

# EVALUATION OF EDUCATIONAL DESIGN METHODOLOGY UTILIZING CONCEPT MAPPING

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*Abstract:* One goal of educational design research is to provide guidelines for the design process. This paper reports on our on-going work on the development of such guidelines by evaluating the design procedure of a pre-service chemistry teacher education course on models and visualization. In the design of the course, the concept maps were utilized as interactive road maps for coordination and documentation of the co-operative development of the design solution. Description of the roles and collaboration between the developers in the design process are presented as a design narrative based on the analysis of semi-structure interviews of three course developers. The evaluated design process had six phases: (i) establishing goals for the design procedure, (ii) evaluation of the initial design solutions, (iii) collaborative construction of the design solution, (iv) implementation of the design solution, (v) evaluation of the design solution, and (vi) evaluation of the design procedure. During the course, the concept map created during the co-operative construction of the design solution was used as a summary of the objectives of the course, management tool, and description of the design process. Based on the results, the presented design methodology is a promising way of utilizing concept maps in coordinating the co-operation of multiple designers in educational design-based research.

*Keywords:* design research, design based research, concept maps

## BACKGROUND AND RATIONALE

For the past 20 years, several papers have discussed educational design research (e.g. Bell, Hoadley & Linn, 2004, Brown, 1992; Cobb, 2001; Dede, 2004; Edelson, 2002; Juuti & Lavonen, 2006). In design research the research-based development is carried out in a real-world situation systematically, flexibly and iteratively through continuing evaluation and expertise of various interest groups (Wang & Hannafin, 2004).

Daniel Edelson (2002) describes three elements of design research: (i) the *problem analysis* characterizes the goals and opportunities of the design as well as the challenges and constraints it has, (ii) the *design solution* describes the resulting design, and (iii) the *design procedure* specifies the processes and people that are involved in the development of the design. According to Edelson, design research produces three types of theories corresponding with these elements: (i) *domain theories* are generalizations of some portion of the problem analysis, (ii) *design frameworks* describe the characteristics of a successful design solution, and (iii) *design methodologies* provide guidelines for the design process.

One possible way to organize, to visualize, and to document a design process is to use concept maps. Concept maps are graphical teaching, learning, evaluation, and presentation tools that were devised as a device of Ausubel's (1968) theory of meaningful learning. Concept mapping helps organize concepts related to the topic, shows interrelationships among concepts, and illustrates how the concept structure of the topic is constructed (Novak 1998).

As design research has tended to focus on descriptions of design frameworks and domain theories rather than on developing design methodologies, there is a need for new approaches

in design procedures. This paper reports on our on-going work on the development of an educational design methodology utilizing concept mapping.

## **METHOD**

In this study, the design procedure of a pre-service chemistry teacher education course on molecular modelling is evaluated by providing a description of the process for pedagogic course design as well as the roles and collaboration of the developers (see Edelson, 2002). A researcher, who did not take part in the design and development of the course, interviewed the three teachers responsible for the course. In semi-structured interviews, these co-developers were asked to describe the design procedure and their role in it, and how they utilized concept mapping in the design and implementation of the course.

Design narrative is a comprehensive description of the whole design process. It explains design conditions, decisions, goals, challenges, and results and is usually created by the developers (Bell et al., 2004; Juuti & Lavonen, 2006). In addition to interviews, the results presented in this study are based on the published initial design narrative written by the developers (Pernaa, Aksela & Västinsalo, 2010).

By qualitative content analysis of the interviews and initial design narrative, a new design narrative was created, focusing on the design methodology, the roles of the developers and the use of concept mapping in the design process.

The questions driving this study were:

- (1) How the co-developers collaborated during the design process?
- (2) How the roles the three co-developers assumed contributed to the design process?
- (3) What purposes concept mapping served in the design process?

## **Role of Researchers**

Second and third authors worked as co-developers and teachers of the course. To objectively analyse the roles developers assumed in the design process, a decision was made that someone who had not worked on the course should make the interviews and analysis. This was the case, as before the interviews the first author had no previous affiliation with the course. However, as the first author is working in the same teacher education unit, the authors recognized there is a possibility for bias, as even the first author has vested interest in the program.

Although the evaluation was done solely by the first author, two co-developers (second and third author) contributed to writing the final design narrative presented here. To ensure the credibility of the results (see Lincoln & Guba, 1985), a member check was carried out by providing also the third co-developer with the results and conclusions for comment.

## **RESULTS**

### **Collaboration during the design process**

Based on the interviews and initial design narrative (Pernaa et al., 2010) the design process had six phases: (i) *establishing goals for the design procedure*, (ii) *evaluation of the initial design solutions*, (iii) *collaborative construction of the design solution*, (iv) *implementation of the design solution*, (v) *evaluation of the design solution*, and (vi) *evaluation of the design procedure*.

The first phase was not reported in the initial design narrative and the developers did not

explicitly discuss the goals of the design procedure. Every developer saw the need for improving the design solution, but at least one of the developers was not aware of the goal of developing the design process as well as the design solution. This caused some problems during the later phases. For example the initial problem analysis and the changes made to the design solution during the implementation were not adequately documented, as all the developers were not aware on how the documentation would be used in the evaluation of the design.

To evaluate the initial design solutions, the developers got acquainted with the feedback and materials from the previous implementations of the course. Based on this problem analysis describing the goals, needs, and opportunities presented by the design context, the developers worked collaboratively to produce a description of the design solution. The concept map was used as a tool for documentation and visualization in constructing a consensus design solution. Concept map created by one of the developers was used as a root model, where all changes, solutions and challenges were documented. The process is visualized in figure 1.

