JOURNAL OF BALTIC SCIENCE EDUCATION

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

PRE-SERVICE TEACHERS´ BELIEFS ABOUT THE BENEFITS AND CHALLENGES OF STSE BASED SCHOOL-INDUSTRY COLLABORATION AND PRACTICES IN SCIENCE EDUCATION

Päivi Kousa,
Maija Aksela,
Vesna Ferk Savec

Abstract. *School-industry collaboration can be an effective way to implement STSE issues to teaching. However, teachers´ negative beliefs, lack of knowledge, resources, support and opportunities to collaborate with companies can impede the efficient implementation. In this case-study, 42 Finnish and Slovenian pre-service teachers´ STSE beliefs were first examined before and after the school-industry collaboration course by survey. After the course, beliefs of 8 Finnish pre-service teachers were analyzed in more detail by open-ended questionnaires and reflective writing. The pre-service teachers were more confident to teach STSE issues after the course in both countries. However, they needed more support and knowledge from the community members they collaborated with (i.e. representatives of industries, university teacher, student colleagues and school teachers). The industry-based teaching material was considered beneficiary especially for mixed-ability classrooms and the whole course was regarded useful for future practices. The results of this research highlight the importance of pre-service teacher education and practices with STSE issues. The positive and negative beliefs should be examined frequently already during the pre-service education in order to develop tools for teacher support and encouragement. This research promotes a practical example and ideas of a local school-company collaboration.*

Keywords: *school-industry collaboration, sience teacher education, STSE issues, teachers´ beliefs.*

Päivi Kousa, Maija Aksela
University of Helsinki, Finland
Vesna Ferk Savec
University of Ljubljana, Slovenia

Introduction

Science, technology, society and environment (STSE) issues have well known benefits and the issues are therefore widely used and part of curricula in many countries. However, implementing STSE issues can be both challenging and unefficient. One of the challenges might be that there is a vast amount of vague options for the teachers that either may or may not fulfill the needs of the large variety of students. Considerable effort has been made to support pre- and in-service teachers to assimilate and implement STSE issues to teaching (e.g. Lawrence, Yager, Sowell, Hancock, Yalaki, & Jablon, 2001). Despite of this, the teacher education programs throughout the world have not adequately succeeded (Chowdhury, 2016). More knowledge and support about how to plan and implement teaching with STSE approach is needed (Pedretti, Bencze, Hewitt, Romkey, & Jivraj 2008).

Teachers´ own beliefs often obstruct the efficient implementation of STSE issues (Hofstein, Eilks, & Bybee, 2011). Consequently, there is an incongruity between teachers´ beliefs that are often immutable and the world that is constantly changing (Marbach-Ad & McGinnis, 2008). Although the teachers´ beliefs and the confidence to teach STSE issues are mainly positive (e.g. Pedretti et al., 2008), there is still an abundant list of challenges that teachers face in their work. Therefore, it is important to find out more about teachers´ beliefs during their pre-service phase in order, to support them in their practices (Lumpe, Haney, & Czerniak 1998) and ensure the equity of teaching also in mixed-ability classrooms (Bryan & Atwater, 2002). The teachers´ beliefs and values should comport with the goals of STSE education (Rubba, 1991). It can be summarized as a goal to "teaching citizens, not only students" (Halwany, Zouda, Pouliot, & Bencze, 2017, p. 423).

This case-study promoted an example of a novel, STSE based school-industry collaboration course which was held in two countries at the same time. The aim of this research was to find tools to support and encourage

pre-service teachers to have better outcomes and success with local school-industry collaboration and field trips in their future practices. The research questions were:

1. Does the school-industry collaboration of a teacher education course in two countries promote pre-service teachers´ beliefs about teaching STSE issues?
2. What are the pre-service teachers´ beliefs about the benefits and challenges of STSE based school-industry collaboration and practices?

Theoretical Background

STSE Based Issues in Education

The specific definition of science, technology and society (STS) education is challenging to provide. One of the challenges in defining STS education is its´ purpose to assist students to understand and deal with the issues that are present and constantly changing in the world (Pedretti & Hodson, 1995). Because of the environmental consequences that STS issues have, the form STSE education has been used in this research. STSE education can be related to an umbrella with different theories and ideas about the relations between science, technology, society and environment (Chowdhury, 2016). Cultural, societal, ethical, political, economic and ecologic concerns are also connected to STSE issues (Hodson, 2003).

The benefits of Science, Technology, Society and Environment education are indisputable (e.g. Amirshokoohi, 2016; Yager, 2007). For example, STSE-themed teaching improves both teachers´ and students´ positive attitudes toward science, even in mixed-ability classrooms (Caseau & Norman, 1997). Furthermore, STSE issues can be used as instruments to inspire students from different backgrounds and achievement levels to better understand, adopt and apply scientific content knowledge (Pedretti & Nazir, 2011). Teaching with STSE issues also improves students´ classroom behavior, co-operating skills, critical and problem-based thinking and achievement in science Caseau & Norman, 1997) Furthermore, using STSE-based issues is an effective way to enhance students´ personal and societal interests (Hodson, 2003). Students can find, for example, medical, health, environment, energy, material science and industry-based issues personally meaningful (Chowdhury, 2014). Those issues can help students to learn from everyday life examples and become responsible and cabable citizens (Chowdhury, 2013). On the other hand, science teachers do not tend to integrate the understanding that all their students are future citizens who make decisions and can produce more knowledge. They may think that there are only a few interested students who might be future scientists (Halwany et al., 2017) although science should be equally available for all students (Aikenhead, 2006).

