

CS 6795 Spring 2024 – Term Project Milestone 1

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Abstract—This assignment shows an overview and introduction of the Term Project I am planning to complete by the end of this semester. I will pursue the Literature Review Track and attempt to answer the questions about the current state of cognitive science practice in Education and what computer engineers can contribute. This essay addresses the background, the design of the review process and the initial research I have conducted so far, followed by a detailed breakdown of the task for the remaining semester.

Keywords—Cognition Science, Computer Science, Education, Learning, Educational Technology.

I. INTRODUCTION

For this project, I am primarily studying the development of Cognition Science in the Learning and Education Context and investigating what software engineers can contribute through the literature review approach. My review aims to understand the current and possible future state of Cognition Science practice in Education and Learning and answer the question, “How can engineers help?”

In my undergraduate years, I was involved in developing an interactive learning platform, called Tapestry Tool project. Over time, this project has evolved into an open-source tool that makes me very proud. What intrigued me most about this tool was its innovative graph-based structure, which simplifies the concept of content relevance through edges and nodes, transforming traditional teaching into a multidimensional and engaging experience. This unique approach harnesses the human memory's capacity for making correlations and connections, aiming to enhance the overall quality of Education and Student Learning. This experience gave me my first exposure to Cognitive Science and its practice using programming, so now I want to take CS 6795 as my opportunity to explore more.

II. THE IMPORTANCE OF THIS LITERATURE REVIEW

A. Acceleration of Iteration and Innovation in Technology

Understanding the current state of cognitive science practice in Education allows computer engineers to integrate the latest findings and methodologies into educational technology. By staying informed about cognitive science research, engineers can design and develop tools that are technologically advanced and aligned with the most effective learning strategies. This accelerates the iteration and innovation in educational technology, ensuring that the tools and applications evolve to meet the changing needs of learners and educators. Through this collaboration, computer engineers contribute to creating more efficient and adaptive educational technologies, ultimately enhancing the overall learning experience.

B. Facilitating Difficulty Identification and Equality in Education

Cognitive science can shed light on various learning difficulties and factors contributing to educational inequalities. Armed with this knowledge, computer engineers can develop targeted solutions and technologies to address specific challenges learners face. For example, adaptive learning platforms can use cognitive science insights to personalize content based on individual learning styles, helping students with diverse needs. This not only aids in difficulty identification but also promotes educational equality by providing tailored support to learners, irrespective of their backgrounds or learning abilities. Equipping with that knowledge, Educators can also design, implement or adjust their teaching methods to create a more inclusive and equitable educational environment for their students.

III. LITERATURE REVIEW CONDUCTION

According to the subjects I would like to research, the relevant topics of literature I am interested in looking at are:

- Cognitive processes for human learning
- Cognition Load Theory
- Educational Technology
- Human Learning Phases

I have done an initial literature search based on those keyword concepts and designed a process for the remaining literature review.

A. Research design

My research will be divided into three main segments: where cognitive science is currently and how it is developing in Education, where cognitive science may be going in the future in Education, and how frontline programmers perceive the development of cognitive science in Education.

I will focus on the first two parts and spend most of my time searching, reading, and extracting relevant literature. Although the emphases of the literature reviewed for the first two sections are different, I will provide a practical synthesis and analysis of the literature for each.

The third part, however, consists of designing the interview, performing the interview, collecting data, analyzing and presenting the findings. I will spend the next week (week 6) designing specific interview questions and completing the recruitment of interviewees for this project. This section aims to understand the implementation and future possibilities of cognition science in Education from the industry perspective. I also look forward to learning about creative ideas from frontline developers.

B. Expected outcomes

By completing this project, I expect to get the following outcomes:

- Know and outline the current development of Cognitive Science in Education and the relevancy of different topics.
- Understand and list potential future directions for Cognitive Science development in Education and Learning.
- To identify the difficulties and limitations in developing Cognitive Science in Education.
- Be aware of the importance of Cognitive Science in Educational Technology.
- After reviewing the final presentation, people with no relevant background can get a sense of the big picture of current Cognitive Science developments.

