Paper ID #44635

First Year Civil and Architectural Engineering Student Project

Dr. Elin Jensen, Lawrence Technological University

Dr. Elin Jensen is associate professor and chair of the Department of Civil and Architectural Engineering at Lawrence Technological University (LTU). She has extensive analytical and experimental research experience in the area of performance of materials used in building and infrastructure applications.

The earned M.Sc. in Civil Engineering degree from Aalborg University, Denmark, entitles degree holder to practice in the European Union. The use of the earned academic title ”Civilingeniør” is restricted to holders of diplomas from the relevant Danish schools or equivalent schools.

Assessment of Student Learning in First Year Civil and Architectural Engineering Project

(Work in Progress)

Elin Jensen
Department of Civil & Architectural Engineering
Lawrence Technological University
Southfield, MI 48075
Email: ejensen@ltu.edu

Introduction

This paper presents *Work in Progress* and is an assessment of an educational strategy developed to introduce students to systems thinking, social responsibilities and sustainability in a first-year architectural and civil engineering project. The educational strategy is designed in the convergent space of the Entrepreneurial Mindset (EM)[1] and Engineering for One Planet (EOP) Framework[2]. EM emphasizes the development of habits and characteristics that allow students to discern unique opportunities in the creation of valuable and impactful engineering solutions. The EOP Framework seeks to integrate the fundamental skills and principles of social and environmental sustainability in engineering curricula. These mindset models encourage students to question why (abstract mindset) a certain approach is taken and not only focus on the how (concrete mindset) to execute the approach. The field of social cognition have studied and demonstrated that adopting an abstract mindset affects how the individual perceives the world, and also the behavior of the individual tends to align more with their values[3]. Both EM and EOP Framework aim to equip the student with experiences that encourage development of mindsets while also applying relevant technical and professional skills. Early exposure to different ways of thinking goes beyond introduction of the different views as it can form the student's ability to envision comprehensive, valuable, impactful and maybe entirely different solutions[4].

Mind maps and concept maps have been used by the educational community to visualize understanding and measure student learning and mindset[5,6,7]. Mind maps, being concept maps without the linking words or phrases, are ideal for students to create during a time limited class module. The goal in this project is to expose students to a wider perspective and to use mind maps to quantify the change in student learning realized during a first-year architectural and civil engineering term project. A quantitative measure of student learning may not directly equate to a development of a mindset as it relates to EM and EOP. Yet, the changes to mind map knowledge structure over time is an indicator of the student's change in understanding, perspectives or vision, openness to learning, and effort.

Mind Map Scoring System and Assessment of Student Learning

The scoring system developed by Evrekli et al.[8] has been applied in this study. Evrekli et al. evaluated the reliability of the scoring system and determined it to be consistent in areas such as inter- and intra-rater reliability, and variances. The scoring system is depicted in Figure 1 and Table 1. In this *Work in Progress* paper, mind maps have been evaluated by one rater, the author.

Table 1. Mind map scoring system (adapted from Evrekli et al.[7])

Component Excluding the Main Topic	**Points for each** (if valid)
1st level concept links	2
2nd level concept links	4
3rd level concept links	6
4th level concept links	8
Cross links	10
Examples	1
Relationships	3
Invalid component	0

