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CS6460 Educational Technology
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# Project Proposal

"You don't understand anything until you learn it more than one way."
– Marvin Minsky[1]

## 1 Introduction

A concept map is a graph representation of a subject's underlying ideas, where nodes are concepts at different hierarchical levels and edges are relationships between concepts. According to Novak and Cañas, concept mapping is "powerful for the facilitation of meaningful learning [because] it serves as a kind of template or scaffold to help to organize knowledge and to structure it, even though the structure must be built up piece by piece with small units of interacting concept and propositional frameworks."[2] Figure 1 (from Novak & Cañas) is an example of a concept map, where the subject of the map is concept mapping itself. This meta concept map provides both an example of the method and its underlying structure.

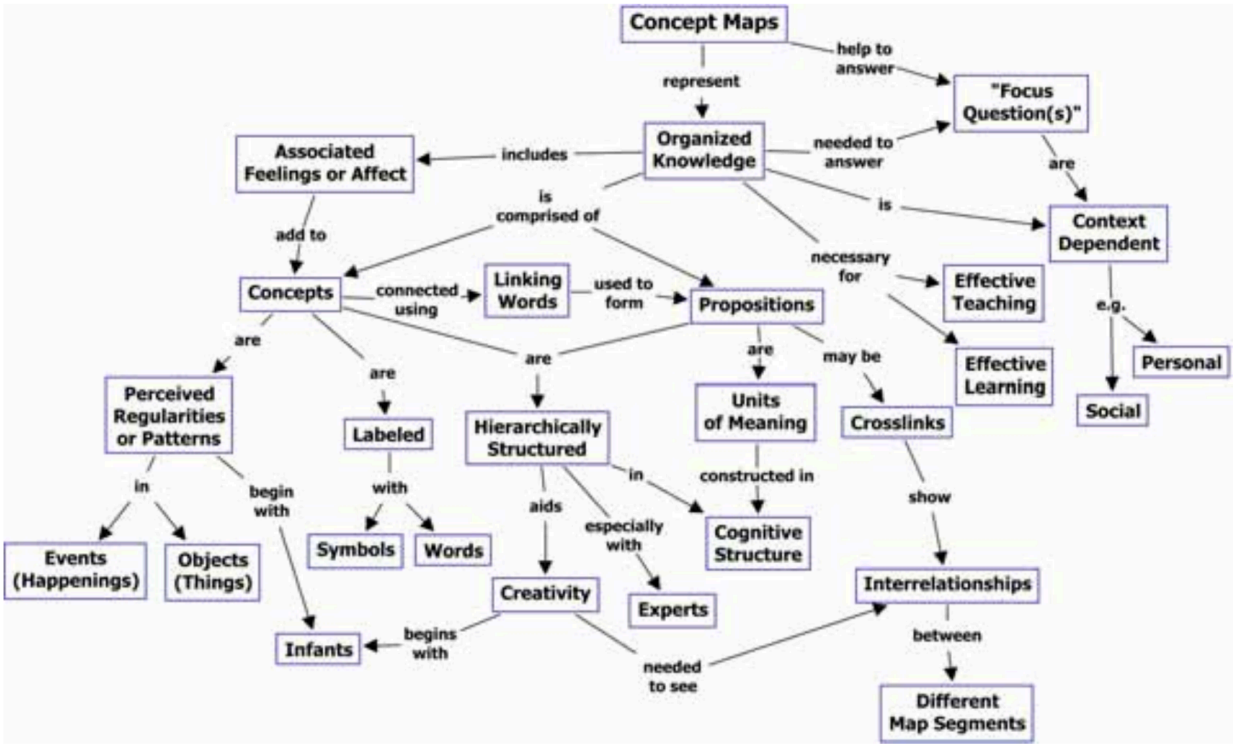



Figure 1. A concept map showing the key features of concept maps. Concept maps tend to be read progressing from the top downward.

## 2 Experiment Design

In order to see if using concept maps as a learning aid has a positive effect on students' understanding of computer science, I will run two experiments. The first experiment will be a longitudinal study on 10 seventh and eighth graders over the course of an after school computer science tutoring program, where some lessons will be accompanied with a concept map and others will not. The second experiment will be a single online trial where any demographic can participate, and the experimental group will get be provided with a concept map and the control group will not.

