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An OER Tool for Writing-to-Learn in Undergraduate STEM Courses

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Description *

This "Listen and Learn" (Research paper) session demos an updated browser-based writing tool and then provides the 1st year data outcomes of a free open education resource (OER) called GIKS to provide STEM students with a teacher-made writing prompt that then scores the essay and displays it as a network to compare to an expert referent network.

Reimagining Learning and the Classroom *

Writing -to-learn is an active and engaging learner-centered strategy for learning domain conceptual knowledge that is well documented across STEM fields including biology, chemistry, ecology, and physics. This free GIKS tool can be used for writing and assessment online or in the classroom with even large student audiences.

Diversity, Equity and Inclusion *

presenter: Roy Clariana, Penn State College of Education Multiple-choice tests favors males over females, but females outscore males on essays, a shift towards more writing could level the playing field for female success that could increase retention of females in STEM majors.

Purpose and Objectives *

Summary writing of domain content is an active learning approach that is intimately related to conceptual development of the content, and in this case providing students with network graphs of the lesson content explicitly presents the patterns and conceptual regularities

of expert domain knowledge (referred to here as knowledge structure). This NSF funded interdisciplinary project in engineering and education intends to further develop a knowledge structure approach and software tool through two quantitative investigations to determine the influence of knowledge structure feedback as network graphs of lesson concepts when writing to learn. The investigations, in order, compared (1) writing with network feedback to no writing (study 1) and (2) writing with network feedback to writing without feedback (study 2) to address the questions: Does summary writing about lesson content with immediate concept network structure feedback support classroom learning outcomes? (Classroom learning is measured using the existing course end-of-unit tests.)

Perspective or Theoretical Framework *

Jonassen, Beissner, and Yacci (1993) note "The meaning for any concept or construct is implicit in the pattern of relationships to other concepts or constructs" (p.5), these patterns are the lexical–semantic organization of memory that can be shared over time and space, and that systematically change across the lifespan due to experiences (Krethlow, Fargier, & Laganaro, 2020). Relationship patterns among concepts are referred to here as knowledge structure (KS) that can be represented as network graphs of concepts, in this case, as nouns (Elman, 2004; 2009; Furtner, Rauthmann, & Sachse, 2009) that offer "a geography of the human mind" (p. 8, Gorgeakopoulos & Polis, 2018).

Nesbit and Adescope (2006) note, "Structural knowledge establishes a spatial frame that references visual features and verbal knowledge to enable efficient, spatially-indexed memory searches." (p. 418). Extending this idea to knowledge building in STEM, Trumpower and Sarwar (2010) coined the terms "structural assessment" as measures of students' domain-normative conceptual relationships and "structural feedback" as any form of feedback that aims to improve

the quality of students' domain-normative conceptual relationships. Research with structural feedback points to an important mediating role of network graphs as feedback for developing students' conceptual understanding, especially feedback on the correct, incorrect, and missing connections formed by students between concepts (Kim, Clariana, & Kim, 2019; Sarwar, 2012; Sarwar & Trumpower, 2015).

This project is grounded on structural feedback, that when students receive structural feedback, the form of their conceptual model becomes more like an expert's model. The project software uses network maps of students' written responses as formative feedback at the individual level and at the group level. The individual network graph that immediately originates from a student's written response is a personal representation of that student's own conceptual understanding that may be especially potent for that student.

Research Methods *

Participants were recruited to participate in the two studies from an undergraduate architectural engineering course, total enrollment n = 110, and 87 volunteered to participate and received a $50 gift card for participation. In study 1, after completing the normal lessons on masonry and wood construction, half received the GIKS writing prompt and wrote a 300-word lesson summary with immediate network feedback while the other half did not write at all (control group). In study 2, after completing the normal lessons on concrete and sustainable construction, half received the GIKS writing prompt and wrote a 300-word lesson summary with immediate network feedback while the other half wrote a 300-word essay in a word processor with no feedback.

Data consisted of the already existing end-of-unit multiple-choice tests of these topics as well as a list-wise measure on concept knowledge structure that was rendered into networks

using Pathfinder software. In addition, students' essays were rendered into network graphs and analyzed also suing Pathfinder software.

Data were analyzed using multivariate analysis of variance (MANOVA) as well as descriptive measures of the essays (mainly term frequencies).

Results or Expectations *

For study 1, MANOVA showed that the concept knowledge structure networks (elicited as listwise measures of concrete and then of wood lesson terms) of the group receiving GIKS summary writing were significantly more like the expert network referent compared to the networks of those wo did not write at all (control).

However, this pattern was reversed for the end-of-units test (elicited as multiple-choice items), the no writing control group outperformed the GIKS writing group.

For study 2, data has been collected but is not yet analyzed. The analysis results for study 2 (masonry and sustainability) will be available by November 2023 and so will be included in the ISTE presentation in June 2024.

Educational Or Scientific Importance *

It was expected that the GIKS intervention would improve students' knowledge structure (i.e., more like the expert) and then this would result in improved performance on classroom measures of declarative knowledge. Results show that knowledge structure did significantly improve with GIKS, but at the expense of declarative knowledge.

This interaction of conceptual and declarative knowledge has been reported before, and challenges and extends understanding of how knowledge exists in memory and how it influences cognition and production tasks. Because expert-liken knowledge structure is believed to support higher-order tasks, especially problem solving, this begs the question, if an instructor must

prioritize one or the other, then which is more important, declarative knowledge (memorizing facts) of conceptual knowledge structure?

Further, GIKS is an open-ended tool that can be used in many ways, how can GIKS be used to meet instructor and course requirements? For example, GIKS can immediately complement and extend existing STEM writing pedagogies such as peer-writing, the immediate network feedback provided by GIKS could be used to improve the quality and timeliness of peers' feedback since the network is an artifact that can support peer discussion, and the network graph should decrease the inclusion of common misconceptions that are more likely with peer feedback

GIKS is designed to be quick and simple to set up by a course instructor (or a course designer), it is easy to share with other instructors, and can be used in any content area, thus GIKS can be used in any STEM courses at the undergraduate and even the high school levels. This approach can add an active learner-centered approach to traditional STEM lecture classrooms that engages both the student and the instructor. In fact, GIKS has wide application in any content area, for example, since it works in any language it can be used in bilingual settings.

When You Do Expect To Have Your Data Collected? *

The data Results section for Study 2 will be ready by November 2023

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