Innovating with Concept Mapping
Proc. of the Seventh Int. Conference on Concept Mapping
Tallinn, Estonia 2016

# MAP/UML OUT: CONVERGENT CONCEPTUAL CONSTRUCTS

*Pia Niemelä, Tampere University of Technology, Finland*
*Jarkko Mylläri, University of Helsinki, Finland*
*Email: pia.s.niemela@gmail.com, www.tut.fi*

**Abstract**. This research initiative suggests continuing the concept map experiment that was carried out in Hope International School in Cambodian among Year 8 and Year 9 students of the extended math. In the previous experiment students were taught the concept map technique and the first implementation was to describe the whole IGCSE math syllabus. The intended study should be executed by transforming the students' syllabus map on the paper as an electronic version, and then use it as a knowledge building tool, when new topics are introduced and old revised. The map visualizes the existing conceptual structure and whenever new information is brought in, it will be placed and situated in the map and the linkage to the prior knowledge will be explicated. For revising, the map will also contain links to revision questionnaires and exercises of the past GCSE/IGCSE papers. The system authenticates users and responses will be stored for assessment and data analysis purposes, hence, the system functions simultaneously as a research instrument. However, it would be good to complement the information with the traditional pre- and post-tests. Instead of measuring the skills in only one particular area, these tests should be targeted in measuring the "big picture" of math and preferably compared with results of a control class regarding the traditional subject domains but additionally getting a better overview of math in general. However, the concept mapping as a metacognitive tool belongs to the bigger entity of 'learning to learn' cross-curricular learning goals, thus we propose that while launching mapping in math it will be simultaneously supported with parallel activities in the subjects of English (mother tongue) and ICT.

## 1 Introduction

Alas, school mathematics is oftentimes understood plainly as problem solving. Mastering math concepts is not in the center, which might lead to weak concept possessing that in continuation may cause problems especially with word problems. Embracing essential concepts paves the way for the next phase of linking concepts together and to prior knowledge. Deep learning is claimed to happen when data is associated robustly to the existing conceptual structure, and concept maps may be used as a tool that enables connecting concepts to each other explicitly. The visualized connection phase also exposes possible misunderstandings. In math a more detailed development of conceptual understanding and getting a bigger picture of math is less frequently set as one the main learning goal not to speak of examining it - a deficiency, which is addressed by this research initiative.

Ausubel (1962) stresses conscious elaboration as the main means of meaningful learning requires conscious effort to link new knowledge to existing cognitive structure that may be illustrated as a concept map. In teaching and learning this calls teachers for explicating the underlying principles and connecting it to prior knowledge, whereas learners should become more aware of concepts, their relations. In general, modelling and abstraction skills are beneficial for 'learning to learn' purposes. Being aware of one's best strategies for learning is a part of meta-cognitive skills. Ultimately, the learner is meta-cognitively mastering the process of making necessary associations in order to deepen the learning. The high road transfer means that the abstract knowledge is transferrable to other domains as well (Perkins & Salomon, 1988), and explicit abstraction and linking to other domains foster the transfer.

Concept maps as visual representations of the schema enable grasping a bigger picture of the content (Novak & Cañas, 2008). In this research initiative, we propose that the map should be designed to be digested at a glance to give the whole overview with the option of zooming into details, if desired. In addition, individual nodes should be visually appealing and contain visual hints as images and even video tutorials. The map should be implemented by using state-of-art tools such as Prezi and Google Docs. The students should be allowed to add content, for example, videos demonstrating solutions to past paper exercises.

We note that the concept map of the math syllabus is only one application of the bigger target of learning-to-learn skills. As other complementing applications, we suggest that the concept mapping will be used both in English (mother tongue) and ICT lessons. In English, when writing a data essay, the bigger text mass should be first illustrated as a map, after which the initial text will be taken away and the map will be used as a parsing tool and organizer or the abstract to be written. Conceptualization is an essential skill also in ICT modelling, e.g. to communicate the overall component and class structure of a system when a new artifact is being implemented. This initiative notes the value of conceptualization not only for learning to learn, but paving the way for UML diagrams used in describing the architecture of ICT systems.