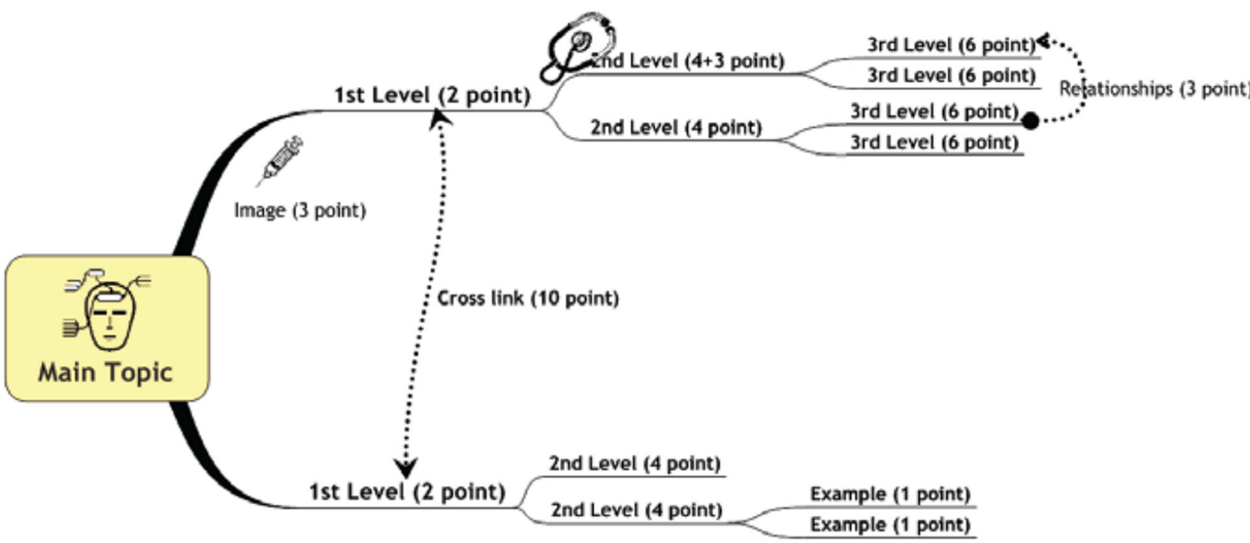
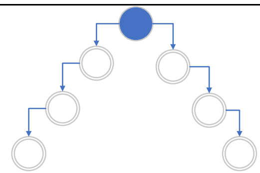
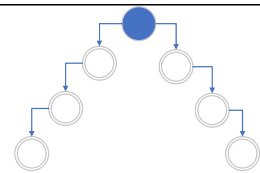
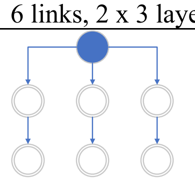
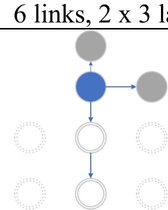
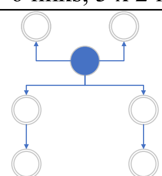
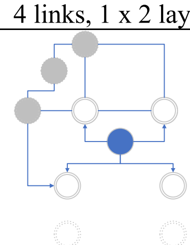


Figure 1. Illustration of scoring of a model mind map[7]. Note, this study did not include images in the mind maps.

This study applies two measures of student learning. The first measure compares the mind map scores of the student generated mind maps. The second measure determines if the knowledge structure of the mind maps have changed and categorized the learning as Non-Learning, Surface Learning and Deep Learning. Figure 2 illustrates the approach as proposed by Hay et al.[5] In this *Work in Progress*, the categories of learning are assigned based on the numerical change in numbers of concepts, layers, relationships, cross links, and examples, if applicable.

The study was approved by the Lawrence Technological University Institutional Review Board (IRB) under the exemption Category 2(i), approval #02323. Informed consent was obtained from all participants.

	Before Intervention	After Intervention	Notes
Non-learning	 6 concepts, 6 links, 2 x 3 layers	 6 concepts, 6 links, 2 x 3 layers	Knowledge structure remains unchanged
Surface Learning	 6 concepts, 6 links, 3 x 2 layers	 4 concepts, 4 links, 1 x 2 layers	Some prior-concepts are rejected and new ones are added, but no new links are made and newly added concepts are not linked to the prior knowledge structure
Deep Learning	 6 concepts, 6 links, 2 x 2 layers	 6 concepts, 10 links, 2 x 3 layers	New concepts are linked to the retained knowledge structure and the new links are made between those parts of the prior knowledge structure that are retained

top (main topic) concept added concept retained concept rejected concept

Figure 2. Assessment of student learning using the mind map knowledge structure[5].

