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# USING CONCEPT MAPPING TECHNIQUE TO PROMOTE THE CREATION AND IMPLEMENTATION OF SCIENCE CAREER-RELATED SCENARIOS – THE MULTICO PROJECT EXPERIENCE

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**Abstract**. The purpose of this paper is to illustrate the use of concept mapping to create science career-related scenarios as part of a teaching approach to raising middle school students career awareness. The paper shows the role played by concept mapping in aiding the construction of a scenario. Within the project, 4 scenarios were created, each focusing on one science subject, but at the same time involved an interdisciplinary problem setting related to a socially relevant issue. The scenarios formed the 1st part of a theoretically justified 3-stage model teaching approach, which encompassed a created context (motivating students at the beginning of lessons by means of a scenario), de-contextualizing (gaining new conceptual science) and re-contextualizing (incorporating the science learning in socio-scientific decision making based on issues arising from the initial scenario). Within the project, the scenarios were utilised in a longitudinal study on middle school students (grade 7-9) with each intervention following the 3-stage teaching approach. In general, science teachers found the concept map support useful as they learned, in addition to creating scenarios, how to relate social issues with science learning and how to introduce science careers within lessons.

**Keywords**: concept mapping, scenarios, 3-stage teaching approach, science careers

## 1 Introduction

An evidence-based, attractive science education provision can enable all students to play a more active role in acquiring science, technology and engineering processes, to make informed choices and to more fully engage in a knowledge-based society. Furthermore, motivational science teaching and learning is perceived as connecting with everyday life (Hulleman & Harakiewicz, 2009) and with everyday life situations.

In MultiCo, a Horizon2020 European project, the science education approach is through creating learning materials containing an introductory scenario, intended to be perceived by students as interesting and hence motivational (Krapp & Prenzel, 2011). The scenarios are also intended to initiate the promoting of science education competences and an awareness about science-related careers among middle school (grade 7-9) students. Such scenarios are created through stakeholder co-operation between science educators, experts from science fields including industry and also involving civil society organisations, non-formal science educators and possible the students themselves.

In aiding the promotion of student competences seen as valued by society, the scenario forms the first part of a 3-stage model for science teaching, suggested as an effective pedagogical approach (Holbrook & Rannikmäe, 2010). The scenario as the first stage of the model is based on self-determination theory (Ryan & Deci, 2002) and seeks to highlight the importance of intrinsic motivation in driving human behaviour (students' learning). The learning is initiated by a familiar contextual frame of reference, intended to link to a perceived need in the eyes of students and for this initial stage, the aspect of relevance is seen as a major focus. This first stage is seen as an essential component for relevance-anchored, interest-enhanced instruction by guiding students to recognize, within the scenario, a social issue which has a scientific aspect. Within the subsequent learning process, the de-contextualised second stage aids students, with help of the teacher, conceptualise needed science learning from a known to an unknown situation. Hence the second stage provides enhances science conceptual learning, focusing on the interrelated scientific ideas through solving inquiry-based scientific problems. Stage 3 seeks to consolidate of the scientific learning through transference of the conceptual ideas to the earlier contextual frame and promoting socio-scientific decision-making (as a re-contextualisation stage) important for student learning.

Research has shown that the crucial part is stage 1, encompassing the initial scenario in terms of a constructivist part of anchored instruction), the relevance to the learners and introducing the sophisticated multidisciplinary science aspect, hidden within a society-relevant, socio-scientific issue (Kotkas, Holbrook, & Rannikmäe, 2017).

Yet developing motivational scenarios is no easy task and teachers need additional support. The current paper introduces the role of using concept map techniques in helping to make the creation and implementation of career-

related scenarios meaningful for teachers, while also highlighting the benefits for students. To teach effectively using a scenario in a classroom setting, science teachers need to develop an understanding about all learning aspects (content, competences, career motivation). The concept map technique is seen as useful, as it allows teachers to monitor how they can relate different science concepts.