## 2 Learning Artefact for internalizing Math Concepts and Big Picture


Year 8 and Year 9 of Hope International School cooperated in preparing the poster. Together with students we painted the background and produced the syllabus area transparencies. We were capable of finalizing the map a day before the semester end, see Figure 1.

The next phase was to transfer the syllabus map in Prezi, see Figure 2. In addition, the underlying system should be implemented to support all the needed functionality, i.e. authentication, auto-assessment, saving user's actions and responses for further manipulation and a portal for students to add their own content, e.g. solutions videos or new questionnaires.

Figure 1. IGCSE math syllabus map on the paper

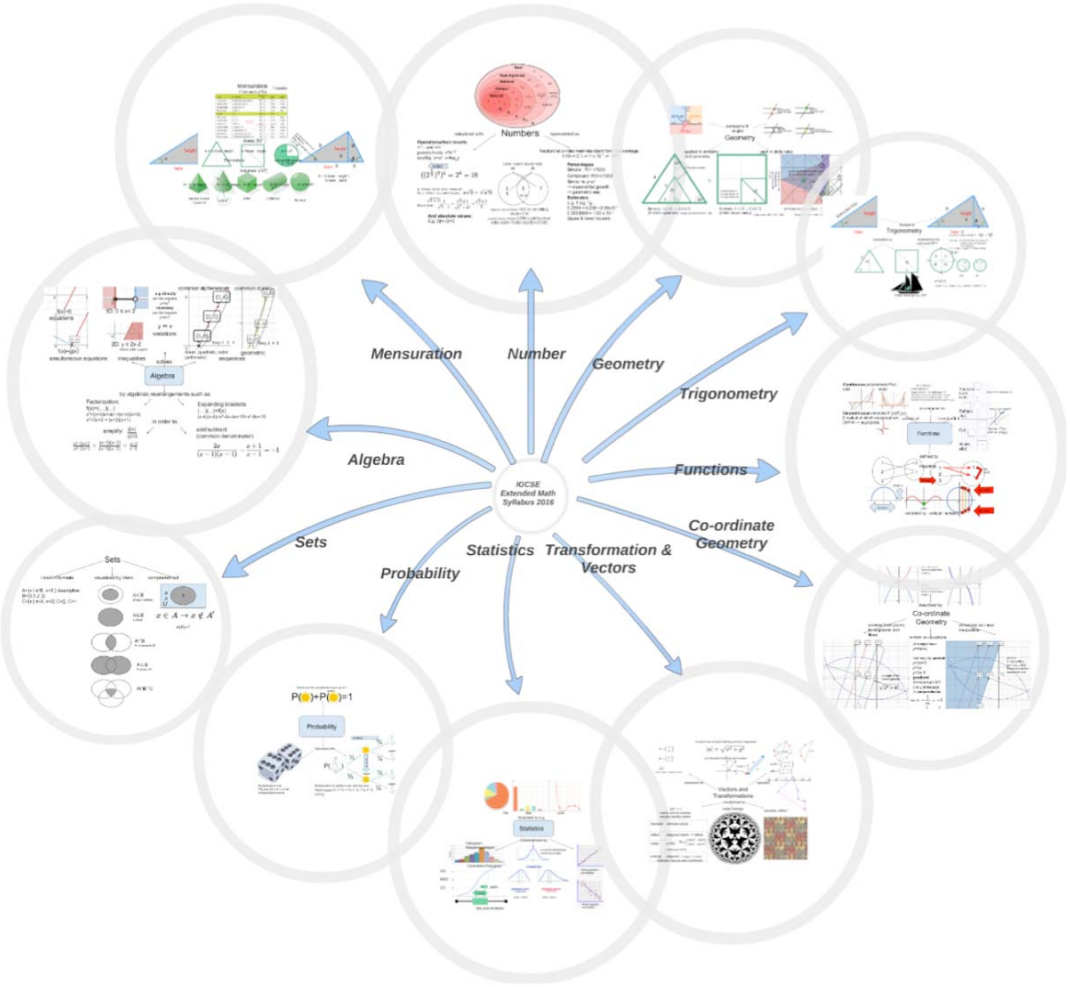


Figure 2. IGCSE math syllabus in Prezi and as the graphical user interface (GUI) of the intended learning artefact

The map should contain links to both questionnaires, past paper exercises and their solutions. Even if the first page is static, the next page should allow both a teacher and students to manage content, e.g. to add questionnaires and videos. The teacher should get results as histograms illustrating clearly the performance of

the whole class, also zooming to one students at a time should be provided. The student should be able to see his own results and manage his uploaded content.