### 2.1 In-Person Experiment Details

The in-person experiment will be administered weekly to a group of the same 10 seventh and eighth graders (except in the case of absences) for a total of five lessons. The lessons will alternate the usage of concept maps with the usage of a bulleted list lesson summary (no heirarchy).

The order of lessons will be as follows:

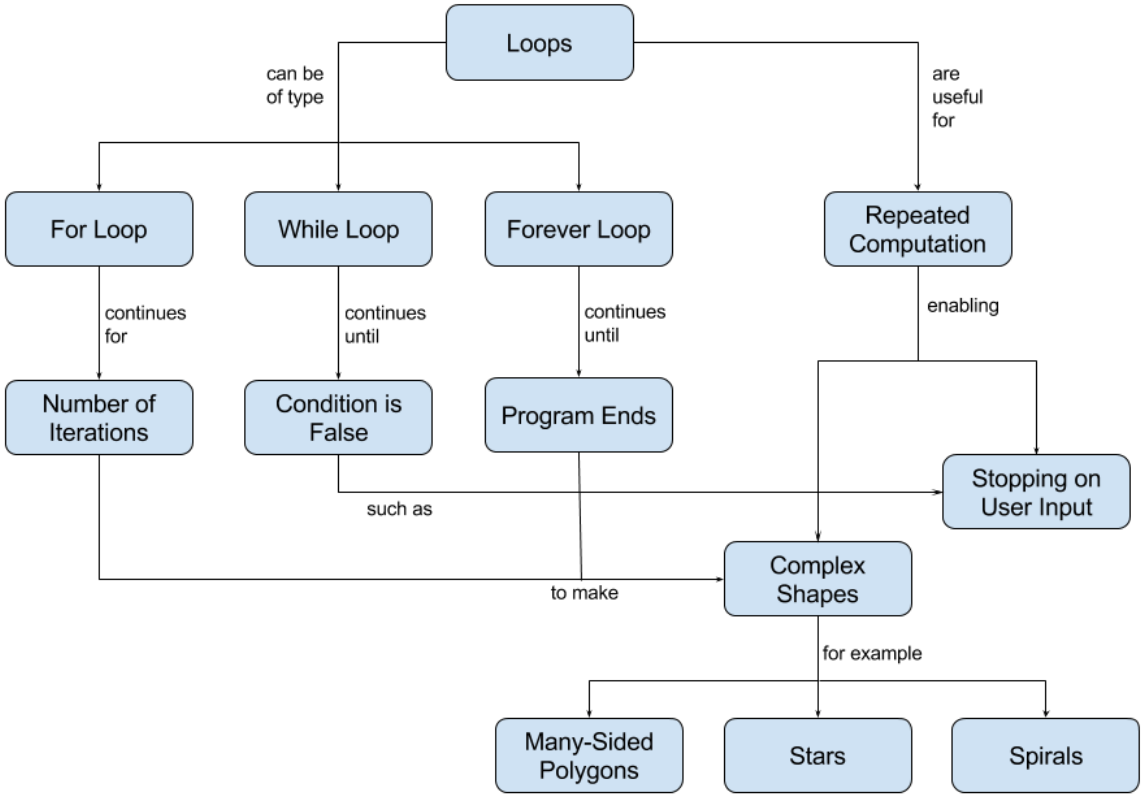
1. Loops (Concept Map)
2. User Input (No Concept Map)
3. Functions (Concept Map)
4. Debugging (No Concept Map)
5. Recursion (Concept Map)

As an example, here are the questions that will be included in the post-test for the first lesson on loops:

> What did you find interesting about today's lesson?
> What are the names of the three loops that were used in today's lesson?
> Which loop makes the turtle keep going until the program stops?
> List two shapes that are easier to draw using a loop.
> What shape would the following program make?
>
> ```
> pen red
> for x in [1..8]
>  fd 100
>  rt 90
> ```
>
> How much did you enjoy today's lesson?
> (Not at all) 1 2 3 4 5 (Very Much)
>
> How well do you think you understand the material from today's lesson?
> (Not at all) 1 2 3 4 5 (Very Much)

Like in the example test above, each of the post-tests will have a combination of technical and conceptual questions from that day's lesson. Also, each test will have a question asking the student to rate their own enjoyment and understanding of that day's lesson. This will allow me to track their motivation and satisfaction with the lessons throughout the course, and I will analyze these responses for differences on concept map days versus the other days.

