions. The SME's were asked to rate different learning progression subskills as to the essentialness of the stated indicator that encouraged the acquisition of these skill sets. A Q-sort statistical analysis supported the alignment of two raters on the questionnaire. A Lawshe content validity ratio analysis determined the representativeness of each task contributing to a learning progression.

Keywords: critical thinking, problem-solving, learning progressions, dental hygiene, Content Validity Ratio, Q-sort

INTRODUCTION

An ongoing question in academia is how to assess critical thinking and problem-solving skills in students. In critical thinking development, two positions have emerged regarding a pathway for attainment. The generalist supports the view that student learns skills in a systematic way across all disciplines (Ennis, 1989). Whereas, the specifiers argue that these skills are contextual to a particular subject matter (McPeck, 1990). The same perspectives apply to problem-solving capabilities. Also, research by Richard Arum and Jospia Roska found college students gain little in critical thinking skills as measured by the student's scores on the Collegiate Learning Assessment (Arum & Roksa, 2011). This study identified subskills of critical thinking and problem-solving that are considered essential in a dental hygiene curriculum. The study investigated the identification of subskills by SME's of learning progressions in the development of critical thinking and problem-solving skills. Once the indicators were deemed valid, then the learning progression subskills would be embedded into a dental hygiene program to demonstrate the student's acquisition of these skill sets.

CRITICAL THINING AND PROBLEM-SOLVING CONCERNS IN HIGHER EDUCATION

The Association of American College & Universities (AAC&U) defines critical thinking as a habit of mind in which the student comprehensively explores issues, ideas, artifacts, and events before formulating an opinion or conclusion (Association of American Colleges & Universities, 2018). Whereas, problem-solving is the process in which the student designs, evaluates, and implements a strategy to answer an open-ended question (Association of American Colleges & Universities, 2018). These two skill sets go hand and hand because both refer to using knowledge, facts, and data to solve problems effectively (Lumen Learning, 2018). However, many professional program accrediting agencies require evidence that these two skill sets have to be master separately by students. For example, the Commission on Dental Accreditation (CODA) has developed academic standards for dental hygiene programs. Dental hygiene programs must demonstrate that students are competent in both critical thinking and problem-solving skills to achieve accreditation. Current research indicates that 89% of university faculty claim that critical thinking was the foremost student learning objective of their course (Paul, Elder, & Bartell, 1997). However, only 19% of faculty could define critical thinking, and only 9% were teaching essential strategies of thinking within their daily lesson plans (Paul, Elder, & Bartell, 1997). Therefore, the challenge for instructors is to have a clear understanding of these definitions and have a definitive plan to execute the teaching of these skill sets within a course and across the curriculum.

Regardless of the college program, the curriculum needs to plan the development of these higher-order cognitive skills strategically. Unfortunately, research indicates that critical thinking skills are on a decline in today's college. Arum referenced that approximately a third of graduates from a four-year university showed no improvement in critical thinking skills (Arum, 2011). Given these numbers, critical thinking and problem-solving skills need to be taught overtly as other content in college courses (Schlueter, 2016).

According to Diane Halpern (1999), there are identifiable critical thinking skills that can be taught and learned in college (Halpern D.F., 1999). She has introduced a four-part model of

instruction. These are skills, dispositions, structure training and metacognition (Halpern D.F., 1999). The component of this model that is highly applicable to the development of critical thinking and problem-solving in a college program is structured training. Structure training is the ability to direct learning activities that allow an increase in the probability of contextual transfer of subject matter (Halpern D., 2014). This approach compliments both the generalist and specifiers positions on critical thinking and problem-solving achievement. Confirming that critical thinking skills can be taught, learned, and contextually transferred is ideal for developing learning progressions across the curriculum.

LEARNING PROGRESSIONS

Learning progressions are descriptions of increasingly sophisticated pathways of thinking about a topic that allows students to master core concepts (Council of Chief School Officers and Interstate Teachers Assessment and Support Consortium, 2013). Learning progressions research hypothesizes that students achieve proficiency if they have a sequential level of defined learning which allows mastery of skills (Corcoran, Mosher, & Rogat, 2009). The core concepts are knowledge domains which focus on central learning themes. Smith and colleagues (2006) outlined five essential components of learning progressions which are clear learning endpoints; over time progress is developed; definitive levels of achievement; and student assessment is tracked (Smith, Wiser, Anderson, & Krajcik, 2006). Salina (2009) provides an operational definition of learning progressions. He describes learning progressions a successive and interconnected step in a person's thinking and knowledge skills that start from simple to more complicated way of understanding (Salina, 2009). Learning is not a series of distinct events, but a trajectory of development that connects the objects within a knowledge domain (Heritage, 2008). Also, learning progressions consist of subskills that require the student to master before they move to the next level.

Moreover, similar to designing a course where one starts from the end-product and work backward, this is the same principle when developing learning progressions. The instructor needs to identify what does the student needs to know and how will they be able to master this aim (Popham, 2007). Therefore, the incorporation of learning progressions along a continuum into a curriculum will provide the opportunity for students to develop a higher cognitive way of thinking. This mechanism allows instructors to evaluate students in the skill sets of critical thinking and problem-solving.