C. Reviewed literature

Based on the subject and objective I would like to pursue, I searched the following literature this week to start my review:

1) C. Ou, D. A. Joyner, and A. K. Goel, "Designing and Developing Video Lessons for Online Learning: A Seven-Principle Model," *Online Learning* (Newburyport, Mass.), vol. 23, no. 2, p. 82, 2019.

This study explores the design and development of online courses using seven principles from instructional design, providing valuable insights and procedures for designing instructional videos for online courses. This is within the scope of Educational Technology and related to this project.

2) Y. Ha and H. Im, "The Role of an Interactive Visual Learning Tool and Its Personalizability in Online Learning: Flow Experience," *Online Learning* (Newburyport, Mass.), vol. 24, no. 1, pp. 205, 2020.

This paper discusses the impact of interactive online learning tools on students' learning experiences, guided by the "Flow" concept, partially derived from Cognitive Science. This can help me understand the human learning process.

3) B. Tabibian, U. Upadhyay, A. De, A. Zarezade, B. Schoelkopf, and M. Gomez-Rodriguez, "Optimizing Human Learning," *arXiv.Org*, 2017.

This paper explores the concept of spaced repetition for efficient memorization and aims to find the optimal reviewing schedule for long-term retention. The author leveraged Duolingo for data collection and analysis. Memory, an essential part of human Cognition, is also significant for human learning. Proposing guidelines for optimizing human learning outcomes from a cognitive science perspective is the first step for practical implementation.

4) M. C. Wittrock, "Learning as a Generative Process," *Educational Psychologist*, vol. 45, no. 1, pp. 40–45, 2010.

This literature presents a cognitive model of human learning called the generative model and summarizes empirical research that supports it. It would be helpful because it contains much discussion about human learning models, which would improve my research efficiency.

5) D. R. Shanks, "Learning: From Association to Cognition," *Annual Review of Psychology*, vol. 61, no. 1, pp. 273–301, 2010.

This article addresses the tension between association-based and cognitive learning theories. Associationism explains various learning phenomena through concepts like excitation, inhibition, and reinforcement, while cognitive theories propose that learning involves hypothesis testing, cognitive models, and propositional reasoning. It would be helpful for me to justify cognitive learning theories with pros and cons.

6) J. Sweller, "Cognitive load theory and educational technology," *Educational Technology Research and Development*, vol. 68, no. 1, pp. 1–16, 2020.

Cognitive load theory suggests strategies based on understanding human Cognition and categorizing knowledge into biologically primary and secondary information. This article's standpoint aligns with the textbook used in this class, and I would like to learn more about how Cognition works with Educational Technology from it.

7) P. Van den Broek, "Using Texts in Science Education: Cognitive Processes and Knowledge Representation," *Science (American Association for the Advancement of Science)*, vol. 328, no. 5977, pp. 453–456, 2010.

This literature emphasizes that comprehension and learning from a text depend on constructing a coherent mental representation that integrates the text with existing background knowledge. Similar to the previous one, this article also shows the Cognitive Process plus the knowledge representation, which can support my project's explanation of human learning.

8) UBC Department of Psychology, "The tapestry tool creates space for accessible and engaged hybrid learning," [Online], 2022.

This write-up on Tapestry gives a brief overview of this tool's features and what it is developing towards. By comparing the current state and my previous involvement in the development, one can get a general idea of how this platform has evolved over the last few years. It can also be a great example to appear in this term project.

9) L. Zou and L. von Ahn, "Interview with the founder of Duolingo," *YouTube*. [Online], 2023.

As Duolingo is one of the most popular educational software today, I am interested in learning about the design philosophy of the team behind it and how the

team is implementing theories from cognitive science to optimize the user experience and learning outcomes.