Here is the concept map that I will use for the first lesson to accompany the post-test that the students will take:

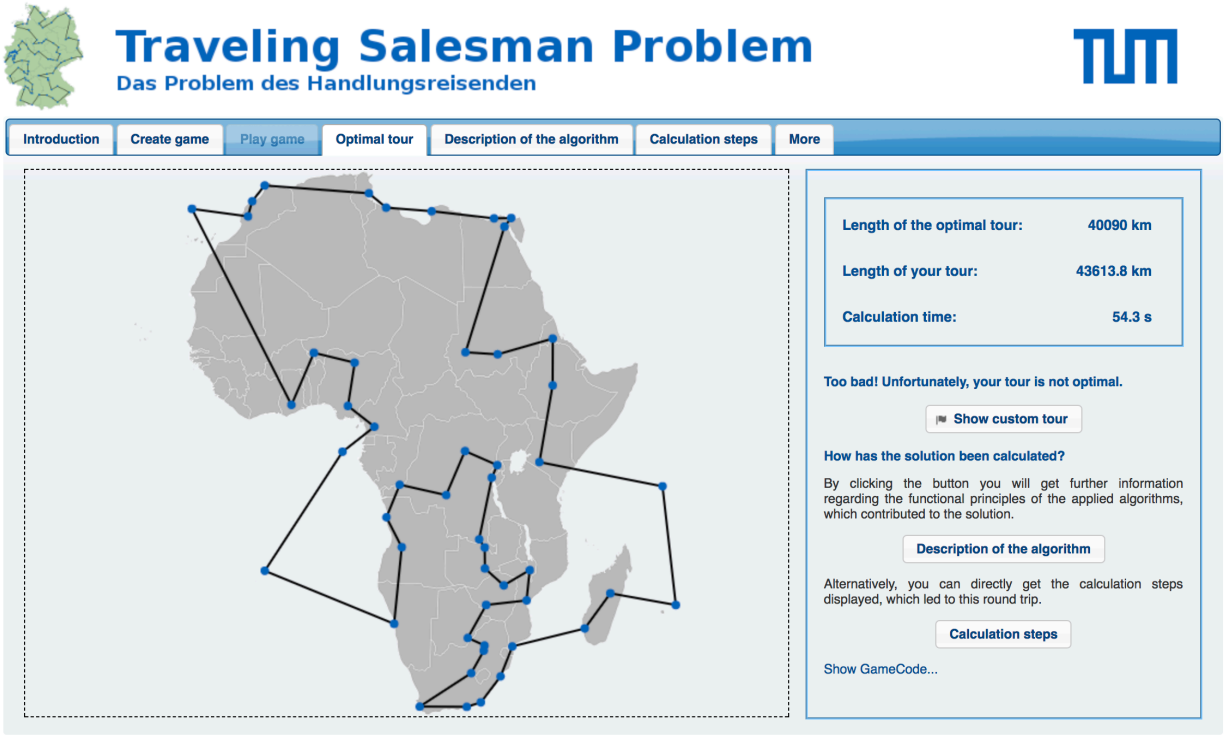


## 2.2 Online Experiment Details

The in-person experiment should yield some interesting data, but one downside to that experiment is my sample size – I only have 10 students to work with. That limitation makes splitting the class into a control group and an experimental group on a lesson-by-lesson basis problematic since my groups would be even smaller in that case (5 or fewer students per group, considering absences). To supplement this data, I will create an online experiment to test participants on a computer science related problem, with the control group getting a bulleted list aid to help them solve the problem and the experimental group getting a concept map aid.

