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PROJECT BASED TEACHER EDUCATION TO DEVELOP MATERIALS, INSTRUCTION AND CULTURE FOR PHENOMENON-BASED STEAM PROJECTS WITH PUPILS IN SCHOOLS

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Abstract

In Finland, the most radical ongoing school reform is fading out the borders around school subjects to better prepare young people for future challenges. The new National curricular guidelines include phenomenon-based learning (PhBL) at all school levels. In teacher education, we have adopted a project-based approach for accustoming teachers to this change. Communities of learners with diverse areas of expertize are called together to accomplish projects, along with student teachers. The driving questions are directing the development of materials and guidance to realize cross-subject educational projects with pupils in schools. We are applying Ajzen's Theory of Planned Behaviour to examine student teachers' salient beliefs for three primary constructs: attitude, subjective norm, and perceived behavioural control defining their intention to accomplish PhBL. The initial data were collected by a questionnaire from 14 special education student teachers, after participating in a Checkpoint Leonardo: Stealth –project to develop teaching for cross-subject science, technology, engineering, arts and mathematics (STEAM) learning sequence. Three of the students were interviewed after the project. The main findings for improving teacher education are the perceived opposition of pupils' parents towards PhBL and the variance of concerns that student teachers have towards realizing PhBL. These findings are used as the basis of an intervention in the following years' project-based teacher education.

Key words

Student teachers' beliefs, Phenomenon-based learning (PhBL), STEAM education, Project based teacher education

INTRODUCTION

Finnish 15-year-old students performed extremely well in all categories of the last Programme for International Students Assessment (PISA) 2015. Their rankings were 4th, 13th and 5th in reading, mathematics and science, respectively (OECD, 2016). In the collaborative problem solving test, Finnish youngsters were seventh, ranking second in Europe, right after Estonia

(OECD, 2017). However, we face big challenges: boys' average performance lags behind the girls' average more than anywhere in the world; the trend of the rankings is sharply descending, and school satisfaction is low (Currie et al. 2009). The Finnish National board of Education responds to these challenges with the new phenomenon-based National Core Curricula for basic education, grades 1-9 (2014) emphasizing collaborative methods and PhBL. A search in the contents of this 508-page document gives in total 470 hits for the Finnish keywords meaning inter-disciplinary (PhBL) education. Similar searches with words of "community" (of learners) and "learning environment" give 510 and 284 hits respectively. As the interdisciplinary approach to authentic problems and the use of diverse communities of learners in comprehensive learning environments are the cornerstones of project-based education (PBE) as well (Krajcik & Czerniak, 2014), we may presume that the new Finnish curricula ask for project-based methods.

Also the European commission calls for inter-disciplinary approach in education (Hazelkorn et al. 2015). They indicate that too often science education limits only to knowledge of and methods for understanding physical systems, living systems, earth and space systems and technology, referred to by an acronym STEM (science, technology, engineering and mathematics). In addition to that, we should support arts-based initiatives, e.g. film, media, visual arts, etc. to develop resources promoting science learning, positive views of science and a scientific culture. This approach is called the STEAM focus, where A is for arts.

As STEAM is still a new and exotic approach in education, there are not many materials for teaching. In addition, instruction supporting learners' autonomy, collaborative teaching, and learning in PBE, are unfamiliar to many in-service teachers. To overcome these barriers, we have been developing a project based teacher education model for phenomenon-based STEAM education since 2012. The core idea of this model is that (student) teachers collaborate with the community to develop materials, instruction and the culture for STEAM projects with pupils in schools. The next developmental phase of this model is to study student teachers beliefs about STEAM education, to learn if they are going to utilize the model in practice in the future. From this knowledge, we can develop our PBE model to support student teachers to exploit their resistance to benefit their learning (Bronkhorst et al. 2014). Our research question is "*What kind of beliefs student teachers have about PhBL influencing their intentions to implement STEAM PBE in schools?*"