Industry-based Field Trips

Field trips that are based on school-industry collaboration can be successful ways to implement STSE issues to teaching (Brunton & Coll, 2005). Although the scientific field trips are considered as complex and resource-taking activities and the teachers do not prefer them as much as they do traditional methods, the benefits of the field trips are indisputable (Orion & Hofstein, 1994). For example, field trips have a positive impact on students´ achievement (Whitesell, 2016) and attitudes (Jarvis & Pell, 2005) which enhance learning about scientific issues (Eshach, 2007). Despite the fact that industrial field trips have technological characters, both girls and boys find them equally fascinating (Hofstein & Kesner, 2014). In addition, field trips are considered effective and attractive also by teachers and parents (Dori & Tal, 1998).

The collaboration within community using issues from everyday life enhances the value of field trips (Dori & Tal, 1998) and benefits the whole community around school (Brunton & Coll, 2005). Usually, both pre- and in-service teachers participate in field-trips with a passive role as a visitor (Tal & Morag, 2009). However, teachers have an important role in building the students´ awareness of the contents and characteristics of the different parts of community and the STSE issues that are included in their everyday lives (Lawrence et al., 2001). Field trips can be carried out to the different parts of the community: to industries, scientific centers, museums, botanical gardens etc. (Eshach, 2007). There are many studies about using field trips in education (DeWitt & Storksdieck, 2008), but they are mostly about science centers and museums (Eshach, 2007). There are fewer studies about industry-based field trips (Brunton & Coll, 2005) and fewer still about the collaboration between schools and nearby companies within a community. In this research the focus was on the collaboration between pre-service teachers, schools and

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

local companies or institutes that are near schools. The terms school-industry collaboration and industry-based issues were used.

Teachers´ Beliefs about STSE Issues

Pre- and in-service teachers´ beliefs about STSE issues, in general, have been observed as ambivalent in some studies, although the beliefs and the confidence to teach those issues have been mainly positive (Bettencourt, Velho, & Almeida, 2011; Halwany et al., 2017; Mansour, 2010; Pedretti et al. 2008). What teachers know and believe influence their practices in the classroom (e.g. Nespor, 1987; Pajares, 1992; Van Driel, Verloop, & de Vos, 1998). The teachers´ positive attitudes are related to positive outcomes and success of practices like field trips (Jarvis & Pell, 2005). On the other hand, the teachers who are less successful in teaching outside school have more traditional beliefs about learning, and the experiments are considered more like novel or fun (Glackin, 2016). Despite the positive attitudes in general, teachers find that they would need outside support in order to bring STSE issues into practice (Lumpe et. al., 1998). In this research, teachers´ knowledge, views, principles and opinions about teaching and learning are encompassed in a concept of beliefs (Milner, Sondergeld, Demir, Johnson, & Czerniak, 2011). There are also attitudes, confidence, motivation, self-concept and self-esteem that belong to a manifold group of beliefs as well (Pajares, 1992).

It is noticeable that teachers´ beliefs rarely change during the years of their career (Marbach-Ad & McGinnis, 2008). Therefore, pre-service teachers´ beliefs should be examined before STSE issues are implemented in practice (Lawrence et al., 2001). It is important to collect, identify and analyze the teachers´ beliefs in order, to have an influence on their actions. Accordingly, the positive beliefs about the benefits of STSE teaching should be emphasized and fostered. Additional support, training and resources are needed for those occasions where the beliefs are negative (Lumpe et al., 1998). More knowledge about the issues that cause negative beliefs is also needed (DeWitt & Storksdieck, 2008). After the beliefs are construed, pre-service teachers should also practice the STSE approach in order to develop professionally and prepare themselves to teach those issues (Lawrence et al., 2001).

STSE issues are believed to have various benefits to teaching. Pedretti et al. (2008) found that pre-service teachers were more confident in teaching STSE-based issues after the teacher education course, although they were less likely to do so in the future. Some pre-service teachers were more confident and willing to teach STSE issues after the teacher education course and their levels of knowledge and interest were increased (Amirshokoohi, 2016). Generally, STSE issues increase motivation and interest toward science subjects. New experiences and examples from everyday life are considered beneficiary especially when they can be adapted to curriculum. (Lumpe et al., 1998; Kisiel, 2005; Bettencourt et al., 2011) STSE issues help students to learn science concepts and become more responsible and capable citizens (Lumpe et al., 1998). They are also useful for students with different achievement levels (Bettencourt et al., 2011). Altogether, STSE issues are seen as versatile, rewarding and enjoyable by the teachers (Kisiel, 2005). Furthermore, teachers believe that school-industry collaboration benefits the whole community and enhance understanding between its´ members. Most of all, students can receive and implement new knowledge from the industry and industry can upgrade its public appearance and meet the possible working candidates for the future (Brunton & Coll, 2005).

There is an abundant list about the challenges that complicate pre- and in-service teachers work concerning STSE issues. STSE issues take lots of time and effort to plan and implement (Bettencourt et al., 2011; Halwany et al., 2017; Lumpe et al., 1998; Pedretti, 2008). The new, non-traditional way to teach has been found more challenging (Bettencourt et al., 2011; Lumpe et al., 1998; Pedretti et al., 2008). Some teachers have valued traditional methods even more after the STSE course (Halwany et al., 2017). Furthermore, the students´ eagerness to participate in STSE based courses has been questioned in some studies (Bettencourt et al., 2011; Halwany et al., 2017). It can be also questionable, how the parents approve the STSE methods (Pedretti et al., 2008). The STSE issues have also been considered controversial (Lumpe et al., 1998). Additionally, pre-service teachers need more support both with classroom management and content knowledge (Pedretti et al., 2008). Furthermore, teachers can have challenges for example with funding, time-management, logistical issues and safety regulations. The communication with the industry representatives can be complicated as well. (Hofstein & Kesner, 2006) The greatest challenge is to comprise a long-term collaboration and commitment between the school and the industry (Brunton & Coll, 2005).