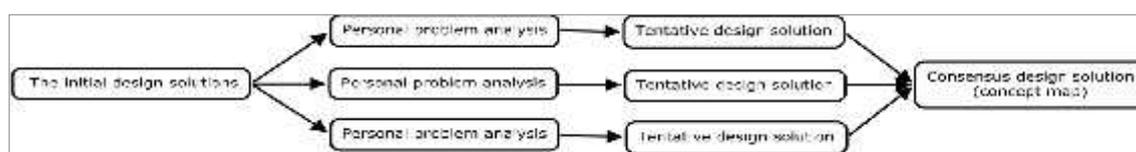


Figure 1. Evaluation of the initial design solutions and the collaborative construction of the design solution.

### **Roles of the co-developers and concept mapping in the design process**

The different roles of the three developers were apparent in the construction of the design solution. The developers included a professor responsible for the course, a PhD student working as an instructor on the course for the second time, and a recently graduated teacher with master's degree in chemistry education.

The recently graduated teacher had been a student on the course previous time the course was held. During the design and implementation of the course, she reflected mainly on her own experiences as a student. Her contributions were mostly concentrated on improving the practicalities of instruction (*e.g.* software tutorials and modelling exercises). She saw the concept map as a tool for coordinating teaching: From the concept map presenting the consensus design solution (see figure 1) she could see what were the objectives of the course and how the teaching responsibilities were divided. Although she participated in analysis of the research data and writing the article reporting the initial design narrative (Pernaa et al. 2010), she did not feel she contributed much to the research part of the design research process. As a newcomer to the development team, she had a hard time evaluating the contributions of the other teachers developers.

The second developer was a PhD student working for the second time as the teacher on the course. He was writing his PhD thesis on the use of design research in chemistry teacher education. As the main author of the initial design narrative (Pernaa et al. 2010), he concentrated on documenting the design process as well as developing the technical aspects of the course. Having the responsibility of coordinating the course and the design research process, he seemed to be very aware of the contributions of the other co-teachers and developers. Although actively involved in the design process, he felt that he should rely on the expertise of the professor on some issues, such as on deciding the overall goals of the course. In his opinion the teaching responsibilities during the course were quite evenly distributed: The professor gave lectures about the more theoretical aspects of the course, while the other teachers were responsible for supervising and evaluating the assignments. With his attention focused on the design research process, he saw the concept map presenting the consensus

design solution mainly as the visualization of the design process. As the design research project was part of his PhD thesis, he had the main responsibility in the research project.

The third developer was professor and head of the unit. She had been involved in every implementation of the course since 2003, when the course was taught for the first time. Her contributions to teaching were mostly directed to develop the goals of the course and the division of labour among the teachers. She saw concept map presenting the consensus design solution as an overview of the course design. Her focus on the development of the course was on the students that the pre-service teachers would one day be teaching. As the supervisor of the PhD students she also participated actively in the research process. Although she wanted to support the autonomy of her PhD students and co-developers, and to encourage them to follow their own interests, she also felt that she is ultimately responsible for the quality of the teaching and research. On day-to-day issues of teaching she trusted the judgement of the other teachers and considered their contribution crucial to the final design of the course. For example, the professor noted that the perspective of someone, who had recently been a student on the course, was direly needed to ensure the relevancy of the course in the eyes of the students.

## **CONCLUSIONS AND IMPLICATIONS**

The developers had distinctly different roles in the construction of the design solution. The less experienced teacher educators focused on the practicalities of teaching and research, and the more experienced professor of teacher education focused on the students as future teachers and supporting the other teacher educators in their teaching and research.

Also other researchers have noted the shift of focus from practicalities of teaching to a more student-centred view. Peter Kugel (1993) describes the professional development of university teacher moving from focusing on their own role as teachers, through focusing on understanding of the subject matter they teach and students' ability to absorb what they have been taught, to finally focusing on helping students learn to use what they have been taught and developing independence and autonomy. The roles designers took in the construction of the design solution seems to be related to their experience as teacher educators much in the way described by Kugel. This does not mean, that inexperienced teacher educators are less valuable for the educational design process: Even though the focus seemed to develop through experience, there was a special need for fresh perspectives.

In the implementation phase, the concept map worked as a "road map" or curriculum for the course. The design solution evolved over the course through analysis and formative evaluation: all things described by the initial concept map were not implemented and some additional elements were added on the course curriculum. The concept map had many uses during the implementation. Developers saw it, among other things, as a description of the objectives of the course, management tool, and description of the design process.

Based on the evaluation of the design procedure, concept map is a useful and versatile tool in educational design research. Edelson (2002) points out that constructing a design solution is a process of creating and evaluating alternative solutions from multiple perspectives. Concept maps can be used to decompose the "complex design problem into manageable components" (p. 109). Concept maps can also be utilized during the implementation as interactive road maps documenting the development of the design solution.

The design methodology presented here is a promising way of utilizing concept maps in coordinating the co-operation of multiple designers in a design research process. The use of concept mapping in the design methodology could be developed even further. To ensure that everyone understands the design process and the importance of adequate documentation, there

was a need for conversation about the goals of the design procedure. In such a discussion, concept maps could be used in visualizing and documenting the decisions made in establishing the goals for the design procedure.

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