

University of Helsinki

**Diversity and science teacher education: supporting
practices for better student achievement**

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DOCTORAL DISSERTATION

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Abstract

Classrooms are becoming more diverse and the number of low achieving students is continuously increasing. About 20% of European 15-year-old-children are not at the required educational levels. There are many reasons for students' low achievement such as negative attitudes, immigrant or low socio-economic backgrounds, learning difficulties etc. Furthermore, students find that science and especially chemistry is boring, uninteresting, irrelevant and difficult. Nevertheless, low achievement can have critical consequences for the entire society, if students are unable to participate in it as equal citizens, make rational and sustainable decisions or be sufficiently qualified for working life demands. Accordingly, more research is needed, how low achieving students could be supported in diverse classrooms.

Science teachers tend have more negative beliefs towards student diversity and teaching practices in diverse classrooms compared to subject teachers. That is crucial, because teachers' beliefs and practices can affect students' achievement. The aim of this thesis is to understand, how science, and especially chemistry teachers could be better supported and prepared for diversity and better student achievement during their entire careers. The main research question is: *What is the relationship between student achievement and teachers' beliefs about diversity and science teaching practices for diverse students?* In order to answer to the main research question, three subquestions are asked. Firstly, low achieving students' thoughts about chemistry and chemistry teaching practices compared to other students is analyzed. The second question clarifies, how does the STSE-based school-industry collaboration affect to pre-service science teachers' beliefs about their future practices. The third question is about pre- and in-service teachers' beliefs about teaching chemistry in diverse classrooms.

This thesis consists of three interconnected studies and one descriptive report (I-IV). Study I describe what is the connection between students' low achievement and most preferred teaching practices compared to other students. Since there was a clear evidence of the fact, that all students in spite of their achievement levels preferred industry visits, it was chosen to be a main topic in study II. In that study, the connection between pre-service teachers' beliefs and STSE-based teaching practices were examined in a context of school-company collaboration and visits. Since pre-service teachers' beliefs were significantly improved after the STSE-based course, the following descriptive report III concentrated on science teacher education and how it could be developed in order to prepare future chemistry teachers for diversity. Furthermore, the last study IV is about the in-service chemistry teachers' beliefs about their work in diverse classrooms.

The mixed methods approach which includes survey and case-study is used in order to answer the research questions. Data for the survey was collected from 2949 secondary school students with the help of the Finnish National Board of Education (study I). Secondly, the effects of STSE-based teaching practices were carried out in Finland and Slovenia with 42 pre-service chemistry and science teachers (study II). The presented teaching model for teaching diverse students (report III) was based on German and Finnish chemistry teacher education programs. Furthermore, the beliefs of eight in-service science teachers were examined by case-study (study IV).

There is not much national or international research about the topic of this thesis. This thesis presents prominent insights and ideas, how especially low achieving students could be supported by developing science and chemistry teacher education. Accordingly, following suggestions are made: (i) Practices for teaching diverse students have an influence on students' achievement. Therefore, it is beneficial to take students' thoughts into account when activities are planned and implemented. It is worth noticing, that students prefer similar practices in spite of their achievement levels: company visits, using digital implementations and working in groups. (ii) STSE-based teaching practices such as company visits are preferred by diverse students and they also have a positive effect on teachers' beliefs. For that reason, teachers should have regular opportunities to practice those skills in authentic environments. STSE-based teaching material can be also beneficial for diverse students. (iii) In-service teachers do have basic knowledge about diversity, and they use a considerable amount of effort in order to take their students' needs into account. However, they need more support and resources. In conclusion, pre-and in-service teachers' concerns, needs and beliefs should be taken into account, when support for them is planned during their entire career. Teacher support for diversity and better student achievement need both national and international collaboration among teacher educators, pre- and in-service teachers, special education teachers, students, parents and other community members. This has a significant effect on student achievement and the entire society in turn.

Tiivistelmä

Alisuoriutuvien oppilaiden määrä on huolestuttavasti kasvanut luonnontieteissä ja erityisesti kemiassa, joka koetaan monen mielestä tylsäksi, epäkiinnostavaksi ja turhaksi. Negatiivisten asenteiden lisäksi myös erilaiset oppimisvaikeudet sekä oppilaiden kulttuuriset, sosioekonomiset tai akateemiset taustatekijät voivat vaikuttaa koulumenestykseen. On arvioitu, että koulutustaso on riittämätön jopa 20 %:lla 15 -vuotiaalla eurooppalaisella lapsella. Puutteellisilla tiedoilla ja taidoilla voi olla vakavia yhteiskunnallisia vaikutuksia, mikäli oppilas ei kykene aikuisenakaan tekemään oman elämänsä kannalta järkeviä ja kestäviä ratkaisuja, vastaamaan työelämän vaatimuksiin tai toimimaan yhteiskunnan tasavertaisena jäsenenä. Tämän takia on tärkeää tutkia, miten alisuoriutujien tarpeisiin voitaisiin paremmin vastata opetuksen keinoin.