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Methodology of Research

This was a case-study with mixed methods approach (Cohen, Manion, & Morrison, 2007). The case-study was chosen in order to examine pre-service teachers´ beliefs and school-industry collaboration in an authentic environment, within a community in two countries where the course was held at the same time. The aim was to examine and describe real-life situations (i.e. industry-based local field trips) and explain the idea of planning and implementing school-industry collaboration more distinctly. The case-study is suitable for monitoring strengths and weaknesses (Cohen et al., 2007), like the benefits and challenges of school industry collaboration and practices in this research. Furthermore, the case-study provides a better opportunity to examine the process as whole, not just as separated facts (Denscombe, 2010). The pre-service teachers´ beliefs was the main foci of this research which had two parts. The first part of the research took place in Finland and Slovenia and the second part in Finland. The Slovenian school-company collaboration course with STSE approach was implemented from the Finnish course and the courses were synchronized. The research process lasted three months from March to May, 2017. The aims were to combine and examine beliefs of teacher students in two countries in order to have cross-cultural validity about the effects of STSE approach in teacher education.

The First Part of the Research

The studied case was about the *topic of the* course "*Science and Mathematics in Society*" which was first organized in spring, 2015 by the Unit of Teacher Education at the University of Helsinki (Aksela, 2010). The topic of the course was unified and implemented in the Finnish and Slovenian teacher training programs by the teacher educators (the authors of the article) in Spring 2017.

Practically, the course "*Science and Mathematics in Society*" (5 ECTS) was implemented for the fourth time in Finland by the University of Helsinki, Unit of Chemistry Teacher Education, Department of Chemistry, Faculty of Science (Study program: Voluntary working life studies). Concurrently, in Slovenia, the topic of the course was integrated as a part of "*Project-based L*earning" (9 ECTS) at the University of Ljubljana, Faculty of Education (Study program: Two-subject teacher) and as well as a part of "*Methodology of Teaching Chemistry for Secondary Schools II*" (5 ECTS) at the University of Ljubljana, Faculty of Chemistry and Chemical Technology (Study program: Chemical Education).

In Finland, eight voluntary pre-service science teachers participated in the first part of research. They formed three groups which collaborated with one local school and company. The companies were selected by their interests. Furthermore, the school and company situated near to each other. The following, local companies participated in the collaboration: a communal wastewater treatment plant, a supplier organization of lab equipment, chemicals and services and a chemical industry group with three segments (paper, oil and minerals). In addition, there were two participating classes from two different upper secondary schools (Grade 9) and one class from the local gymnasium. In Slovenia, thirty-four, voluntary pre-service chemistry teachers contributed to the first part of the research. They formed ten groups (six groups from the two-subject teacher programs and three groups from the chemistry teacher program). The following companies were selected by their sustainability orientation: a communal wastewater treatment plant, three companies that are producing beverages of local fruits, two food manufacturers, one producer of organic fertilizers, a local institute of agriculture, one company that is producing cosmetics and an ecological dry cleaning company. The pre-service teachers selected the suitable company by their interests. There were 24 collaborative upper secondary schools (Grades 8 and 9) and 6 gymnasiums.

The Second Part of the Research

In order, to achieve a deeper understanding of the pre-service teachers´ beliefs about the benefits and challenges of STSE based school-industry collaboration and practices, the second part of the research was implemented in Finland. The mixed-method approach was used in order, to have more reliable comprehensive and thorough results (Cohen et al., 2007; Denscombe, 2010). The instruments included:

A survey by Pedretti et al. (2008) which included pre- and post-questionnaire with interval 5-point Likert scales. The questionnaire about Finnish and Slovenian pre-service teachers´ beliefs had 10 claims about STSE issues (see Table 1). The values of the Likert scales were: 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree and 1 = strongly disagree. The paired samples t-test was calculated with IBM SPSS Statistics 25.0 by in order to compare the results of pre- and post- measurements.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Open-ended questionnaires included four questions about the benefits and challenges of school company collaboration and practices after the course (see Appendix A). The questions had four categories: industry, school, group members/university teacher and teaching material. The categories used in this research are based on the university course in Helsinki and previous studies based on school-industry collaboration (e.g. Hofstein & Kesner, 2006). The reflective writing performed by two groups of pre-service teachers (see Appendix B) was analyzed through content analysis by open-coding technique by two reseachers in order to construct categories (Cohen et al., 2007). The aim was to discover the benefits that pre-service teachers found from the course for their future practices.

The research had some weaknesses in its´ validity and reliability. The small sample size may influence the validity of the data. However, it has been enhanced by having cross-cultural validity by choosing two groups of pre-service teachers from different countries. The Slovenian course was developed from the Finnish course, which had been run three times before: in Spring 2014, 2015 and 2016. The longitude of the research was considered appropriate. The length between pre- and post-tests were three months. Furthermore, for the reliability, the results of the case-study can be difficult to generalize and reproduce, because of the uniqueness of the participants and authentic situations which field trips have. However, this case-study can provide ideas for reminiscent cases. The reproducibility was calculated by using an external interrater after the multiple coding. Cohen´s kappa was calculated in order to indicate the reliable coding. The result of kappa value 0.828 indicated strong agreement (e.g. McHugh, 2012).

The project has been carried out by the Unit of Chemistry Teacher Education in Helsinki and the Faculty of Education in Ljubljana. The research was approved and performed in compliance with regulations and guidelines. Informed consent was obtained from all the participants. The participation was voluntary. The material of this research has been back translated by an independent translator.

The Context of the Research: The Topic of the Course "Science and Mathematics in Society"

The developed school-industry collaboration course was based on a previous research and the new core curriculum. In the course, pre-service teachers practiced collaboration with the industry members and local school and made teaching material. The focus was in the local companies and institutes. The school-industry collaboration term is used in this research.