Educational Strategy

Over a few years, the architectural and civil engineering faculty observed that students lack confidence during the ideation phase of their senior capstone project. Tasks associated with developing the project scope and alternatives, while considering social and cultural factors, and sustainability pose challenges. Faculty hypothesized that these challenges are associated with lack of prior experience in developing a comprehensive collaborative proposal that integrate systems thinking and different perspectives in the ideation phase. An improvement to the senior project proposals is desired and it is hypothesized that improvements can be achieved by introducing experiences earlier in the curriculum. At this time, the curriculum in both the architectural and in the civil engineering program only includes one subject where students engaged with the various program subdisciplines. This is a first-year subject; hence, this is where the educational strategy is implemented.

The key element of the educational strategy is a term project addressing one of the needs identified by a local city in their draft Sustainability Action Plan (SAP). The need is mobility by way of improving public transit and non-motorized transportation networks. The city's population (~75,000) is diverse in terms of ethnicity, race and religion. The majority the residents fall, on average, in the low-income group ($36k+ per year), and the percentage of seniors is higher than the national average. The SAP suggested mobility hubs (transit centers) as part of the solution to address mobility issues. The city planner and sustainability planner identified key design features and priorities to be considered in the project such as: coordinated micro- and macro mobility; coordinated inter-city, regional, and local transit options; diversity, equity and inclusion in the project solution; and sustainability with focus on the transit center energy usage and the site's stormwater management.

The project utilized several teaching methods. The students were introduced to the EOP Framework through lectures, in group class activities, and reflection statements. Note, that when students are enrolled in the first-year civil and architectural engineering course, the students are concurrently or have previously been enrolled in another course that introduced entrepreneurial skills and mindset in the engineering design process. This project focused on the engineering ideation phase of developing the conceptual solution for the transit center that meets the needs of stakeholders.

At the beginning of the term project, the students engaged with city planners, the master plan, and community survey data. Guest speakers shared the design and engineering considerations that went into the design of a nearby regional multi-modal transit center. Throughout the semester, the students were introduced to engineering terminologies, data and concepts such as review of transportation data and geometric designs, teamwork, sustainability, environmental justice data, low-impact development techniques for stormwater management, building systems, and conceptual cost estimation. The semester concluded with the student teams preparing a conceptual project proposal for a transit center. The last six of the sixteen-week semester was dedicated to the project development; from the initial kickoff meeting to the final presentation. The team deliverables were: preliminary project plan, impact statement, and final proposal presentation.

The change in student learning was assessed using mind maps that reflected their vision of the transit center and how the project addressed the priorities. Three sets of mind maps were developed and assessed in the following order:

1. Each student, independently, developed their first mind map. The timing of the activity coincided with the feedback on the preliminary project plan. This mind map is identified as "Prelim".
2. In the same session, the team members subsequent collaborated to develop a mind map that reflected their collective vision. This mind map is identified as "Team".
3. Three weeks later and just before the final presentation, each student developed the final mind map. This mind map is identified as "Final".

Students had been introduced to the construct of mind maps and examples of different styles. Further, the students had engaged in brainstorming activities earlier in the term. The mind maps were either constructed with Post-It Notes and placed on a large sheet of paper or directly on table top size Post It Board. Links, relationships and cross links were added in pen. The Prelim and Final mind maps were graded, low stake, assignments. The student teams verbalized their project vision using the Team mind maps and were provided feedback related to project priorities and deliverables. The teams were able to use the feedback in the project impact statement.

This study aims to determine if a change in student learning occurs throughout the collaborative term project. It is predicted that:

- the Team mind map scores are higher than the Prelim mind maps created by the members of the team demonstrating that collaboration creates opportunity for Surface Learning or Deep Learning.
- the Final mind map score is higher and associated knowledge structure is more complex than the Prelim mind map demonstrating that the project created opportunities for Deep Learning.

Results and Discussion

Figure 3 shows the Prelim mind maps created by Student VI (see Table 2). The selected mind map had scored above average among the Prelim mind maps created by the members of the student's team. Figure 4 shows the Final mind map generated by Student VI demonstrating a change in learning as the vision grew and evolved as noted by the addition of new concepts, branches, layers and cross links.