Before teachers attempt to create concept maps, experiences have shown that they need to be introduced to ways such maps can be developed, based on ideas put forward by Cañas, Novak & Reiska (2015). In this, a good concept map is indicated as having a focus question, concept labels and that linking lines should be short word(s). Also concept maps are shown to help teachers by guiding them to form a hierarchical organisation (most general concepts being at the top), with no more than 3-4 sub-concepts linked to any given concept and with cross-links added between significant interrelationships between concepts in different sub-domains of knowledge. Also the concept maps aid the formation of a good structure which can lead to meaningful learning and indicate the coverage of sufficient content (Cañas, Novak & Reiska, 2015).

## 2 Methodology

### *2.1 The Scenario Development Process*

Within the Multico project, teachers were asked to create four scenarios, each including career parameters relating 'industry to society' challenges e.g. energy, water, waste, climate change, food, health, transportation. Teachers were asked to design the scenarios to be motivational and relevant for students (attractive and interesting e.g. covering an unexpected or extraordinary situation). In addition, each scenario was to be related to the development of both subject content knowledge and general (cross-curricular) competences.

In this paper, the teacher created scenario "Should there be sugar tax?" is taken as exemplary scenario. It focuses on taxing of sugar consumption, seen as relevant because the Estonian government is contemplating the introduction of a sugar tax as a way of trying to reduce the intake of sugar. Such a tax makes soft drinks more expensive compared to current prices and hopefully makes them less popular among students. The created scenario includes advantageous and disadvantageous quotes from newspaper articles spoken by politician and representative members of the soft drinks producers' union. A second part of the scenario, for use after a visit to an industrial company (in this case, a lemonade and beer produced industry), includes in-depth descriptions of two of the industry-related occupations: a food technologist and a biochemist.

All students visited the same type of industrial enterprise – an industry, in which beer and soft drinks were being produced. The visit was guided by an experienced worker from the industry. The students saw the stages of beer production, including the fermenting process and the role of bacteria and fungi. Afterwards, laboratory equipment used for testing the end product was shown to the students. At the end of the visit, the producing and filling of plastic bottles, as well as robots packaging the produce, were shown. In all operations and also in the laboratory, the professional expertise of the employees were introduced, especially the skills needed by a particular job specification.

### *2.2 The Role of the Concept Map*

A teacher developed concept map guided teachers' activities in the classroom. This was undertaken for all four scenarios. Figure 1 is an example of a concept map developed for guiding meaningful teaching using the scenario "Should there be a sugar tax?".