Luonnontieteen opettajilla on negatiivisemmat käsitykset erilaisista oppijoista ja heidän opettamisestaan kuin muilla aineenopettajilla. Tämä on huolestuttavaa, koska opetuksella on keskeinen vaikutus oppilaan koulumenestykseen. Väitöskirjan tavoitteena on selvittää, miten luonnontieteen ja erityisesti kemian opetusta voitaisiin kehittää erilaisten oppijoiden tarpeita vastaavaksi. Päättökysymyksenä on, miten opettajien käsitykset erilaisista oppijoista heijastuvat heidän opetukseensa ja sitä kautta oppilaiden koulumenestykseen. Ensimmäinen alatutkimuskysymys tarkastelee opetusmenetelmien ja oppilaiden koulumenestyksen välistä yhteyttä. Toinen alatutkimuskysymys liittyy opettajaopiskelijoiden käsitysten ja opetusmenetelmien väliseen yhteyteen, kun menetelmät liittyvät STSE (tiede, teknologia, yhteiskunta ja ympäristö) -aiheisiin, esimerkkinä yritysvierailut. Kolmannessa alatutkimuskysymyksessä selvitetään, millaisia käsityksiä opettajaopiskelijoilla ja kokeneemilla opettajilla on erilaisista oppijoista ja heidän opettamisestaan.

Tässä väitöskirjassa esitellään kolme toisiinsa liittyvää tutkimusta sekä yksi kuvaileva raportti (I-IV). Tutkimuksessa I on selvitetty erilaisten opetusmenetelmien ja oppilaiden koulumenestyksen välistä yhteyttä. Koska tutkimuksessa havaittiin, että kaiken tasoiset oppilaat pitävät eniten yritysvierailuista ja haluaisivat niitä lisää, vierailut otettiin tutkimuksen II pääaiheeksi. Tutkimuksessa selvitettiin, miten luonnontieteen opettajaopiskelijoiden käsitykset STSE -aiheista ja erityisesti yritysvierailuista muuttuivat aiheeseen liittyvän kurssin aikana. Koska opettajaopiskelijoiden käsitykset muuttuivat merkittävästi positiivisemmiksi kurssin jälkeen, raportissa III kartoitettiin keinoja opettajankoulutuksen kehittämiseksi. Viimeisessä tutkimuksessa IV on tarkasteltu kemian opettajien kokemuksiin työstä, erilaisista oppijoista sekä heidän opettamisestaan. Raportti ja tutkimus (III ja IV) tuovat yhdessä tärkeää lisätietoa, minkälaista tukea opettajankoulutus voisi tarjota luonnontieteen ja erityisesti kemian opettajille heidän uransa kaikissa vaiheissa.

Tutkimusmenetelmänä käytetään monimenetelmää, johon survey -menetelmä ja tapaustutkimus sisältyvät. Opetushallituksen teettämään survey -tutkimukseen osallistui 2949 yläkouluista (tutkimus I). Seuraavassa tapaustutkimuksessa (II) kartoitettiin STSE -opetuksen vaikutuksia 42 opettajaopiskelijoiden käsityksiin tutkittiin Suomessa ja Sloveniassa (esimerkkinä yritysvierailut). Oppilaiden erilaisuuden huomioivaa kemian opettajankoulutusta ja opettajaopiskelijoiden kokemuksia on esitelty raportissa III. Tapaustutkimuksessa IV on selvitetty kahdeksan kokeneemman opettajan käsityksiä erilaisista oppijoista ja heidän opettamisestaan.