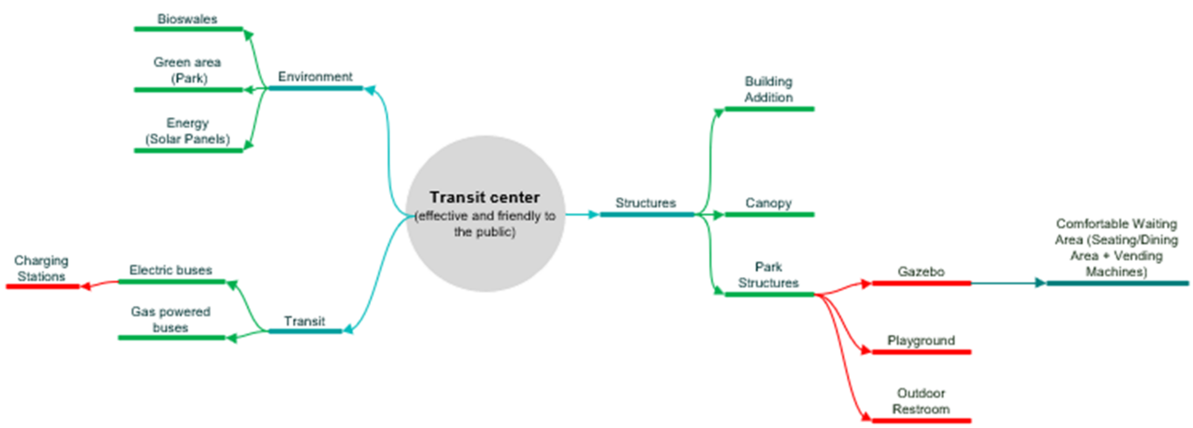


Figure 3. The Prelim mind map generated by Student VI. Mind map was recreated in Microsoft Visio.

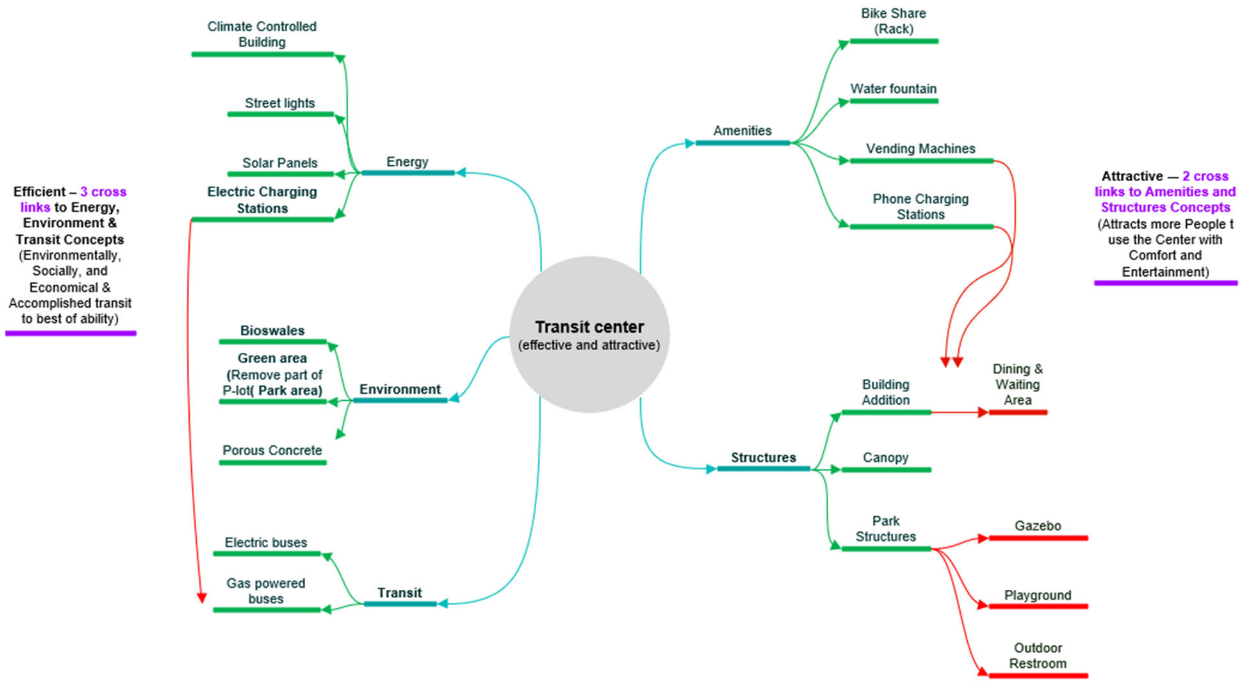


Figure 4. The Final mind map created by Student VI. Mind map was recreated in Microsoft Visio.