The course included three parts. The first part is theoretical and the aim is to improve teachers´ skills and confidence to teach STSE issues (Hofstein et al., 2011). The industry-based STSE issues were taught by using different elements by Hodson (2003): (i) getting familiar with the issue and learning about its´ scientific and technological contents, (ii) creating connections and understanding about the complexity of different processes concerning science, technology, society and environment, (iii) becoming more self-confident and having expertise to solve problems in everyday life and (iv) taking responsible and suitable actions as a member of society.

The second part was an industry visit that pre-service teachers organized for themselves. The aim was to practice, how to find a suitable industry partner for collaboration. During the first visit, pre-service students met the representatives of industry and made a preliminary plan for the collaboration. Afterwards, the pre-service teachers looked for a class from the local school.

The learning material was developed in collaboration with the pre-service teachers, industry members and a local schoolteacher (Hofstein & Kesner, 2006). The structured material for the school was developed in order to improve students´ subject matter knowledge, knowledge about industry-based issues, attitudes and ability to connect their knowledge to everyday life (Orion & Hofstein, 1994). The learning material for the teachers was adapted from Hofstein and Kesner´s (2006) model and it consisted of a) the pre-visit part; b) the actual visit part; c) the post-visit part. The pre-visit part included tasks in order, to find out more about the industry-based issues and how they connect with the interdisciplinary school subjects (i.e. chemistry, mathematics, physics and/or biology). The actual visit part involved some activities at the company and the post-visit part included interdisciplinary tasks and the summary about the visit.

The third part was the actual school visit to the industry with guidance of pre-service teachers. The class from the local school had done the pre-visit part before in order, to be more prepared to the industry based issues and how they are connected to the certain school subjects. During the visit, the students had more knowledge about the industry and its´ products and professions. After the visit, the post-visit part was made at school. The purpose of the school-industry collaboration was that teachers and students could feel connected to the community (Lawrence et al., 2001).

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Results of Research

Pre-service Teachers´ STSE Beliefs Before and After the Teacher Education Course

The Finnish and Slovenian pre-service teachers´ beliefs were examined before and after the school-industry collaboration course. The results of statistical analysis are represented in Table 1. There was a significant difference between the answers of pre- and post-questionnaires concerning claims one, six and eight ($p < .05$). The pre-service teachers´ confidence to teach STSE issues raised significantly from neutral to stronger agreement after school-industry collaboration course (Claim 1). They already agreed about the interdisciplinary requirements of STSE education before the course, and the agreement level was even higher after the course (Claim 6). Furthermore, the pre-service teachers´ beliefs about their readiness to teach STSE issues were almost neutral before the course and significantly better after the course (Claim 8). Although, the other changes in beliefs were not significant, they are worth noticing. The pre-service teachers´ likeliness to teach STSE issues afterwards was quite neutral and did not change much during the course (Claim 4). Nevertheless, there was a higher agreement about the worthiness and importance of STSE education after the course (Claims 9 and 10) and the pre-service teachers were less concerned about the possible lack of resources, too (Claim 5). They also felt more certain about the importance of combining scientific issues to values in education after the course (Claim 2).

Table 1. The difference between pre-service teachers´ STSE beliefs before and after the course.

Claim	Pre-test M	Pre-test S2	Post-test M	Post-test S2	t	t-test p
1. I feel confident in my ability to teach STSE education	3.167	0.630	4.167	0.532	-7.336	.0001
2. Science and values education should not be coupled	2.000	0.878	1.786	0.904	1.546	.065
3. Decision-making skills are an important part of a science curriculum	4.214	0.368	4.333	0.423	-1.000	.162
4. I am unlikely teach STSE in my early years of teaching because of the planning and time demands	3.238	1.064	3.262	1.320	-0.138	.445
5. I am worried about the lack of resources available	2.857	1.150	2.595	1.222	1.567	.062
6. STSE requires an interdisciplinary approach	4.024	0.609	4.238	0.479	-2.036	.024
7. Promoting "action" (i.e. personal, local) should not be the business of public school science educators	2.643	1.016	2.595	1.222	0.255	.400
8. I feel adequately prepared to tackle STSE education	2.929	0.653	3.690	1.048	-5.155	.0001
9. STSE education is not as important as the rest of the science curriculum	2.405	0.832	2.261	0.686	1.602	.147
10. STSE teaching is not worth the effort and time	1.762	0.527	1.643	0.528	1.044	.151

Notes. Significant at the $p < .05$ level. M=mean, S^2=variance, N=42, df=41.

The Beliefs about the Benefits and Challenges of STSE Based School-Industry Collaboration and Practices

The results of open-ended post questionnaires (see Appendix A) were analyzed by content analysis to find out about the pre-service teachers´ beliefs about the benefits and challenges of school-industry collaboration and practices. Four categories were examined: industry, school, group and the teaching material. Additionally, the reflective writing of two pre-service teacher groups about the benefits for their future practices were construed with content analysis and can be found in Appendix B.

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Collaboration with Industry

Pre-service teachers found many benefits from the industry-based collaboration. Most of the representatives of industry were supportive and had positive attitudes. The information about the industry as well as extra ideas and opinions about the teaching material and visit were given willingly. As one of the pre-service students mentioned: "I got a comprehensive picture already during the first visit, what the company was expecting from us and our teaching material." However, there were some challenges. At first, the collaboration was considered uneasy. Secondly, the profound information about the industry, products and vocations was difficult to find in order, to connect it to the science subjects, everyday life and future careers. Finally, there were some confusions about the needs of the visiting students. For example, the students did not get enough lab suitable activities although they were requested. As one of the pre-service teachers stated: "I was hoping that the company would better understand what the students wanted and what kind of tasks would have been more appropriate for their age."