Tässä väitöskirjassa esitetään seuraavanlaisia ideoita ja ehdotuksia, miten luonnontieteen ja erityisesti kemian opettajia ja opettajaopiskelijoita voitaisiin tukea erilaisuuden ymmärtämisessä ja erityisesti alisuoriutujien opettamisessa: (i) Oppilaiden negatiivisilla asenteilla kemiaa kohtaan ja huonolla koulumenestyksellä on yhteys toisiinsa. Suosituimmat oppiaineet ovat kuitenkin samoja riippumatta siitä, miten hyvin tai huonosti oppilas menestyy. Eniten pidetään vierailuista, digitaalisista sovelluksista ja ryhmätyöskentelystä. Opettaja voi vaikuttaa positiivisesti sekä asenteisiin että koulussa pärjäämiseen tarjoamalla aktiviteetteja, joita oppilaat pitävät kiinnostavina ja tärkeinä. (ii) STSE -aiheinen opetus parantaa opettajien osaamista ja kykyä toimia erilaisten oppijoiden kanssa. Opettaja tarvitsee kuitenkin mahdollisuuksia ja tukea uusien, STSE -aiheisten aiheiden toteuttamiseen. Esimerkiksi oppilaiden suosimat vierailut ja koulu-yritysyhteistyö voivat parantaa paitsi opettajien myös erilaisten oppijoiden kiinnostusta ja menestystä. (iii) Kokeneemilla luonnontieteen opettajilla on hyvät perustiedot erilaisista oppijoista, ja heidän tukemisekseen käytetään paljon voimavaroja. Opettajat kokevat silti riittämättömyyttä ja kaipaisivat enemmän resursseja ja tukea. Jatkuvaa, koko uran kestävästi tukea tarvitaan, jotta opettaja voisi vastata alati muuttuvan yhteiskunnan ja luokahuoneiden haasteisiin. Yhteistyöverkostoon tulisi kuulua niin opettajankouluttajia, opettajia kollegoineen kuin heidän oppilaitaankin sekä kouluyhteisön ulkopuolella toimivia tahoja. Erilaisuuden ymmärtämisessä ja tukemisessa ei sovi myöskään unohtaa kansainvälisen yhteistyön merkitystä.

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In Helsinki, May 2019

Päivi Kousa

List of original publications

This thesis is based on the following publications which are referred by their roman numerals in the text:

I **Kousa, P.**, Kavonius, R., & Aksela, M. (2018). Low-achieving students' attitudes towards learning chemistry and its teaching methods. *Chemistry Education Research and Practice*, 19, 431-441.

II **Kousa, P.**, Aksela, M., & Ferik Savec, V. (2018). Pre-service teachers' beliefs about the benefits and challenges of STSE based school-industry collaboration. *Journal of Baltic Science Education*, 17(6), 1034-1045.

III Tolsdorf, Y., **Kousa, P.**, Markic, S., & Aksela, M. (2018). Learning to teach at heterogeneous and diverse chemistry classes – Methods for university teacher training courses. *EURASIA Journal of Mathematics, Science and Technology Education*, 14(10), 1-14.

IV **Kousa, P** & Aksela, M. (2019). The needs for successful chemistry teaching in diverse classes: teachers' beliefs and practices. *LUMAT: International Journal on Math, Science and Technology Education*, 7(1), 79-100.

Author's contribution to the publications:

I: The author was responsible for planning the study and analyzing the data for the present study. The author was involved in the writing of all parts of the article.

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III: The author was responsible for planning and organizing the descriptive report and collecting and analyzing the information concerning Finnish participants. The author was involved in the writing of the article: all parts concerning Finland and parts of introduction, theoretical framework and discussion.

Abbreviations

e.g.	exempli gratia
etc.	et cetera
OECD	Organization for Economic Cooperation and Development
PISA	Research in the Programme for International Students Assessment
STSE	science, technology, society and environment
TIMSS	Trends in International Mathematics and Science Study

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1 Introduction

When society changes, many issues in society change as well, and not always for the better. The constantly changing demands of life and work can cause various problems, which in turn, can reflect negatively on educational issues. It is estimated that as much as 20 % of European children, do not acquire sufficient knowledge of science, mathematics and reading at school (OECD, 2016). For instance, there is already a large gap between students' chemistry skills and working life demands (Overton & McGarvey, 2017). If students' skills remain insufficient after school, they might not be able to make rational decisions in their daily lives, choose science or technology-based careers or have equal possibilities to participate in society (Sjøberg & Schreiner, 2006).