There exists a huge amount of research reports about teachers' and student teachers' beliefs about various issues. However, we could not find any reports on student teachers' beliefs

about PhBL or inter-disciplinary education. Haney et al. (1996) studied teacher beliefs and intentions regarding the implementation of Ohio Competency Based Science Model. They found that attitudes toward implementing the model appear to be critical components to the educational change process. Diakidoy & Kanari (1999) studied student teachers' beliefs about creativity. Their results indicated that student teachers tend to perceive creativity as a general ability primarily manifested in the context of artistic endeavours. They also separate the creative outcomes from the correct answers: creative outcomes were considered novel but not necessarily appropriate or correct. Torff (2015) compared beliefs about learning and teaching in a survey with 214 parents and 196 teachers. He found that parents believe more in curricula and teachers believe more in student-centred way of teaching. The difference should be taken into account in communication between stakeholders. Reeve et al. (2014) investigated the role of three beliefs in predicting K-12 teachers' motivating style toward students. They studied how effective, how normative, and how easy-to-implement autonomy-supportive and controlling teaching motivation styles were believed to be. The average beliefs of this international sample of 815 teachers from 8 countries were that autonomy support was relatively more effective than teacher control, controlling is relatively more normative and easier to implement than was autonomy support.

THEORETICAL BACKGROUND

We are applying Ajzen's theory of planned behaviour (Ajzen, 1985) to find beliefs that influence student teachers' *intention* to engage STEAM PBE. According to this theory, an intention to a behaviour depends on one's attitude, normative beliefs, and control beliefs about that behaviour. These include beliefs about perceived consequences (c_i), others' expectations (f_j) and resources or barriers (p_h) for that behaviour (see fig. 1). How much each of these beliefs affect the intention towards the behaviour, depends on their power in any individual's case. An estimate of whether a perceived consequence is good or bad (g_i) amplifies the attitude component. Similarly, motivation to comply (m_j) with a certain group puts gain on the belief about the expectations of that group. Each resource required by, or barrier against, a behaviour needs to be multiplied by an estimation of one's potential to overcome these (l_h). Multiplying the strength of each salient belief by its estimated individual power we can then determine the direct variables for the attitude (*AB*), subjective norm (*SN*) and perceived behavioural control (*BC*) as averages. The behaviour depends on the intention to the behaviour, which in turn, is dependent on these direct variables. Further, the weight of each of these is still dependent on external variables of demography, general attitudes and personal traits, for example.

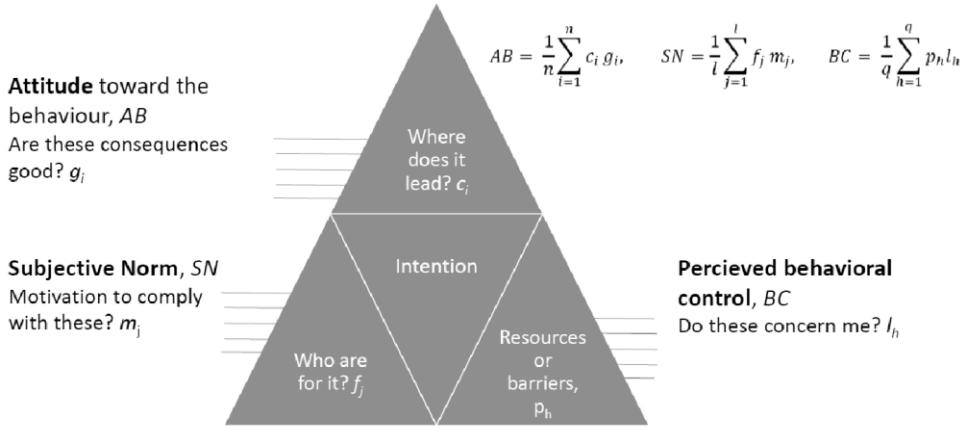

Fig. 1. In the Theory of Planned Behaviour (Ajzen, 1985), beliefs are used to predict an individual's intention to engage in a behaviour using the outlined mathematical model.