There are a number of difficulties in creating this online experiment as well. For example, there will be a wide variety of backgrounds in my participants, so I will need to have a pre-survey to learn demographic and other information, like how much computer science experience they have. Also, online participants will only dedicate so much time to the experiment, so I need to keep it short, easy, and general enough so that the participant isn't expected to do a task outside of his or her ability, such as writing computer code.

To overcome these difficulties my online experiment will be structured around a classic problem in computer science: the traveling salesman problem (TSP). Participants will be presented with an overview of the problem, then they will receive instructions on how to solve an instance of the problem online, using an interactive version of the TSP from Technische Universität München.[3] The participant will record their score with the computer's optimized score for that problem instance. Then I will give the participant a theoretical overview of the TSP that includes strategies and heuristics for arriving at a more optimal solution. This theoretical overview will be the



experimental step, with the control group seeing a bulleted list and the experimental group seeing a concept map. Then, the participant will solve another, more difficult instance of the TSP, and similarly record their score in my survey.

I will then analyze this data to compare the two groups across the variety of demographics and backgrounds of my participants to see if the concept map version of the TSP strategy was more effective than the nonhierarchical list.

### 2.3 Analysis Methods

**Analysis Method for Quantitative Data: Statistical Hypothesis Testing**

In-Person Experiment -
Null Hypothesis: Providing students with a Concept Map review for introductory computer science lessons will have no difference over non-hierarchical, non-graphical review materials on students' (a) test scores, (b) personal assessment of lesson understanding, or (c) enjoyment of lesson.

Online Experiment -
Null Hypothesis: Providing participants with a Concept Map overview of Traveling Salesman Problem (TSP) strategies will have no difference over a non-hierarchical, non-graphical overview on participants' ability to approximate an optimal solution to an instance of the TSP manually.

Significance Level (alpha) for both experiments: 0.05

**Analysis Method for Qualitative Data: Sentiment Analysis**

The only qualitative data I'm collecting is from the middle school students in the in-person experiment. I will plug the student responses into a sentiment analysis program (http://text-processing.com/demo/sentiment/) and use that data in part (c) of the in-person experiment hypothesis test.

## 3 Schedule

**October 15**

- Have in-person post-test and survey format set
- Have results of first week of in-person experiment

**October 22**

- Have results of second week of in-person experiment
- Have a rough draft of online experiment

**October 29 (Milestone 1)**

- Compare first three weeks on in-person experiment
- Complete online experiment and host it

- Submit research methodology for online experiment

**November 5**

- Monitor first week's results from online experiment
- No in-person experiment this week

**November 12**

- Have results of fourth week of in-person experiment
- Monitor second week's results from online experiment

**November 19 (Milestone 2)**

- Have results of fifth (and final) week of in-person experiment
- Report final results from online experiment
- Submit preliminary data analysis of online experiment

**November 26**

- Thanksgiving Break

**December 3**

- Have a rough draft of final analysis/presentation

**December 10**

- Submit final report/presentation

## 4 Conclusion

Concept mapping has been shown to be more effective than other teaching methods in a variety of fields, but its study on computer science related learning is lacking.[4] With the two experiments I've proposed here, I hope to test some aspects on concept mapping's potential in the area of computer science.

In my final analysis, I will include a summary of the current research on concept mapping (more details can be found in my previous assignments on this research), an analysis of the data generated from my two experiments, and reflections on the shortcomings of my experiments due to the limiting circumstances laid out in this proposal, and finally suggestions for future work for researchers interested in concept mapping's effectiveness on computer science education.

## 4 References


1. Managing an Information Security and Privacy Awareness and Training Program (2005) by Rebecca Herold, p. 101

2. Novak, Joseph D. & Cañas, Alberto J. *The Theory Underlying Concept Maps and How to Construct and Use Them*, Technical Report IHMC CmapTools 2006-01 Rev 01-2008, http://eprint.ihmc.us/5/2/TheoryUnderlyingConceptMaps.pdf

3. https://www-m9.ma.tum.de/games/tsp-game/index_en.html

4. McMurray, Donovan, *OMSCS 6460 Assignment 5*. https://github.com/donovanfm/omscs6460-edtech/blob/master/CS6460_Assignment_5_Donovan_McMurray.pdf