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Empowering STEM-teachers: Towards an Interdisciplinary STEM Didactical Approach

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Abstract

Despite the considerable amount of mathematics and science in secondary schools in Flanders, Belgium, a significant number of students experience STEM-courses as abstract and irrelevant. Because STEM is often divided in the different disciplines and taught as such, students build up very little experience in solving realistic multidisciplinary problems. In order to accomplish challenging STEM-education in which pupils acknowledge the relevance and the interaction amongst the STEM-disciplines, STEM-teachers need to be competent to increase the perceived relevance of their own discipline and to stimulate problem solving abilities of their students.

In this project, we aim to develop an integrated STEM didactic course in which pre-service teachers are prepared both to develop/coach specific STEM-projects and to teach separate STEM-disciplines in such a way that links amongst the different STEM-disciplines are revealed.

In a preliminary study we investigated the view of STEM-educators on the current and ideal teaching of STEM-courses. The results show that for all disciplines the current approach focuses on specific discipline knowledge and algorithmic problem solving. All experts indicate the need of a transfer to a more interdisciplinary STEM-approach which focuses on developing problem solving techniques, conceptual thinking, linking different STEM-disciplines and context-rich learning environments.

The main goal of the interdisciplinary STEM-course is to strengthen the PCK of pre-service teachers (specialized in a specific STEM-discipline) in order to accomplish an optimal implementation of the interdisciplinary STEM-aspects. The general outline of the course is:

To optimally educate pre-service teachers to powerful STEM-teachers, a STEM-course was developed in which:

** Pre-service teachers learn to acknowledge the shortcomings in the current approach in high schools*

** Good practice examples with the focus on inquiry based learning for multidisciplinary STEM-classes are offered*

** Pre-service teachers are enabled to implement relevant STEM-aspects in a variety of contexts*

1. Introduction

As indicated in the ROSE-project [1], only a small number of secondary school students tend to choose STEM-related studies after high school. One of the reasons is that STEM courses in secondary schools are divided into the four different STEM disciplines and taught as such [2]. As a result, students fail to grasp the relevance of STEM classes and miss the experience of interdisciplinary problem solving. To increase the engagement of students in STEM classes, the inquiry based learning method, where learning based on problems, projects and designs is a vital teaching practice [3].

An integrated STEM approach is crucial in order to successfully achieve a motivational and challenging STEM education in which pupils acknowledge the relevance and interaction amongst the different disciplines [4;5;6]. Therefore, pre-service teachers should be coached to both recognize the necessity of such approaches, as well as build the competence to develop them.

To achieve such competence, (pre-service) teachers need to obtain a strong pedagogical content knowledge (PCK). Since its introduction in 1986 by Shulman [7], many researchers have acknowledged the importance of PCK for teaching, lesson plan preparations and teacher professional development [8;9;10].

The main research questions to resolve:

1. How can inquiry based learning in a multidisciplinary context provide and strengthen the core of science and technology?

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2. How can the PCK (pedagogical content knowledge) of pre-service teachers be adapted to function powerfully in interdisciplinary STEM-contexts where the integration of mathematics, science and technology is the central thought?
3. How can (pre-service) teachers be made capable to implement the general interdisciplinary aspects of STEM in their own discipline?

This research project aims to develop a blended STEM course in which pre-service STEM teachers (from different STEM disciplines) will learn to take an interdisciplinary approach to teaching.

2. Method

At this stage, we investigated the current as well as the ideal approach to STEM education in Flanders. Therefore, experienced STEM teachers, teacher trainers and pre-service teachers were surveyed. The results of this survey are crucial in the development of the new STEM course.

3. Results

The experts assessed the presence of different STEM aspects in high school STEM education on a scale of 1 (no focus) to 4 (important focus). The mean value was calculated and plotted for each aspect. The results for the current approach (blue bars) versus the ideal approach (red bars) are provided in Fig. 1. The graph shows that in the current approach, specific discipline knowledge and algorithmic problem solving are dominant, while other STEM aspects tend to be neglected. However, respondents indicated that these neglected aspects are exactly those most important to an ideal STEM approach.

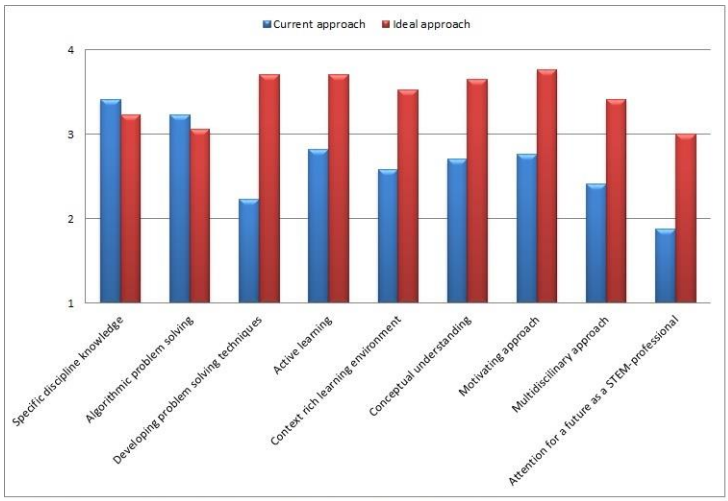

Fig.1: the presence of current and ideal STEM aspects in high school STEM education

The experts were also asked their opinion on a number of statements related to the necessity and possibilities of an interdisciplinary STEM course for pre-service teachers. Their answers were given on the basis of 1) complete disagreement to 4) complete agreement. Fig. 2 shows the mean values of the results.