We started our study by developing a survey instrument to assess beliefs about PhBL. First, five researchers (including the authors) elicited their ideas about students' attitudes, norms and behavioural control in PhBL. To find the beliefs most salient for students, a group of ten student teachers assessed these ideas by a seven-step agree-disagree scale prior to the project. In addition, they were asked to bring up new ideas by open questions about their beliefs. By the results of this study, we chose n=4, l=7 and q=6 emerging beliefs in attitudes, norms and controls, to construct question pairs to find out the 17 products $c_i g_i$, $f_j m_j$ and $p_h l_h$ to calculate the direct variables *AB*, *SN* and *BC* respectively (fig. 1). After the project, 15 student teachers responded to the 34 questions (17 pairs of questions) with step scales from -3 to +3. Thus, each product is a number between -9 and +9. One student from each of the three project groups was called for a semi-structured interview to revisit their pre-questionnaire answers. Roughly described, one student was in favor of, one against, and one with a neutral attitude towards PhBL.

CONTEXT, TASKS AND LEARNING ENVIRONMENTS DURING THE COURSE

The CPL Stealth extended group included four colleagues at the University of Jyväskylä, a supervisory board with eight members from various fields and the head curator from Jyväskylä City art museum. This study was realized within an applied, PhBL course combining pedagogy of arts (2 ECTS) and science (3 ECTS). The course was taken by 15 student teachers (elementary school / special education, 2nd year students).

The course programme started with a VTS (Visual Thinking Strategies) demonstration that was held at the Art museum, focusing on three young Finnish artists` exhibition (https://www.jyvaskyla.fi/taidemuseo/nayttelyt/hautamaki_havia_somervuori). VTS is the

product of a research-based education nonprofit that believes thoughtful, facilitated discussion of art activates transformational learning accessible to all (Housen 2002). The second meeting had preliminary, classical inquiries about vision. Science included inquiries about light sources vs. reflected light, colours, contrast, resolution and lenses vs. apertures. From the artistic point of view, we promoted for instance ideas about looking and likeness: Two colours look alike, A colour has many looks, Additive and subtractive mixing and mixing shades (Albers, 2013). Next the project groups (A - Invisibility cloak, B - Chameleon and C - Camouflage) started designing and testing teaching materials for 3 x 45 min. lessons for 3-6 graders. Topic was to inquire the phenomenon of (in)visibility. The groups presented their teaching materials to the CPL extended groups and improved upon feedback.

Eventually, groups A and C used their teaching materials at local Puistokoulu -school with 4th and 5th grade pupils and group B hosted a workshop at the Natural history museum of Central Finland. After the teaching experiences were finished, we hosted an evaluation session for the groups at the university.

RESULTS

The student teachers' most salient beliefs addressed in our PhBL questions, and the averages of the assessed effects of these beliefs, are presented in Table 1. The calculated averaged sums in the sample for *AB (Attitude)*, *SN (Subjective norm)* and *BC (Perceived behavioral control)* are 4.1, 3.6 and 3.75 respectively. The beliefs that assign most advantage to PhBL are the perceived positive example set by pedagogy experts and possibility of co-teaching with colleagues. The only belief regressing the intentions to utilize PhBL was the belief that parents of pupils oppose PhBL. The three interviewed students were given pseudonyms describing their attitudes to PhBL. They represent three profiles of innovation adapters; each with important strengths and utilizable value in the teacher community.

Table 1 Averages of the effects of salient beliefs on intention to utilize phenomenon-based learning.

