Learning Approaches in Post-Secondary Engineering Education – A Scoping Review

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Abstract

Objective: The objective of this scoping review is to understand the type of evidence available on the learning approaches used by engineering students in post-secondary contexts.

Introduction: There seem to be two dominant perspectives on student learning in the field: deep learning and surface learning (or rote memorization). However, we believe that student learning cannot always be categorized as deep or surface as there can be practices that fall in-between the two (e.g., pattern recognition, mental models, and free learning are some examples reported in the literature [e.g., Felder & Brent, 2005]). This requires exploring what learning approaches are reported in the literature, how they are understood and described, and what remains unexplored for further investigation.

Inclusion criteria: Studies included in this review are focused on learning approaches or approaches to learning, rote memorization, surface learning, deep learning, and learning strategies used by engineering students in post-secondary contexts of all types (e.g., technical schools, universities and colleges). These are peer-reviewed, use qualitative, quantitative, mixed methods, text or opinion methods, and are published in English.

Methods: A search was conducted on December 15, 2023 by the researchers using the search terms (Appendix 1). Data search sources included Compendex, Education Research Complete (EBSCO), ERIC and Scopus. Only complete studies available in English were considered for inclusion.

Results: In total, 2877 studies were found. These included empirical studies published in journals, conference proceedings, books, and others, were written in English, and were focused on learning approaches.

Conclusions An initial overview of the results (topic and abstract screening) indicated a range of topics covered in the found studies. These included student and faculty attitudes towards content, subjects and technology, evaluation methods to understand student learning approaches, learning strategies such as note-taking, explanation, etc., and learning environment development. The studies covered K-12, secondary and post-secondary contexts but were mainly focused on engineering education in these settings.

Introduction

This scoping review is aimed at doing a survey of the learning approaches used by students in engineering education. These approaches could be directly employed by the students or impacted by the teaching strategies used by educators. There seem to be two dominant perspectives on student learning in the field: deep learning and surface learning. The former can be referred to as high-level learning and is highly supported and aimed by educators. The latter is perceived to be a less attractive approach and is often regarded as the opposite of deep learning where students do not necessarily understand a concept but can reproduce the target content during exams or other assessment tasks because they have memorized it. However, we believe that student learning can not always be categorized as deep or surface as there can be practices that fall in-between the two (pattern recognition, mental models, and free learning are some examples reported in the literature). What we intend to do in this scoping review is a survey of the existing approaches reported by the researchers so that we can 1) identify the types of learning approaches dominant in the field; 2) clarify how these approaches are understood and described in the literature; 3) identify and analyze knowledge gaps in the existing literature; and 4) propose a way forward for engineering education in the form of a theoretical framework that can guide future teaching and learning practices as well as research in the field of engineering education. Since there is scarcity of research on the learning approaches in the field of engineering education, a scoping review was considered appropriate to determine what evidence exists on the topic and what "more specific questions can be posed and valuably addressed by a more precise systemic review" (Munn et al., 2018, p. 2).

This scoping review uses the PCC (Population, Concept, Context) framework to create a structure, delineate concepts and clarify inclusion and exclusion criteria. In this review:

Population = Engineering students

Concept = Learning approaches or approaches to learning, rote memorization, surface learning, deep learning, strategic learning, and learning strategies

Context = Post-secondary including all types of higher education such as technical schools, universities and colleges related to engineering education

Review question

This scoping review is intended to answer the following:

RQ1: What can exist between surface and deep learning (strategic learning)? Or more precisely, how are surface and deep learning defined?
RQ2: What are the factors that can affect the adoption of learning approaches by students?

Keywords

Learning approaches or approaches to learning, rote memorization, surface learning, deep learning, strategic learning, learning strategies

Inclusion/exclusion criteria

Inclusion Criteria	Exclusion Criteria
1) Focus on learning approaches	1. Not focused on learning approaches
2) Focus on engineering education	2. Not focused on engineering education
3) Post-secondary context (all types of higher education, including technical schools, universities, colleges, related to engineering education)	3. Not post-secondary
4) Peer reviewed articles	4. Not peer reviewed
5) Qualitative, quantitative, mixed methods, text, conference proceedings, and opinion	5. Blogs, magazines articles, books and book chapters
6) English only	6. Not in English
7) Search terms will include: learning approaches or approaches to learning, rote memorization, surface learning, deep learning, and learning strategies	7. Not including the search terms

Methods

The proposed scoping review will be conducted in accordance with the JBI methodology for scoping reviews (Peters et al., 2020).

Search strategy

The search strategy will aim to locate both published and unpublished studies. An initial limited search of Education Research Complete was undertaken to identify articles on the topic. The text words contained in the titles and abstracts of relevant articles, and the index terms used to describe the articles were used to develop a full search strategy for Compendex, Education Research Complete, ERIC and Scopus (see Appendix # 1). The search strategy, including all identified keywords and index terms, will be adapted for each included database and/or information source. The reference list of all included sources of evidence will be screened for additional studies.