Table 2 lists the mind map scores. The change in score, Δ, is the difference between the mind map labelled Prelim and Final. In addition, the table lists if any change in knowledge structure was observed. Evidence collected from Student XI was not included in the analysis as they were absent when the Prelim and Team mind maps were created.

Table 2. Summary of mind map scores and observed change in learning.

Student	Mind Map Score			Change of Knowledge Structure		Differences between Prelim and Final Mind Map
				Type	Type	
ID #	**Prelim**	**Final**	**Δ**	**Prelim to Team**	**Prelim to Final**	
I	15	106	91	Surface Learning	Deep Learning	New concepts and layers
II	35	115	80	Surface Learning	Deep Learning	New concepts, layers and example
III	54	135	81	Surface Learning	Deep Learning	New concepts, layers and examples
IV	58	112	54	Surface Learning	Deep Learning	New concepts and layers
V	40	50	10	Surface Learning	Non-Learning	Moved concepts to examples
VI	74	179	105	Surface Learning	Deep Learning	New concepts, layers and cross links
VII	30	90	60	Surface Learning	Deep Learning	New concepts and layers
VIII	92	236	144	Surface Learning	Deep Learning	New concepts, layers, relationships and cross links
IX	29	44	15	Surface Learning	Surface Learning	New relationships but not linked to prior knowledge and examples
X	89	220	131	Non-Learning	Deep Learning	New concepts and cross links
XI	Absent	-	-	-	-	-

The statistical analysis presented in the following section is for the purpose of visualizing trends, only. The results may not be representative of a larger study group. Future work will include repetition and validation. Figure 5 shows probability density functions for the mind map scores assuming that the mind map scores can be represented by a theoretical normal distribution. The mind map score is a positive value. Both Q-Q tests and Chi-tests indicate that the (limited) data sets can be represented by either a normal or lognormal distribution. The addition of data from future semesters will be used to further the evaluation. The plot on the left in Figure 5 shows the scores of the Prelim mind maps and the vertical lines represent the scores of the mind maps created by the two teams. The plot on the right shows the students' Prelim and Final mind map scores. Table 3 lists for comparison the average mind map scores for the members of Team A and Team B.

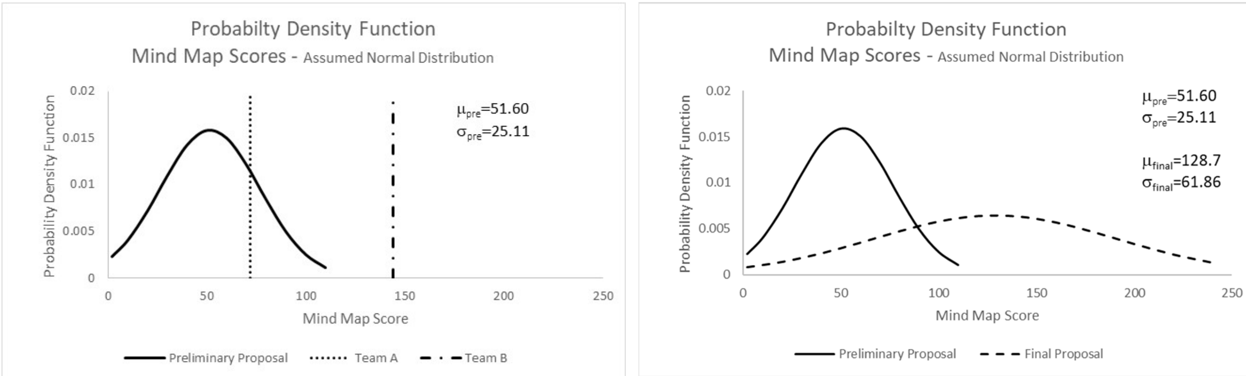


Figure 5. Visual representations of the mind map scores in form of theoretical probability density function for assumed normal distribution of data.