There are many obstacles to successfully teach and learn science and chemistry. Firstly, chemistry has been found to be a difficult subject to both teachers and students in all levels of education (Treagust, Duit, & Nieswandt, 2000). There are many reasons for unsuccessful teaching and learning, such as a complex curriculum structure, overload of information, difficult language of chemistry and students' weak motivation (Sirhan, 2007), just to name a few. Consequently, there is a gap between students' understanding of chemical concepts and chemistry teaching practices (Nakleh, 1992). Secondly, student diversity with its many features, can be a cause of numerous challenges in classrooms worldwide (UNESCO, 2004; Subban, 2006; Santangelo & Tomlinson, 2012; OECD, 2013). For example, students with immigrant backgrounds, low socio-economic status or learning difficulties are more at a risk to become low achievers at school compared to students (Gilleece, Cosgrove, & Soforniou, 2010). One of the major challenges in education is to respond to the needs of all students, despite their achievement levels or diversity (Konstantinou-Katzi, Tsolaki, Meletiou-Mavrotheris, & Koutselini, 2013). Teachers do not have enough knowledge, skills or materials for diverse students (Markic & Abels, 2014; Woollacott, Booth, & Cameron, 2014). One of the major reasons for these challenges is, that teachers are not sufficiently prepared for diversity during teacher education (Knight & Wiseman, 2005; Mumba, Banda, Chabalengula, & Doleng, 2015).

However, the situation is not hopeless, even if there are students who are at a risk of falling behind, if teachers' skills and knowledge are in balance with students' needs. Therefore, teachers should have more opportunities to learn more about diversity, and also to practice teaching skills in diverse classrooms during their entire careers (Dixon, Yssel, McConnell, & Hardin, 2014). Consequently, teacher educators are in an important role in providing these opportunities (Knight & Wiseman, 2015). Well-structured teacher education can enhance teachers' skills and knowledge which can improve student achievement in turn (Knight & Wiseman, 2015; Valiandes and Neophytou, 2017).

1.1 Rationale and research questions

Teaching practices can be predictive factors for better student achievement. For instance, hands-on activities (Areepattamannil, Freeman, & Klinger, 2011), enjoyable science lessons and learning environments (Ozel, Caglak, & Erdogan, 2013), STSE issues (Caseau & Norman, 1997) and using practices that students prefer (Kousa, Kavonius, & Aksela, 2018) can have a positive effect on students' achievement. It is worth noticing, that students' achievement is better in those classrooms, where a teacher knows the students and can provide sufficient support for them, both emotionally and instructionally (Perry, Donohue, & Weinstein, 2007). Moreover, teachers' positive beliefs are related to better student achievement, as well (Jarvis & Pell, 2005). Significantly, those teachers, who regularly work with diverse students, have more positive beliefs towards diversity and differentiative teaching practices (Avramidis et al., 2000; Konstantinou-Katzi et al., 2013). It is therefore essential, that teachers are adequately prepared for diversity (Valiandes and Neophytou, 2017).

It is hypothesized in this thesis that teachers' positive beliefs can have a positive effect on their practices in diverse classrooms, and if those practices are also preferred by students, it affects their achievement positively in turn. Accordingly, this thesis aims to find ways in which science and chemistry teachers could be professionally supported for diversity and better student achievement during pre- and in-service teacher education. The main research question is: *What is the relationship between student achievement and teachers' beliefs about diversity and science teaching practices for diverse students?*

The main research question has following subquestions:

(RQ1) What do low achieving students think about chemistry and chemistry teaching practices compared to other students in diverse classrooms?

(RQ2) How does STSE-based school-industry collaboration affect to pre-service science teachers' beliefs about their future practices?

(RQ3) What kind of beliefs pre- and in-service teachers have about teaching chemistry in diverse classrooms?

1.2 Structure of the research

This thesis has 6 chapters. The theoretical framework in chapter 2 begins with the discussion about the connections between student achievement and teaching practices (2.1). Secondly, teaching practices in diverse classrooms are presented and the features of diversity are explained (2.2). Thirdly, the relationship between teachers' beliefs and practices is clarified (2.3). The mixed methods approach with survey and case study is presented and reasoned in

the methodology chapter 3.