As a learning experiment, concept mapping was well received by the students of Hope International School in Cambodia. However, executing the research remotely from Finland is not a functional solution, so the math syllabus must be first localized in Finnish condition. However, IGCSE provides past papers and solutions a free resource online, whereas in Finland the matriculation exams are not public. Moreover, the IGCSE math syllabus provides various descriptions, both verbal and more concise checklists, where only the essential concepts and rules are highlighted, which reduces the need for going through extensive amount of material, whereas in Finnish Curriculum the syllabus is more verbose, hence localization will require an extra effort, besides implementation.

Table 1. Modified TOGAF Enterprise Architecture of the Learning Artefact

| | Motivation / Strategy | Information Architecture | Implementation / Tools |
|---|---|---|---|
| Conceptual level | **Student**: improve conceptual learning and give an overview of math, help in revising. Option of reviewing own development as well<br>**Teacher**: assessment aid and learning analysis tool | Concept map as a GUI, authentication, questionnaires, auto-assessment, saving results, adding video tutorials (e.g. solutions for exercises)<br><br>Key concepts are Math Syllabus Concepts to be learnt<br>Actors: Teacher, Students | Implementation tools should support<br>• Online use<br>• User authentication<br>• Integration with various systems and media |
| Logical level | Syllabus concept map as a tool for linking content to prior knowledge and revision<br><br>Process1: Teacher introduces a new topic. First she shows a syllabus map and revises the prior knowledge to which she links the new knowledge<br>Process2: As homework a student fills the questionnaire linked to the area, which adds to the grade<br>Process3: A student reviews past paper exercises of the domain<br>Process4: A student may upload a solution video to the exercise, which credits a bonus<br>Process5: A teacher reviews the results of the whole class to be able to decide, whether it is time to move on<br>Process6: A teacher assessed the class and uses conceptual development as one of the measures<br>Process7: A student reviews his own development, e.g. past questionnaire results and time spent with each question | • Modeling domains of maths:<br>1. Number<br>2. Algebra<br>3. Functions<br>4. Geometry<br>5. Transformation & Vectors<br>6. Mensuration<br>7. Co-ordinate geometry<br>8. Trigonometry<br>9. Sets<br>10. Probability<br>11. Statistics<br>• Activities types<br>o Questionnaires<br>o Past paper exercises<br>o Student-made solution videos<br>• Assessment model | Types of Tools<br>• concept mapping<br>• questionnaire<br>• feedback<br>• analyses<br><br>Concept map as a GUI that contains links to the static collection pages. The content in the collection pages, however, is dynamic (cumulatively increasing) |
| Physical level | | Database for storing assessment results (e.g. Google Spreadsheet) | Prezi, Google Classroom auth, Google Forms, Flubaroo, Google Spreadsheet, YouTube's non-public videos<br>GUI + links to collection pages are static, every class should add questionnaires and video tutorials |

## 3 Summary

The motivation for this research initiative is the identified gap in the concept possessing and having a limited overview of math. The sketched artefact should help in putting new concepts in place, linking them to the prior knowledge and revising. However, concept mapping should be introduced and used in parallel in other subjects as well, to strengthen the effect. We suggest a bigger cross-curricular concept mapping initiative, that would include English and ICT as well. In English, a concept map could be used as a parsing tool as suggested by Åhlberg (2002). In ICT students could be introduced to UML basics.

## References


Ausubel, D. P. (1962). A Subsumption Theory of Meaningful Verbal Learning and Retention. *The Journal of General Psychology, 66*(2), 213-224.

Novak, J. D., & Cañas, A. J. (2008). The Theory Underlying Concept Maps and How to Construct Them. Technical Report IHMC CmapTools 2006-01, Pensacola, FL: Institute for Human and Machine Cognition. Available at: http://cmap.ihmc.us/docs/theory-of-concept-maps

Perkins, D. N., & Salomon, G. (1988). Teaching for Transfer. *Educational Leadership, 46*(1), 22-32.

Åhlberg, M. (2002). Käsitekartat tutkimusmenetelmänä.