Collaboration with the School

Almost all pre-service teachers felt that the school teachers had positive attitudes in general. The pre-service teachers were especially pleased to notice that the school students showed real interest during the actual visit. "It was good to have positive feedback although it came from the students, not from the school teachers." On the other hand, the collaboration with school teachers had more challenges than benefits. Firstly, the school teachers had almost no opinions or ideas for the visit or teaching material and they had a passive role both in collaboration and during the visit. One respondent stated: "The teacher did not take any active role with this. He did not have any suggestions or ideas. Although we had total freedom to plan the visit and the teaching material, it would have been nice to know what the school students wanted."

Collaboration within the Group

The university teacher who worked with a group as a guide was considered supportive and inspiring. Moreover, the collaboration within the group was felt mainly positive. Almost all group members were active and invested their ideas successfully according to their professional skills, like for example in physics, mathematics, biology or chemistry in order to have interdisciplinary material. There were also remarks about the dissonance. Lack of time and passivity of some group members as well as disagreement about the contents were considered challenging. "All in all, we finished the teaching material successfully after discussing that we are different people with different opinions and there is not just one, right way to do things."

The Teaching Material

The pre-service teachers believed that the industry-based teaching materials had many benefits. Among other things, they were called as "versatile and multi-purpose." The comprehensive materials were stated beneficiary because they provided ideas from everyday life and included different teaching methods. Moreover, the connectivity to curriculum was mentioned essential. Furthermore, there was a consensus that the interdisciplinarity, openness and multi-purposedness of materials would be remarkably beneficial to the students with different achievement levels. Presumably, the material would increase interest to science subjects and mathematics. One comment from the survey suggests: "The industry-based visit helps school children to realize that the subject knowledge at school is also needed in the working life." On the other side, the openness of some materials was also remarked challenging because some of the tasks did not include a singular correct answer. Some of the pre-service teachers were skeptical about the willingness of the school teachers to change the traditional materials to the STSE based, multi-purpose materials. There were also some suggestions that the teaching materials focused too much on industry and too little to the science subjects and curriculum.

The Benefits for Future Practices

Both two groups found the STSE based school-industry collaboration course beneficial for their future practices: "The course gave the opportunity to practice skills that are needed in teacher´s profession. It was especially

important to learn how to take responsibility and work spontaneously and in schedule." Both groups also felt more confident and ready to plan and implement school-industry collaboration and contact the industry members. Smaller, local companies were especially preferred because they were so "active and flattered" about the collaboration. Teamwork and an opportunity to practice was also considered important. Moreover, the sufficient quality requirements of an interdisciplinary material are fundamental at all stages of the visit. "The material should not be just an information package for two hours." Most of all, the pre-service teachers hoped that they can provide interesting and encouraging ideas for the students as well as vocational knowledge. The course can be culminated to a sentence from one group: "The implementation of the industry-based visit is not so hard after all, if you plan it carefully enough."

Discussion

Science, Technology, Society and Environment (STSE) education has many benefits (e.g. Amirshokoohi, 2016; Yager, 2007), yet the successful implementation is often obstructed by teachers´ own beliefs (Hofstein et al., 2011). Even though the general beliefs and confidence to teach STSE are positive (Pedretti et al., 2008), there are also challenges that affect teachers´ practices at school (Lumpe et al., 1998). It is worth noticing that teachers´ beliefs barely change over the course of their career (Marbach-Ad & McGinnis, 2008). Therefore, it is critical that the beliefs are investigated already during the teacher education (Lumpe et al., 1998). It is worth considering that bringing STSE issues into practice is not a straightforward process. It needs time, effort and proper planning as well as collaboration (Lawrence et al., 2001). It also differs from the traditional methods (Yager, 2007). Therefore, the opportunities to practice those issues especially during the pre-service education are fundamental (Lumpe et al. 1998). In this case-study, mixed methods were used to examine what Finnish and Slovenian pre-service teachers´ STSE beliefs were and what kind of benefits and challenges Finnish teacher students identified from the school-industry collaboration and practices. The field trips were chosen because they have many advantages (e.g. Orion & Hofstein, 1994), they are the most preferable teaching methods (Kousa et al., 2018), there are fewer studies about industry-based field trips (Brunton & Coll, 2005) and hardly any studies about field trips and local industry-based collaboration. The main purpose of this research was to find tools to support and encourage pre-service teachers to have better outcomes and success with local school-industry collaboration and field trips in their future practices.

The Pre-service Teachers´ STSE Beliefs

The Finnish and Slovenian pre-service teachers´ confidence and readiness to teach STSE issues were significantly higher after a school-industry collaboration course. The previous multi-media based case studies have raised pre-service students´ confidence to teach STSE issues similarly (Pedretti et al., 2008). The increased levels of pre-service teachers´ knowledge and interest can be a reason for higher confidence after the course (Amirshokoohi, 2016) because STSE issues generally increase motivation and interest (e.g. Bettencourt et al., 2011). On the other hand, Pedretti et al. (2008) have discovered that pre-service teachers are less likely to teach STSE issues after a multi-media course focused on these sujects. In the present research, the likeliness to teach STSE based courses afterwards was more neutral and the results did not differ significantly. The variation of teachers´ confidence beliefs is in line with previous studies, some of which are ambivalent but mainly positive (e.g. Halwany et al., 2017). Therefore, it is challenging to generalize what kind of courses could enhance pre-service teachers´ confidence and readiness. However, it can be assumed that the interdisciplinary school-industry collaboration course with local companies and schools can significantly raise pre-service teachers´ confidence and readiness to teach STSE issues as indicated in Finland and in Slovenia.