10) T. J. Shuell, "Cognitive Conceptions of Learning," *Review of Educational Research*, vol. 56, no. 4, pp. 411–436, 1986.

The article underscores the trend toward adopting a cognitive psychology approach to learning, focusing on the impact of shifts in human performance, knowledge structures, and conceptions. I would like to investigate these subjects for my project, and the quantitative analysis and data provided in this article make the point more compelling.

11) F. Gobet, P. C. R. Lane, S. Croker, P. C.-H. Cheng, G. Jones, I. Oliver, and J. M. Pine, "Chunking mechanisms

in human learning," *Trends in Cognitive Sciences*, vol. 5, no. 6, pp. 236–243, 2001.

This article provides an overview of chunking mechanisms in human learning, introducing the EPAM/CHREST family of computational models and their practical usage. By combining the Cognitive Load Theory and the spaced repetition method, I can better understand current applications of Cognitive science in Education and Learning.

IV. TERM PROJECT TASK LIST

The following two pages list the detailed task breakdown and time commitment estimation.

Week #	Task #	Task Description	Estimated Time (Hours)	Member Responsible	Complete? (Y/N)
5	1	Create the template task list.	0.25	Cleo	Y
5	2	Plan the Task	0.5	Cleo	Y
5	3	Approve the template task lis	0.25	Cleo	Y
5	4	Init Literature Search	5	Cleo	Y
5	5	Init Literature Review	10	Cleo	Y
5	6	M1 Assignment Write up	3	Cleo	Y
5	7	M1 Assignment proofreading	1	Cleo	Y
5	8	M1 Assignment Submission	0.25	Cleo	Y
MILESTONE 1 DUE					
6	1	Design the Review Process	3	Cleo	N
6	2	Literature Search - Current	3	Cleo	N
6	3	Design the interview for idea	3	Cleo	N
6					
6					
7	1	Literature Review - Current 1	5	Cleo	N
7	2	Summary and Analysis the L	3	Cleo	N
7	3	Literature Search - Future	2	Cleo	N
7					
7					
8	1	Conduct the interview	5	Cleo	N
8	2	Literature Review - Current 2	5	Cleo	N
8					
8					
9	1	Literature Review - Current 3	5	Cleo	N
9	2	Update the template task list	0.25	Cleo	N
9	3	Plan the remaining Tasks	0.25	Cleo	N
9	4	Approve the template task lis	0.25	Cleo	N
9	5	M2 Assignment Write up	3	Cleo	N
9	6	M2 Assignment proofreading	1	Cleo	N
9	7	M2 Assignment Submission	0.25	Cleo	N
MILESTONE 2 DUE					
10	1	Literature Review - Future 1/	5	Cleo	N
10	2	Collect and organize data fro	1	Cleo	N
10	3	Analyzing and summarizing i	3	Cleo	N
10					
10					
11	1	Literature Review - Future 2/	5	Cleo	N
11	2	Literature Review - Future 3/	5	Cleo	N
11					
11					
12	1	Summary and Analysis the L	5	Cleo	N
12	2	Plan the remaining Tasks	0.25	Cleo	N
12	3	Approve the template task lis	0.25	Cleo	N

12	4	M3 Assignment Write up	3	Cleo	N
12	5	M3 Assignment proofreading	1	Cleo	N
12	6	M3 Assignment Submission	0.25	Cleo	N
MILESTONE 3 DUE					
13	1	Summarize the findings to ar	5	Cleo	N
13					
13					
13					
13					
14	1	Come up with the poster	3	Cleo	N
14					
14					
14					
14					
15	1	Prep transcripts for the prese	2	Cleo	N
15	2	Presentation Rehearsal	1	Cleo	N
15	3	Record the Video Presentati	1	Cleo	N
15	4	Term Project Submission	0.25	Cleo	N
FINAL REPORT (MILESTONE 4) DUE					

Total Hours	100.25
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Cleo	100.25
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