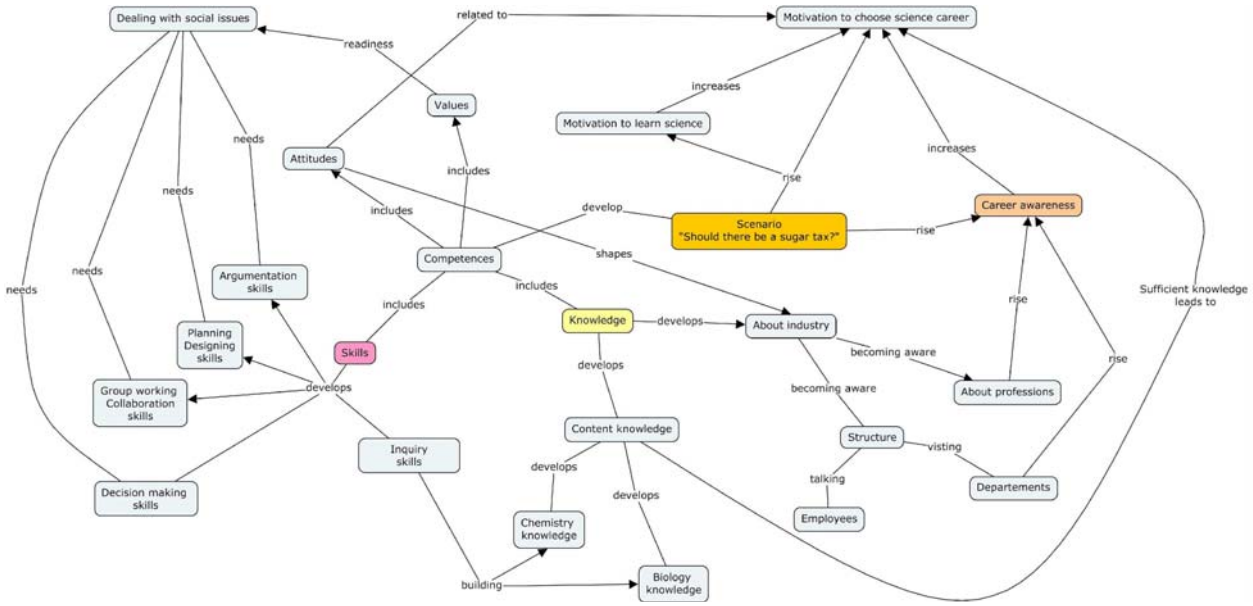


**Figure 1**. Concept map about developing scenario for meaningful science teaching

This figure shows the centre of teaching for raising students' science-related career awareness and meaningful learning. It illustrates that the scenario is for:

- motivating students to learn science, choose science related career in future and to rise overall career awareness (right top side of the figure);
- developing competences (including values dealing with socially relevant issues in future; attitudes towards choosing science-related career and industries giving work to many employees; skills and knowledge are sub-sets in this approach) (left side of the figure):
- to develop skills needed in dealing with socially relevant issues in future and to construct new knowledge (inquiry skills) based on already existing knowledge about phenomena investigated in this scenario) (left side of the figure);
- to develop knowledge at two levels (subject related content knowledge and knowledge about industries, both structure and profession level for rising career awareness) (bottom side of the figure).

### *2.3 Guiding Teachers to Use the Scenario in Teaching*

To guide other teachers to use a given scenario in their teaching and to relate it to the 3 stage model, an additional concept map, developed by the teacher or teachers creating the scenario, was formed. This was made up of 3 parts:

- Part 1 guided the teacher to support student to construct new knowledge, develop attitudes and be able to work within a group.
- Part 2 guided the teacher to establish meaningful teaching promoting student acquisition of competences.
- Part 3 guided the teacher to involved students as a community group so as to be able to make informed decisions in response to the socio-scientific issue raised in the scenario.

The overall map guided teachers to create a meaningful learning situation (Figure 1 inclusion of industry and science related careers) and promote educational competences, such as skills needed for dealing with social issues). The map also guided teachers in ways to stimulate communication between teachers and students (through discussions in the classrooms).