Table 3. Longitudinal Comparison of Mind Map Scores.

Team	**Prelim (Average)**	**Team (-)**	**Final (Average)**
A	43	72	108
B	65	144	161

Teamwork and Collaboration – The Team mind maps scored higher, on average, than the Prelim mind maps created by the individual team member. This finding suggests a synergistic effect where the students cooperate to integrate their different perspectives and visions of the project. The change in the knowledge structure, as noted in Table 2, suggests that there was an opportunity for Surface Learning during this collaborative activity. Note, that Student X's Prelim mind map (1 of 10 students) was more evolved than the Team mind map, and therefore, the change in learning was categorized as Non-Learning.

Mindset – The review of the results shows the Final student mind map scores and knowledge structures are more complex than the Prelim mind maps. The change in mind map scores between the Final and Prelim mind map was positive for all students. At the same time, the knowledge structure of 8 of 10 mind maps suggested Deep Learning. While these mind map only indirectly relates to mindset by way of visualizing concepts and connections, the positive change in mind map score and knowledge structure are indications that, in general, the students are open to learning and engaged with the development of conceptual design project.

Concluding Remarks

The study indicates that the deployed educational strategy is effective in engaging students in 1) collaborative and cooperative teamwork, and 2) learning opportunities where students become aware of different perspectives and incorporates these perspectives in the project solution.

Future work will focus on evolving the assessment of the student mindset with qualitative assessment of the mind maps and other student evidence. In addition, interviews will be performed to get a better understanding of the students' perspective of the study findings. The use of intra- and inter-rater reliability tests will also be deployed to evaluate the method used to score the mind map and categorize the knowledge structure. Furthermore, the project concept will be repeated in the upcoming academic year. It is anticipated that 15-20 students will enroll in the future session. With the opportunity for obtaining a larger data set, the reliability of the analysis will be tested.

Acknowledgement

This work is supported by Engineering Unleashed Fellowship, funded by Kern Entrepreneurial Engineering Network (KEEN). The author specially thanks Keith Kowalkowski, Lawrence Technological University, for collaborating to integrate the term project in Architectural Engineering curriculum.

.

Bibliography

1. https://engineeringunleashed.com/mindset Accessed 01.23.24
2. https://engineeringforoneplanet.org/ Accessed 01.23.24
3. Antonio L. Freitas, Peter Gollwitzer, Yaacov Trope. (2004) The influence of abstract and concrete mindsets on anticipating and guiding others' self-regulatory efforts. Journal of Experimental Social Psychology. Volume 40, Issue 6, November 2004, Pages 739-752. ISSN 0022-1031, https://doi.org/10.1016/j.jesp.2004.04.003
4. Lynch, M.; Andersson, G.; Johansen, F.R. (2021) Merging Systems Thinking with Entrepreneurship: Shifting Students' Mindsets towards Crafting a More Sustainable Future. Sustainability 2021, 13, 4946. https://doi.org/10.3390/su13094946.
5. Hay, David & Wells, Harvey & Kinchin, Ian. (2008). Quantitative and qualitative measures of student learning at University level. Higher Education. 56. 221-239. 10.1007/s10734-007-9099-8.
6. Bodnar, Cheryl, and Elise Barrella. (2022). ""Master" Entrepreneurial Mindset Concept Map". Engineering Unleashed. Friday, October 14, 2022. https://engineeringunleashed.com/card/1018
7. Zhu, Haolin, and Tirupalavanam Ganesh. (2022). "Concept Mapping, a Tool for Assessment of First Year Students' Understanding of the Design Process". Engineering Unleashed. Friday, October 14, 2022. https://engineeringunleashed.com/card/1606
8. Ertug Evrekli, Didem Inel, Ali Günay Balim. (2010). Development of a scoring system to assess mind maps, Procedia - Social and Behavioral Sciences, Volume 2, Issue 2, 2010, Pages 2330-2334, ISSN 1877-0428, https://doi.org/10.1016/j.sbspro.2010.03.331.