Studies published in only English language will be included. There is no restriction on the date of publication of a study.

Study/Source of Evidence selection

Following the search, all identified citations will be collated and uploaded into Covidence and duplicates removed. Following a pilot test, titles and abstracts will then be screened by two independent reviewers for assessment against the inclusion criteria for the review. Potentially relevant sources will be retrieved in full and their citation details imported into the JBI System for the Unified Management, Assessment and Review of Information (JBI SUMARI) (JBI, Adelaide, Australia) (Munn et al., 2019). The full text of selected citations

will be assessed in detail against the inclusion criteria by two independent reviewers. Reasons for exclusion of sources of evidence at full text that do not meet the inclusion criteria will be recorded and reported in the scoping review. Any disagreements that arise between the reviewers at each stage of the selection process will be resolved through discussion, or with an additional reviewer/s. The results of the search and the study inclusion process will be reported in full in the final scoping review and presented in a Preferred Reporting Items for Systematic Reviews and Meta-analyses extension for scoping review (PRISMA-ScR) flow diagram (Trico et al., 2018).

Data Extraction

Data will be extracted from papers included in the scoping review by two independent reviewers using a data extraction tool developed by the reviewers. The data extracted will include specific details about the participants, concept, context, study methods and key findings relevant to the review questions.

A draft extraction form is provided (see Appendix 2). The draft data extraction tool will be modified and revised as necessary during the process of extracting data from each included evidence source. Modifications will be detailed in the scoping review. Any disagreements that arise between the reviewers will be resolved through discussion, or with an additional reviewer/s. If appropriate, authors of papers will be contacted to request missing or additional data, where required.

Data Analysis and Presentation

Findings will be synthesized to create statements that reflect the results of the review and help categorize the findings into themes that share similar meanings. These themes will be used to generate final results that will be reported as a comprehensive report that can guide pedagogical, curricular and assessment practices in the field of engineering education.

The reviewers will discuss the methods of data analysis prior to conducting the review and developing codes.

Funding

Funder: Schulich School of Engineering

Project Title: Imaginative Learning for Engineering Design Education

Conflicts of interest

None.

References

Felder, R. M., & Brent, R. (2005). Understanding student differences. *Journal of Engineering Education, 94*(1), 57-72. https://doi.org/10.1002/j.2168-9830.2005.tb00829.x

Munn, Z., Aromataris, E., Tufanaru, C., Stern, C., et al. (2019). The development of software to support multiple systemic review types: The Joanna Briggs Institute System for the Unified Management, Assessment and Review of Information (JBI SUMARI). *International Journal of Evidence-based Healthcare*, *17*(1), 36-43.

Peters, M. D. J., Godfrey, C., Mclnerney, P., Munn, Z., Tricco, A. C., & Khalil, H. (2020). Scoping reviews. In E. Aromataris & Z. Munn (Eds.), *JBI manual for evidence synthesis*. https://doi.org/10.46658/JBIMES-20-12

Tricco, A. C., Lillie, R., Zarin, W., & O'Brien, K. K. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Research and Reporting Methods*, https://doi.org/10.7326/M18-0850