CONSTRUCTION OF LEARNING PROGRESSIONS SUBSKILLS

According to Heritage (2008), there are two primary ways of constructing a learning progression. The first approach is the bottom-up which begins with the teachers' understanding of how students learn (Heritage, 2008). In this technique, the teacher and curriculum content experts develop progressions based on their teaching experience (Heritage, 2008). The second method is the top-down that evolves experts in the subject area. Their focus is to teach the big ideas and how they interconnect (Heritage, 2008). The procedure used in this study was top-down in which experts in the subject matter of dentistry identified concepts relevant to the discipline. This approach was necessary because the Commission on Dental Accreditation (CODA) has established standards.

The second step towards constructing learning progressions is to identify subskills that would lead to the understanding or acquisition of the core domain (Heritage, 2008). The researcher referred to teaching strategies such as case studies, oral and written communications, evidenced-based research analysis, patient case presentations, developing open-ended questions and problem-solving activities (Nilson, 2003). Integration of these teaching techniques during the development of the questionnaire allowed the student to move from a novice level incrementally towards an expert (Heritage, 2008).

INTER-RATER RELIABILITY OF CORE DOMAIN SUBSKILLS

The study used the Q-sort method to assess the reliability of the questionnaire items during the pre-stage test development. Methods used was based on the research by Nahm, Rao, Solis-Galvan, and Ragu-Nathan (2018) that used agreement between two raters during questionnaire development of subskills (Nahm, Rao, Solis-Galvan, & Ragu-Natha, 2018). The assessors were dental hygiene educators (N=2). An inter-rater agreement was measured using Cohen's Kappa index. Indicators identified as too ambiguous were either reworded or deleted to improve understanding between the raters. This process was carried out repeatedly until an excellent agreement level was obtained (Nahm et al., 2018).

CONTENT VALIDITY RATIO OF CORE DOMAIN SUBSKILLS

The research instrument was designed using the Lawshe method. Lawshe created the Content Validity Ratio (CVR) which gauged the content validity of items on an empirical measure (Johnston & Wilkinson, 2009). Content validation aims to assure that an instrument measures the content area that it is expected to quantify (Ayre & Scally, 2014). The process involved using a panel of eleven SME's rating items into three categories: Essential, Useful, but not Essential, or Non-Essential. "Essential" items or assessment tasks are ones that best represent the desired goal (Johnson & Wilkinson, 2009). The subject matter experts included the dentist (N=3), practicing dental hygienist (N=3) and dental hygiene educators (N=5). The core domains were critical thinking and problem-solving. The measurement item, in this case, were the indicators in the core subskills. To collect evidence, the researcher used the following process:

1. Created a group of eleven SME's in the dental profession. SME's verified information which supported their expertise in dentistry.
2. The SME's were sent the questionnaire and asked the "essentialness" of each critical thinking and problem-solving subskill.
3. Calculated the CVR proposed by Lawshe (1995) for each subskill (Lawshe, 1975).
4. CVR ratios determined if they were essential; useful, but not essential; and non-essential.
5. Calculated the CVR for the combination of essential, and useful, but not essential indicators.
6. Comparative analysis of essential indicators with useful, but not essential indicators.

RESULTS OF THE STUDY

The inter-rater reliability of the questionnaire between the different raters was estimated. Landis and Koch (1997) provided guidelines to interpret Cohen's Kappa index by associating different values of the index to the degree of agreement beyond chance (Nahm et al., 2018). The interpretative values as indicated in Table 1 (Appendix). The Cohen's Kappa index for the final questionnaire in both critical thinking and problem-solving subskills were 1.00 as indicated in Table 2 (Appendix). Demonstrating the two rater's performance levels and strength of association was excellent. This process provided a reliable questionnaire allowing the researcher to continue the study with the SME's in the determination of the essentialness of subskills as seen in Figure 1.

The researcher used the Lawshe CVR to calculate eight learning progressions. Ayre and Scally (2014) have suggested a revision to the critical values table, and its correction was used in this study as indicated in Table 3 (Appendix) for a panel size, N=11(Ayre & Scally, 2014). CVR values range from -1.00 to +1.00, where a CVR value of .636 (N=9) demonstrate agreement of essentialness between the SME's. Fourteen was considered essential out of thirty.

DISCUSSION

The results of this study provide dental hygiene educators the basis for sound learning progressions that could be embedded into a curriculum to demonstrate the student has achieved competency in critical thinking and problem-solving skills. Estimates for the inter-rater reliability for the questionnaire are high and suggest agreement in scoring.

Agreement of essentialism of subskills for the learning progressions rated at approximately 47%. The greatest inconsistency was in Learning Progression 5 (Critical thinking) as seen in Figure 2. This learning progression identified the need for students to access databases and demonstrate writing an article review, integrated literature review and a research paper in APA format. The essentialness of these subskills ranged from -.272 to .09. However, when merging the essential with the useful category raised all of these subskills in this learning progression to .818. This value is considered agreement of essential amongst the SME's.