	Average of the strength of salient beliefs multiplied by its estimated power				
Attitude, cg_i	Self-guidance, 2,9	Motivation, 4,3	Theory and practise, 4,6	Creativity, 4,6	
Subjective norm, fm_i	Parents, -1,0	Teachers, 1,9	Pupils, 5,2	Curricula, 5,2	Pedagogy experts, 6,8
Perceived behavioral control, pi_i	School culture, 0,6	Resources, 1,6	Education, 6,0	Co-teaching, 6,8	

The first, Ada Adapter, believed in benefits of PhBL: *"Pupils gain such skills and thinking strategies that they can benefit from in their real life and environment, more than*

studying something minor within a school subject". She also counted on pedagogy experts and curricula: *"Because phenomenon-based learning and integrating different subjects is supported [by these instances], there must be some evidence for its benefits".* Ada considered collaboration between teachers important, wishing for *"a good professional community and atmosphere and time for co-operation and good colleagues who are engaged in (phenomenon-based) practise. Co-teaching or just a collaboration and discussing together".* Her strength is in openness and being an early adoptee, ready to try out different things.

Priscilla Pragmatic longed for concrete resources for teaching: "*There will be no time or resources for that"* and *"Concrete examples and materials are needed, so that one won't need to start to build everything from scratch".* She approached the issue from the school community point of view, saying: *"In practise, everyone but the teachers are rallying for [phenomenon-based learning], but those who need to do the job are not quite in on it yet"* and *"Of course one must listen to the experts and follow the curriculum, but mainly the teacher colleagues who are around…in one's own professional community."* Her strength is in building a strong teacher community and ensuring support: not setting out on a new path alone, unless there are fellow colleagues sharing the journey.

Christine Critical doubted that all learning should be phenomena based. *"In our (pedagogical) studies we have done so much phenomena based projects, that we are already tired with them… There should be a limit for how many can be done at a time."* It was almost as if a confession to make: *"Sometimes it is nice to study, you know, so that you read a topic from a book and do the exercises."* She also considered critically the possibility of PhBL in a class of a new teacher *"If I consider, when I start as a teacher, well– I'll be a new teacher and it will be my first year and it would probably take all my resources more to that I will learn more effectively and manage the group of pupils and it may be so that in the beginning I need to go by a more traditional model, but after gaining some routine for my own action it might clear up and it might be easier for me to see those whole topics."* Her strength is in looking at the personal resources of each actor in the process and recognizing possible difficulties ahead of time; she will plan her way around difficult spots and be able to lower the bar until she or her students are back in full strength.

CONCLUSIONS

We approached our research question from two directions: what are the actors influencing student teachers' opinions and beliefs - and ultimately their intentions - about PhBL, and is

there considerable diversity amongst the intentions within a group of student teachers? The reason for doing this study is in improving our teaching so that it better meets the needs of our student teachers. Here we revisit these results and envision relevant improvements.

From the initial stages of questionnaire making and assessing, we were able to list belief components in categories of attitude (*AB*), subjective norm (*SN*), and perceived behavioral control (*BC*). The use of TPB allowed us to compare the relative strengths of the effects of each category and component. While in the pre- and post-questionnaires we allowed for student teachers to also write open answers, no new components arose from these responses. We consider the listed examples in Table 1. to be a fair representation of actors and salient beliefs influencing student teachers' intentions towards utilizing PhBL.

The whole group had an overall positive attitude towards PhBL. When interviewing student teachers whose answers were off from the averages, we gained a more nuanced picture of their concerns and intentions. We understand now that for some teacher students, the ownership of self-created learning materials does not outweigh the time and effort spent creating them, and they would benefit from knowledge that ready, easily accessible materials are also available for PhBL. For some teacher students, project-based instruction had become a burden; for these students, we wish to convey that project-based learning is one instructional technique amongst many and there certainly is a time and place for it, but it is not for all time.

In the next iterations, we will be able to target some of the overall high-ranking influences to student teachers' intentions towards teaching with PhBL techniques, and give positive examples about them. We will also be pinpointing some of the lower ranking influences, such as the in-service teachers, and especially the parents (who were perceived in the opposition), and designing an intervention where the student teachers have an opportunity to meet with representatives of both groups.

We can also offer targeted support according to student teachers' individual answers in the pre-questionnaire in the future courses, and discuss the different stances towards PhBL within the group, highlighting the strengths and support needed by each profile.

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