The Issues that Benefit STSE Based School-Industry Collaboration and Practice

Field trips are found effective and attractive by teachers and parents (Dori & Tal, 1998). Moreover, teachers believe that the collaboration benefits the whole community because it enhances the understanding about its´ different members and activities (Brunton & Coll., 2005). In this research, the activity and supportiveness of industry representatives were considered very beneficial. The benefits about school-industry collaboration are twofold: the students can have new information about industry-based STSE issues, and vocational knowledge and the collaboration can influence positively to the industry´s publicity. The collaboration can also conduct the industry to its´

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

future professionals (Brunton & Coll, 2005). The interest of the school students as well as their positive feedback during the visit is an essential part of the school-industry collaboration as this research points out. The students´ positive attitudes for field trips are substantiated before (e.g. Jarvis & Pell, 2005) as well as their preference towards them (Kousa et al., 2018). According to this research, the industry-based field trip can be more successful and beneficiary if the information from the industry is profound and supportive in nature, if the connection between industry-based issues, everyday life examples and school subjects can be developed. It is also necessary to ask students´ feedback about the visit.

The guidance of the university teacher and support from the other group members with different professional skills (i.e. biology, chemistry, mathematics and physics) was assessed beneficial to the pre-service teachers while planning and implementing the teaching material. Firstly, the teaching materials had many benefits according to all pre-service teachers, such as its versatility and multi-purposedness. As proven, STSE issues are felt versatile, rewarding and enjoyable (Kisiel, 2005). Secondly, the interdisciplinarity, openness and suitability for different achievement levels was most beneficial about the materials. Provably, the STSE based materials can benefit students with different levels of achievement (Bettencourt et al., 2011). It is crucial to take into consideration, that there is a shortage of suitable teaching materials and methods (Markic and Abels, 2014) and the fact that low-achieving students would benefit from school-industry collaboration and visits. Field trips like company visits can improve students´ attitudes towards science and thus, their achievement. (Kousa et al., 2018) Thirdly, pre-service teachers believed that the topics and contents of materials were interesting and would enhance students´ knowledge that is needed in everyday life. STSE issues can help students to learn science concepts and become more responsible and capable citizens (Lumpe et al., 1998). Finally, like in the previous studies (e.g. Bettencourt et al., 2011), the connectivity to curriculum was mentioned important and beneficial. Although the connectivity between field trips and curriculum is highly valued, teachers´ have different perceptions about its´ meaning (Kisiel, 2005). This research suggests that the industry-based STSE teaching material benefits from interdisciplinarity, openness and connections with everyday life as well as curriculum. Moreover, versatility and multi-purposedness of teaching material as described in this research, is also suitable for different achievement levels and can be used in mixed-ability classrooms.

The Challenges of STSE Based School-Industry Collaboration and Practice

There were some notable challenges with the school-industry collaboration. At the beginning, the collaboration with industry was identified as uneasy. The communication with industry has been remarked as complicated before (Hofstein & Kesner, 2006). The other challenges were mostly about the lack of profound information from the industry. To begin with, the information was difficult to find. Accordingly, the information was mostly about the industry and not about the issues that were considered important by the pre-service teachers: connection to the subject knowledge, everyday life and different careers. The pre-service teachers felt that the industry representatives did not understand what kind of activities and knowledge the visiting students would need. Furthermore, the collaboration with school teachers had more challenges than benefits. Most of all, the participating teachers were passive before and during the visit and gave no significant support or ideas to the pre-service teachers. The passive role of pre-and in-service teachers during field trips is identified previously as well (Tal & Morag, 2009). This research suggests that the teachers need to have proper information about the industry and its´ connections to subject knowledge and vocations in order to plan and implement a successful STSE based field trip. The needs of students should be explicitly specified to the company representatives. Yet the teachers should not forget their important role with developing students´ awareness of STSE issues (Lawrence et al., 2001). The teacher should have a more active role already from the beginning in order to succeed in the collaboration. The greatest challenge is, to form a longer-term collaboration and commitment between the school and the industry (Brunton & Coll, 2005).

The pre-service teachers faced some challenges while planning and implementing the teaching material. The lack of time, passivity of some group members and disagreement about the contents were regarded most challenging. It is well known that STSE issues take time and effort to implement (e.g. Halwany et al., 2017). With field trips, the issues with funding, time-management, logistics and safety regulations can be also demanding for the teachers (Hofstein & Kesner, 2006). In this research, the multi-purposedness and interdisciplinarity of the material were also considered to be too far from the traditional materials and curriculum. The non-traditional way of teaching STSE issues has discovered challenging before (e.g. Bettencourt et al., 2011). Like in this research, there have been also previous doubts that neither the students (Halwany et al., 2017), nor their parents (Pedretti et al., 2008) accept the

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

new materials. Eventually, the pre-service teachers found that the materials included too much information about the industry itself and not so much about the subject knowledge and examples from everyday life. Although the suggestion for more practice with STSE issues is not new (e.g. Hofstein & Kesner, 2006), this research proposes that it might be even impossible to accomplish successful school-industry collaboration with proper teaching material if the teacher students get only one opportunity to practice it during the teacher education. The repetitive practices would be more effective and lead to a fruitful, longer lasting collaboration (Brunton & Coll, 2005). By regularly visiting local, smaller companies saves not only time and money, but familiarize the community members to each other and most of all, combines the industry-based issues better to school subjects and everyday life.