An interesting trend in this study was the 100% agreement throughout all subskills when combining the essential and useful rating. This statistic indicates a consensus with the SME's regarding the educational value of each subskill. Therefore, the study revealed an agreement that all the subskills had merit. This evidence suggests the eight learning progressions provided representativeness of tasks in the critical thinking and problem-solving skill sets.

Further research may include defining rubrics for each subskill. This investigation will allow continuity between the different levels of learning progressions. Also, more research is needed to determine at what point in the curriculum would faculty embed these subskills. Finally, further inquiry is necessary to identify other learning progressions as recognized by CODA or other accrediting agencies.

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APPENDIX

Table 1
Cohen's Kappa Value Index

Performance Level	Strength of Association
Excellent Agreement	.76 – 1.00
Fair to Moderate Agreement	.40 - .75
Poor Agreement	.39 or less

Table 2
Average Cohen's Kappa Value Index for the Final Questionnaire Learning Progression Subskills

Learning Progression	Performance Level	Strength of Association
Learning Progression 1 (3 subskills)	Excellent Agreement	1.00
Learning Progression 2 (3 subskills)	Excellent Agreement	1.00
Learning Progression 3 (4 subskills)	Excellent Agreement	1.00
Learning Progression 4 (4 subskills)	Excellent Agreement	1.00
Learning Progression 5 (4 subskills)	Excellent Agreement	1.00
Learning Progression 6 (4 subskills)	Excellent Agreement	1.00
Learning Progression 7 (3 subskills)	Excellent Agreement	1.00
Learning Progression 8 (5 subskills)	Excellent Agreement	1.00

Table 3
$CVR_{critical}$ one-tailed test ($\propto = 0.05$)based on exact binomial probabilites

N (panel size)	Proportion agreeing essential	$CVR_{critical}$ exact values	One-sided p-value	$N_{critical}$ (minimum number of experts required to agree item essential)
11	.818	.636	.033	9

Table 4
CVR for Learning Progression (N=11): Essential and Essential & Useful

Learning Progression	CVR Values (Essential)	CVR Values (Essential & Useful)
Learning Progression 1 (Problem-solving)		
1. Subskill 1	-.454(3)	.818
2. Subskill 2	.636 (9)	1 (11)
3. Subskill l	1(11)	-
Learning Progression 2 (Problem-solving)		
1. Subskill 1	.272 (7)	1 (11)
2. Subskill 2	.636 (9)	1 (11)
3. Subskill 3	1 (11)	-
Learning Progression 3 (Problem-solving)		
1. Subskill 1	.272 (7)	1 (11)
2. Subskill 2	-.09 (5)	.818 (10)
3. Subskill 3	.636 (9)	1 (11)
4. Subskill 4	.09 (6)	.636 (9)
Learning Progression 4 (Problem-solving)		
1. Subskill 1	.272 (7)	1 (11)
2. Subskill 2	-.09 (5)	.818 (10)
3. Subskill 3	.636 (9)	1 (11)
4. Subskill 4	.09 (6)	.636 (9)
Learning Progression 5 (Critical thinking)		
1. Subskill 1	.09 (6)	.818 (10)
2. Subskill 2	-.05 (5)	.818 (10)
3. Subskill 3	-.272 (4)	.818 (10)
4. Subskill 4	.09 (6)	.818 (10)
Learning Progression 6 (Critical thinking)		
1. Subskill 1	.272 (7)	1 (11)
2. Subskill 2	.818 (10)	1 (11)
3. Subskill 3	1 (11)	-
4. Subskill 4	.636 (9)	1 (11)
Learning Progression 7 (Critical thinking)		
1. Subskill 1	.09 (6)	.818 (10)
2. Subskill 2	.818 (10)	1 (11)
3. Subskill 3	.818 (10)	1 (11)
Learning Progression 8 (Critical thinking)		
1. Subskill 1	.09 (6)	.818 (10)
2. Subskill 2	.09 (6)	.818 (10)
3. Subskill 3	.818 (10)	1 (11)
4. Subskill 4	.636 (9)	1 (11)
5. Subskill 5	1 (11)	-

Figure 1
Critical Thinking Learning Progression 5 Questionaire

Task	Essential	Useful	Non-essential
1. Demonstrates using library databases to acquire scientific based literature.			
2. Demonstrates writing a research article review in APA format.			
3. Demonstrates writing an integrated literature review in APA format.			
4. Demonstrates writing a research paper in APA format.			

Figure 2
SME's Scoring Sample of Critical Thinking Learning Progression 5

Critical Thinking Learning Progression 5				
Task	Essential	Useful	Non-essential	Essential & Useful
1. Demonstrates using library databases to acquire scientific based literature.	6	4	1	10
2. Demonstrates writing a research article review in APA format.	5	4	1	10
3. Demonstrates writing an integrated literature review in APA format.	4	6	1	10
4. Demonstrates writing a research paper in APA format.	6	4	1	10