The scoring of statements A to C is rather low (< 3); the experts indicate that achieving competence or studying good practices does not necessarily prepare pre-service teachers to implement it in a wide range of contexts.

The high scores (> 3) on statements D – G reveal the possibilities of implementing an interdisciplinary approach with problem solving as a central theme.

Finally, the results on statement H point out the limitations of a pre-service STEM course.

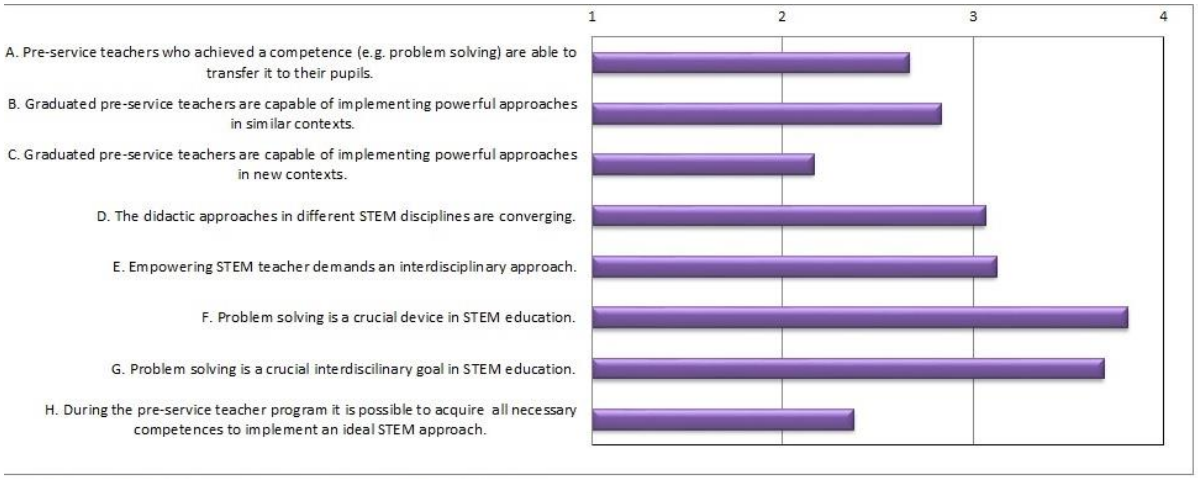

Fig.2: necessities and possibilities of an interdisciplinary STEM course

4. Discussion and conclusions

As can be seen in Fig.1, there is a discrepancy between the current and the ideal STEM education approach in high schools in Flanders. The results indicate the need for a shift in focus from specific knowledge and *algorithmic* problem solving to the development of problem-solving *techniques*, conceptual thinking and the integration of different STEM disciplines to form a context-rich learning environment.

Fig. 2 shows that experts believe in an interdisciplinary STEM course which provides a foundation for implementing a strong educational approach in a variety of contexts.

In order to achieve sustainable change, a pre-service teacher course should

a. create awareness of the shortcomings of the current approach;
b. provide good practices for an ideal STEM education, with a focus on inquiry-based learning; and
c. enable pre-service teachers to develop the competence to implement the relevant STEM aspects in a wide range of contexts.

In the ongoing process of developing an interdisciplinary STEM course, we have measured the needs and expectations of both experienced and pre-service teachers. Based on these results, a model is proposed in which inquiry based learning and metacognitive understanding play a central role.

The general outline of the course is as follows:

a) Investigation of the current perceptions of students:

At the start of the course, students will fill out a questionnaire that captures their current perceptions of STEM teaching.

b) Blended modules in multidisciplinary student teams:

- *Module 1*: Create awareness
  Students will be made aware of the importance of developing problem solving techniques, conceptual thinking, linking different STEM disciplines and context rich learning environments in high school STEM teaching. They also need to recognise that current STEM teaching puts too much focus on content knowledge and as such is perceived as irrelevant by pupils.
- *Module 2*: Confrontation with ‘good’ and ‘bad’ practices in different STEM disciplines
- *Module 3*: Analysis by the students of examples of ‘good’ or ‘bad’ practices, using literature-based metacognitive argumentation
- *Module 4*: Application of these principles in group projects involving multidisciplinary teams
  - Test case: during the course
  - Practice case: during internship teaching
- *Module 5*: Supervision sessions

This blended course approach derives its power from the fact that students will have time away from class to craft an opinion and shape their argumentation based on literature and preliminary discussions in class [11]. As such, we can ensure that class time can be optimally utilised in discussion and reflection on the important topics prepared in advance by the students.

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