The Benefits for the Future Practices

Both two groups found the STSE-based school industry collaboration course very beneficial for their future practices. They also felt more self-confident and ready to contact industries as well as plan and implement and take responsibility to organize the collaboration, preferably with the local companies. Teachers´ preference to collaborate with local industries has been previously observed. The desirable ways of collaboration from the teachers´ point of view could include sponsorships, visits, industry-made materials and future careers for students. (Brunton & Coll, 2005) In order, to be efficient, field trips should have educational quality. Issues like the structure of the field trip, methods and materials as well as the possibility to connect learning to the environment gives the field trip its´ quality (Orion & Hofstein, 1994). In this research, the sufficient quality of the teaching material was considered critical. The pre-service teachers hoped that they could provide information that interests students and encourages them to learn, be active and apply their knowledge to the everyday life as well as get knowledge about different vocations. Moreover, pre-service teachers believed that the industry-based practices would be more efficient with the outside support and teamwork also in the future.

Conclusions and Future Research

Teacher educators around the world need tools to support and encourage pre-service teachers in order to have better outcomes and success in their future practices. The pre-service teachers´ confidence to teach STSE issues can be raised by promoting authentic examples from students´ everyday life and community. This research indicates that interdisciplinary school-industry collaboration and visits can enhance pre-service teachers´ confidence and readiness to teach STSE issues. The potential of local industries and companies can be utilized in order, to save resources and familiarize the community members to each other.

Teachers´ beliefs which affect their practices are considered immutable. In order to succeed in future practices, pre-service teachers´ positive and negative beliefs should be examined carefully and regularly both before and after the activities with STSE approach. That could be done by small surveys or interviews in order to accomplish deeper perceptions about the beliefs and find the suitable tools for proper support and encouragement. There are challenges in school-industry collaboration as this research points out. Therefore, teachers´ beliefs about the challenges as well as the benefits should be examined already in the beginning of pre-service teacher education.

It is necessary to have courses with STSE approach more than once during teacher education. To accomplish better skills and knowledge, the pre- and in-service teachers should have regular opportunities to participate in local school-industry collaboration by planning and implementing field trips with a support from other members of community. That could be arranged during teacher education or providing further education for in-service teachers. In order to have a successful and beneficiary collaboration, the support and profound information from the community members (i.e. industry, university teacher, student colleagues and school teacher) should be equally shared and discussed.

According to this research, the versatile, interdisciplinary and curriculum-based teaching material which connects industry-based issues to scientific knowledge and everyday life would interest and benefit also students with different achievement levels. Although this research has proposed some ideas for pre-service teacher education, some issues acquire further investigation. Firstly, more knowledge is needed how to support teachers to implement school-company collaboration into teaching in mixed-ability classrooms. Secondly, the effects of more frequent school-company collaboration should be examined. Thirdly, it would be necessary to explore other STSE issues and their effects to pre-service teachers´ beliefs in order to find out about their similarities and differences. Finally, teachers´ beliefs should be explored and compared both locally and globally. That could be done by col-

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

laborating and sharing knowledge and expertise also between schools and companies in different countries. The cross-cultural collaboration could help teacher educators to develop more efficient tools to support and encourage future teachers to meet the needs of diverse students.

References

Aikenhead, G. (2006). *Science education for everyday life: Evidence-based practice* (pp.21-55). New York, NY, Teachers College Press.
Aksela, M. (2010). Evidence-based teacher education: Becoming a lifelong research-oriented chemistry teacher? *Chemistry Education Research and Practice*, *11* (2), 84-91.
Amirshokoohi, A. (2016). Impact of STS issue oriented instruction on pre-service elementary teachers´ views and perceptions of science, technology and society. *International Journal of Environmental & Science Education*, *11* (4), 359-387.
Bettencourt, C., Velho, J., & Almeida, P. (2011). Biology teachers´ perceptions about science technology-society (STS) education. *Procedia Social and Behavioral Sciences*, *15*, 3148-3152.
Brunton, M., & Coll, R. (2005). Enhancing technology education by forming links with industry: A New Zealand case study. *International Journal of Science and Mathematics Education*, *3*, 141-166.
Bryan, L., & Atwater, M. (2002). Teacher beliefs and cultural models: A challenge for science teacher preparation programs. *Science Teacher Education*, *86*, 821-839.
Caseau, D., & Norman, K. (1997). Special education teachers use science-technology-society (STS) themes to teach science to students with learning disabilities. *Journal of Science Teacher Education*, *8* (1), 55-68.
Chowdhury, M. (2013). Incorporating industry case study to motivate and engage students in the chemistry of daily life. *Journal of Chemical Education*, *90*, 866-872.
Chowdhury, M. (2014). The necessity to incorporate TQM and QA study into the undergraduate chemistry/science engineering curriculum. *The TQM Journal*, *26* (1), 160-187.
Chowdhury, M. (2016). The integration of science-technology-society/science-technology-society environment and socio-scientific-issues for effective science education and science teaching. *Electronic Journal of Science Education*, *20* (5), 19-38.
Cohen L., Manion L., & Morrison K. (2007). *Research methods in education* (6th ed.). Oxford, GBR: Routledge.
Denscombe, M. (2010). *Good research guide: For small-scale social research projects* (4th ed.). Berkshire, GBR: McGraw-Hill Education.
DeWitt, J., & Storksdieck, M. (2008). A short review of school field trips: Key findings from the past and implications for the future. *Visitor Studies*, *11* (2), 181-197.
Dori, Y., & Tal, R. (1998). Formal and informal collaborative projects: Engaging in industry with environmental awareness. *Informal Science*, *84*, 95-113.
Eshach, H. (2007). Bridging in-school and out-of-school learning: Formal, non-formal and informal education. *Journal of Science Education and Technology*, *16* (2), 171-190.
Glackin, M. (2016). 'Risky fun' or 'authentic science'? How teachers' beliefs influence their practice during a professional development programme on outdoor learning. *International Journal of Science Education*, *38* (3), 409-433.
Halwany, S., Zouda, M., Pouliot, C., & Bencze, L. (2017). Supporting pre-service teachers to teach for citizenship in the context of STSE Issues. In Bencze, L. (Ed.), *Science and technology education promoting wellbeing for individuals, societies and environments: Cultural studies of science education*, (pp. 405-427). New York, NY: Springer.
Hodson, D. (2003). Time for action: Science education for alternative future. *International Journal of Science Education*, *25*, 645-670.
Hofstein, A., Eilks, I., & Bybee, R. (2011). Societal issues and their importance for contemporary science education-A pedagogical justification and the state-of-the-art in Israel, Germany and the USA. *International Journal of Science and Mathematics Education*, *9*, 1459-1483.
Hofstein, A., & Kesner, M. (2006). Industrial chemistry and school chemistry: Making chemistry studies more relevant. *International Journal of Science Education*, *28* (9), 1017-1039.
Jarvis, T., & Pell, A. (2005). Factors influencing elementary school children´s attitudes toward science before, during and after a visit to the UK national space centre. *Journal of Research in Science Teaching*, *42* (1), 53-83.
Kisiel, J. (2005). Understanding elementary teacher motivations for science fieldtrips. *Science Education*, *89* (6), 936–955.
Kousa, P., Kavonius, R., & Aksela, M. (2018). Low-achieving students´ attitudes towards learning chemistry teaching methods. *Chemistry Education Research and Practice*, *19*, 431-441.
Lawrence, C., Yager, R., Sowell, S., Hancock, E., Yalaki, Y., & Jablon, P. (2001). Proceedings of the annual meeting of the association for education of teachers in science: *The philosophy, theory and practice of science-technology-society orientations*. Costa Mesa, CA, U.S. Department of Education.
Lumpe, A., Haney, J., & Czerniak, C. (1998). Science teacher beliefs and intentions to implement science-technology-society (STS) in the classroom. *Journal of Science Teacher Education*, *9* (1), 1-24.
Mansour, N. (2010). Science teachers´ perspectives on science-technology-society (STS) in science education. *Eurasian Journal of Physical and Chemical Education*, *2* (2), 123-157.
Marbach-Ad, G., & McGinnis, R. (2008). To what extend do reform-prepared upper elementary and middle school science teachers maintain their beliefs and intended instructional actions as they are inducted into schools? *Journal of Science Teacher Education*, *19*, 157-182.
Markic S., & Abels S. (2014). Heterogeneity and diversity: A growing challenge or enrichment for science education in German schools? *Eurasia Journal of Mathematics, Science and Technology Education*, *10* (4), 271–283.
McHugh, M. (2012). Interrater reliability: The kappa statistic. *Biochemia Medica*, *22* (3), 276–282.