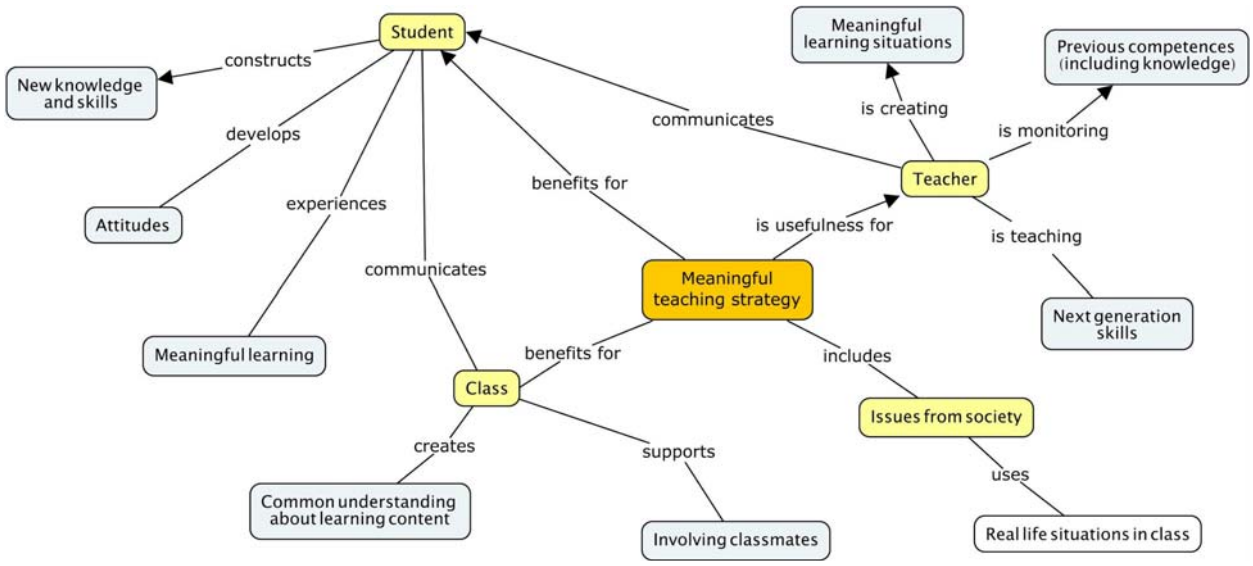


**Figure 2**. Concept map about meaningful teaching strategy

### *2.4 Data Collection and Analysis*

After implementing such scenarios in the classroom, teachers were interviewed (N=10) and their responses were analyzed using qualitative content analysis. All responses were coded individually by two coders.

Students (N=120) opinions were also asked after being involved in scenarios using the questions: *How do you evaluate the module in terms of enjoyment and interest? What aspects made the module enjoyable and interesting for you? How do you evaluate the intended learning outcomes?*

## 3 Results

### *3.1 General Outcomes from the Interviews with Teachers*

Outcomes from interviews with teachers, after implementing the scenarios, indicate that teachers were satisfied with their developed scenarios, but they found it difficult to create a meaningful concept map related to all knowledge domains (content, competences, career).

For example, one teacher pointed out that “Becoming more aware about which skills are essential for science careers; so far thinking is around science knowledge and skills - indeed this is what chemistry textbooks show”. Another added that “Mapping competences for science-related careers put forward is a good idea; this directs thinking towards crossing the borderline between school chemistry, biology and physics”. These results showed that teachers need more knowledge and guidance about science careers and how to link together all three important components in a meaningful way for students learning. This was confirmed by the findings from concept maps and interviews.

### *3.2 Students Opinions in General*

This module was interesting and enjoyable for students. Students pointed out that the module was interesting, because it included the visit to a real industrial company and students were able to undertake inquiry work. By studying using the module, students indicated they acquired new knowledge and skills, which was also the initial purpose.

Starting from on the main points in scenario, one intended outcome was career awareness. Results showed that students in general agreed that this scenario was good for this and they named after this intervention more than 35

science related career possibilities (e.g. statistician, an architect, a biochemist, author of books, builder, lawyer, researcher, cosmetics industry worker).

Students also said that they got new knowledge and skills from this intervention and this leads to another main area that were intended to receive by using this module in classrooms (initially planned as re- and de-contextualization of the context.

## 4 Conclusions

This study showed that it is possible and helpful to develop concept maps for stimulating student motivational scenarios (in the current study career relatedness gives extra elements to the scenarios aiding meaningful learning. While teachers in general are familiar with creating science-related concept maps, the study shows that it is possible to guide teachers to move towards more sophisticated real-life related concept maps.

For more meaningful teacher, the study shows that teaching strategy concept maps are a helpful extra guidance for teachers, facilitating and justifying the 3-stage approach.

## References


Cañas, A. J., Novak, J. D., & Reiska, P. (2015). How Good is My Concept Map? Am I a good Cmapper? *Knowledge Management & E-Learning*, 7(1), 6–19.

Holbrook, J. & Rannikmäe, M. (2010). Contextualisation, de-contextualisation, re-contextualisation - A Science Teaching Approach to Enhance Meaningful Learning for Scientific Literacy. In: I. Eilks, & B. Ralle (Ed.). *Contemporary Science Education* (pp 69−82). Shaker Verlag.

Hulleman, C. H., & Harackiewicz, J. M. (2009). Promoting Interest and Performance in High School Science Classes. *Science,* 326, 1410-1412.

Ryan, R. M., & Deci, E. L. (2002). An Overview of Self-Determination Theory. In E. L. Deci & R. M. Ryan (Eds.), *Handbook of Self-Determination Research* (pp. 3-33). Rochester, NY: University of Rochester Press.

Kotkas, Tormi, Holbrook, Jack, & Rannikmäe, Miia (2017). A Theory-based Instrument to Evaluate Motivational Triggers Perceived by Students in STEM Career-Related Scenarios. *Journal of Baltic Science Education*, 16(6), 836−854.

Krapp, A., & Prenzel, M. (2011). Research on Interest in Science: Theories, Methods, and Findings. *International Journal of Science Education*, 33(1), 27-50.