Appendices

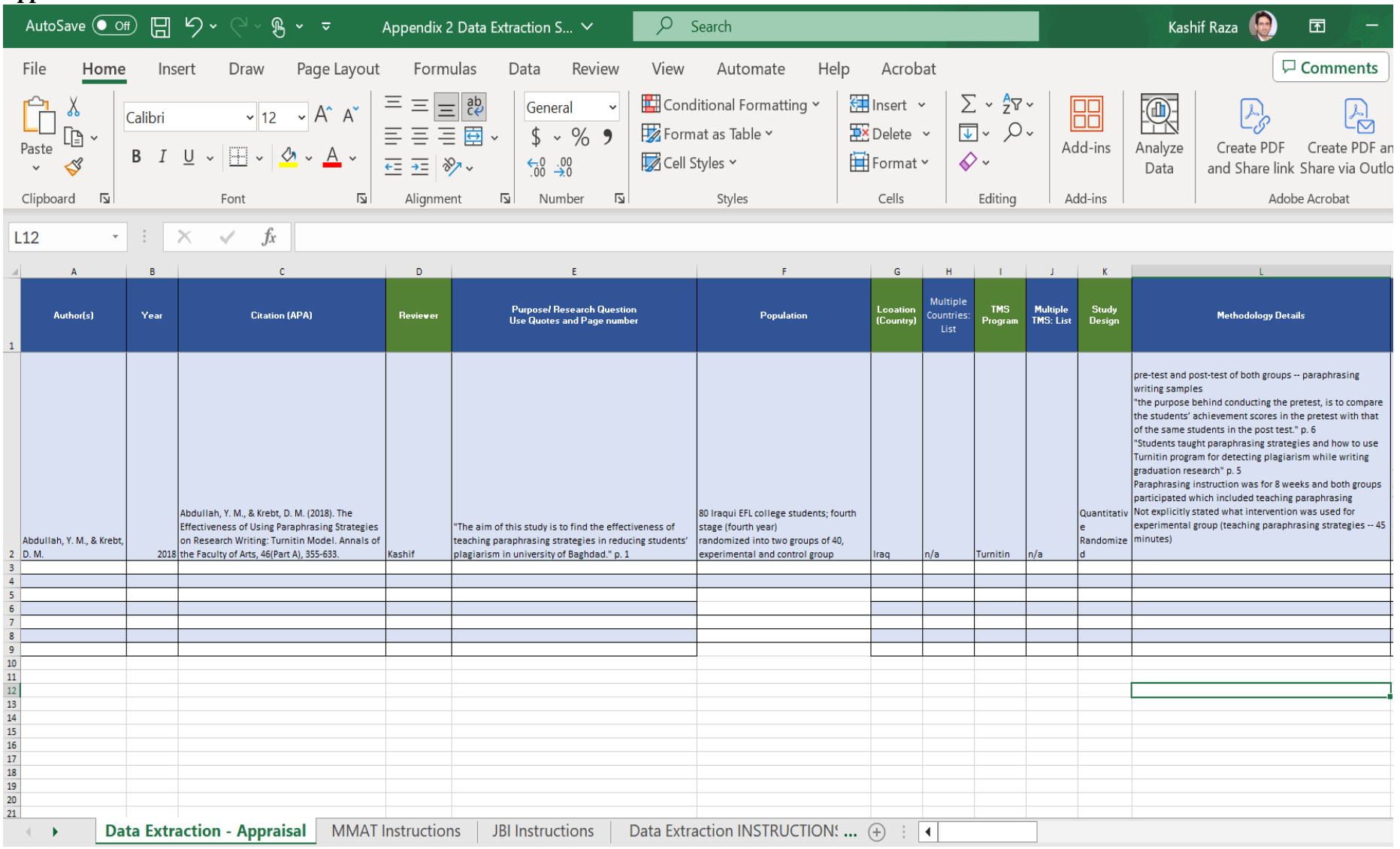
Appendix 1: Search Strategies and Terms

Database(s): Education Research Complete (EBSCO), Education Resources Information Center (ERIC), Compendex (Engineering Village), Scopus (Elsvier) on December 11, 2023

Search Strategy:

#	Searches	Results
1	((DE "ENGINEERING education" OR DE "CHEMICAL engineering education" OR DE "CONTINUING engineering education" OR DE "ELECTRICAL engineering education" OR DE "ENGINEERING education in graduate schools" OR DE "MECHANICAL engineering education" OR DE "EDUCATION of engineering technicians") OR (engineering N3 (education OR student* OR course*))) ((DE "LEARNING strategies" OR DE "COMPREHENSION strategies" OR DE "LEARNING by teaching" OR DE "READING strategies" OR DE "RETRIEVAL practice") OR (DE "ROTE learning" OR DE "MEMORIZATION") OR ("learning approaches" OR "approach* to learning" OR rote OR "surface learning" OR "deep learning" OR "learning strateg*"))	1349
2	"engineering education" or "engineering course*" or "engineering student*"	1500
3	"learning approaches" or "approaches to learning" or "learning strategies"	25

Appendix 2: Data Extraction Instrument



Author(s)	Year	Citation (APA)	Reviewer	Purpose/ Research Question Use Quotes and Page number	Population	Location (Country)	Multiple Countries: List	TMS Program	Multiple TMS: List	Study Design	Methodology Details
Abdullah, Y. M., & Krebt, D. M.	2018	Abdullah, Y. M., & Krebt, D. M. (2018). The Effectiveness of Using Paraphrasing Strategies on Research Writing: Turnitin Model. Annals of the Faculty of Arts, 46(Part A), 355-633.	Kashif	"The aim of this study is to find the effectiveness of teaching paraphrasing strategies in reducing students' plagiarism in university of Baghdad." p. 1	80 Iraqui EFL college students; fourth stage (fourth year) randomized into two groups of 40, experimental and control group	Iraq	n/a	Turnitin	n/a	Quantitative Randomized	pre-test and post-test of both groups -- paraphrasing writing samples "the purpose behind conducting the pretest, is to compare the students' achievement scores in the pretest with that of the same students in the post test." p. 6 "Students taught paraphrasing strategies and how to use Turnitin program for detecting plagiarism while writing graduation research" p. 5 Paraphrasing instruction was for 8 weeks and both groups participated which included teaching paraphrasing Not explicitly stated what intervention was used for experimental group (teaching paraphrasing strategies -- 45 minutes)