Milner, A., Sondergeld, T., Demir, A., Johnson, C., & Czerniak, C. (2012). Elementary teachers´ beliefs about teaching science and classroom practice: An examination of pre/post NCLB testing in science. *Journal of Science Teacher Education*, *23*, 111-132.
Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies*, *19* (4), 317-328.
Orion, N., & Hofstein, A. (1994). Factors that influence learning during a scientific field trip in a natural environment. *Journal of Research in Science Teaching*, *31* (10), 1097-1119.
Pajares, M. (1992). Teachers´ beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, *62*, 307-332.
Pedretti, E., Bencze, L., Hewitt, J., Romkey, L., & Jivraj, A. (2008). Promoting issues-based STSE perspectives in science teacher education: Problems of identity and ideology. *Science and Education*, *17*, 942-960.
Pedretti, E., & Hodson, D. (1995). From rhetoric to action: Implementing STS education through action research. *Journal of Research in Science Teaching*, *32* (5), 463-485.
Pedretti, E., & Nazir, J. (2011). Currents in STSE education: Mapping a complex field, 40 years on. *Science Education*, *95*, 601-626.
Rubba, P. (1991). Integrating STS into school science and teacher education: Beyond awareness. *Theory into Practice*, *30* (4), 303-308.
Tal, T., & Morag, O. (2009). Reflective practice as a means for preparing to teach outdoors in an ecological garden. *Journal of Science Teacher Education*, *20*, 245-262.
Van Driel, J., Verloop, N., & de Vos, W. (1998). Developing science teachers´pedagogical content knowledge. *Journal of Research in Science Teaching*, *35* (6), 673-695.
Whitesell, E. (2016). A day at the museum: The impact of field trips on middle school science achievement. *Journal of Research in Science Teaching*, *53* (7), 1036-1054.
Yager, R. (2007). STS requires changes in teaching. *Bulletin of Science, Technology & Society*, *27* (5), 386-390.

Appendix A

An open-ended questionnaire

3. What were the benefits and challenges of collaboration with industry?
4. What were the benefits and challenges of collaboration with school?
5. What were the benefits and challenges of collaboration with your group members/university teacher?
6. What were the benefits and challenges of the industry-based teaching material?

Appendix B

A reflective writing

What were the benefits of school-industry collaboration course for your future practices as a teacher?

Received: *September 26, 2018* Accepted: *November 22, 2018*

Päivi Kousa	PhD Student, The Unit of Chemistry Teacher Education, Department of Chemistry, Faculty of Science, P.O. Box 64, FI-00014 University of Helsinki, Finland. E-mail: paivi.kousa@helsinki.fi Website: https://tuhat.helsinki.fi/portal/en/person/pkousa
Maija Aksela	Professor, The Unit of Chemistry Teacher Education, Department of Chemistry, University of Helsinki, P.O. Box 64, FI-00014 University of Helsinki, Finland. E-mail: maija.aksela@helsinki.fi Website: https://tuhat.helsinki.fi/portal/fi/person/aksela
Vesna Ferk Savec	Professor, Faculty of Education, University of Ljubljana, Kardeljeva pl. 16, 1000 Ljubljana, Slovenia. E-mail: vesna.ferk@pef.uni-lj.sl Website: https://www.pef.uni-lj.si/1149.html