Chapter 4 concentrates on pre- and in-service science teacher education in order to find out more information about the aspects of beliefs that influence teachers' practices and student achievement in turn (I-IV). First, the relationship between student achievement and teaching practices is discussed (study I) in order to underline the importance of teachers' work in diverse classrooms (RQ1). In study II, the relationship between pre-service teachers' beliefs and teaching practices with the STSE approach is examined (RQ2). The STSE approach with school-industry collaboration is presented as an example, because school visits are one of the most preferred teaching methods in spite of students' achievement levels (study I). Descriptive report III and study IV concentrate on teachers' beliefs starting with the features of pre-service science teacher education for diversity in Finland and Germany (report III). Study IV deepens the discussion towards in-service teachers' beliefs about their work in diverse classrooms (RQ3). Studies I, II and IV and report III aim at providing answers to the main research question: *What is the relationship between student achievement and teachers' beliefs about diversity and science teaching practices for diverse students?* The aim is to find out the ways in which science and chemistry teachers could be professionally supported for diversity and better student achievement during pre- and in-service teacher education.

The validity and reliability of this thesis is discussed in chapter 5. The last chapter, chapter 6 is divided into three parts according to the research questions. The relations between four studies and one descriptive report are discussed in order to clarify the general view and importance of teachers' professional development for diversity. The implications and further research are also discussed. The main characteristics in this research and their relations are presented in the following Figure 1. A model for teacher support based on the main characteristics and results is presented in Figure 2., p. 29.

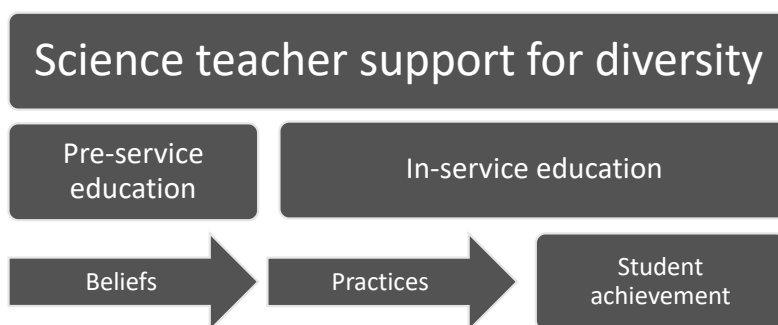


Figure 1. Science teachers' support for diversity during pre- and in-service education affects teachers' beliefs, practices and student achievement in turn.

2 Theoretical framework

This chapter begins with the discussion about the relationship between teaching practices and student achievement (2.1). The next chapter (2.2) takes a look at teaching practices in diverse classrooms in general, defining also diversity and introducing differentiation and STSE-based teaching practices. Thirdly, the relationship between pre- and in-service teachers' beliefs and teaching practices including differentiation and teaching with the STSE approach are thoroughly examined (2.3).

2.1 The relationship between teaching practices and student achievement

Achievement in science can be defined in many ways. For example, if a student does not reach a sufficient level of scientific skills and knowledge at school, it can be considered as low achievement which is often, but not always, temporary (OECD, 2016). Research in the Programme for International Students Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) have come up with different interpretations for achievement levels, but these are not defined in this thesis, as this thesis is focused especially on low achievement and its various features in general. There are many reasons for deficient student achievement, and it is known that especially students from immigrant and low socio-economic backgrounds as well as students who have difficulties with learning are at risk of performing under general requirements (Gilleece et al., 2010). For example, if OECD countries are compared, the largest achievement gap between native and non-native 15-year-olds is in Finland (OECD, 2016). Non-native students are also suffering more often from school burnouts which can lead them to quit school way too early (Salmela-Aro, Minkkinen, Kinnunen, & Rimpelä, 2017). Although there are some evident risk factors, low achievement can appear in all families, in spite of their backgrounds or special needs. It is also notable that low-achievement is not a synonym for learning difficulties, although they might be present at the same time. (OECD, 2016) Furthermore, negative attitudes towards schoolwork can be a cause for low achievement, as well (Brigham, Scruggs, & Mastropieri, 2011).

There are some predictive factors for better student achievement such as positive attitudes and motivation for science and using hands-on activities (Areepattamannil et al., 2011) along with other enjoyable science lessons and learning environments (Ozel et al., 2013) as well as authentic examples from students' everyday lives, which are found either from the classroom or outside of school. There are also teaching practices that could enhance students' success in the classroom such as study groups with different achievement levels and alternative teaching strategies, instead of traditional ones. (Schroeder et al., 2007) Teachers should also pay attention to teaching practices such as school visits that are highly preferred among diverse students (Kousa et al., 2018). By using appropriate teaching practices, a teacher can for example,

minimize the gender-gap (Bennett, Lubben, & Hogarth, 2007), prevent non-native students from falling behind or giving up studying (Gilleece et al., 2010), or alleviate learning difficulties (Rivard, 2004). In spite of all implications that could be provided to the students regardless of their diversity, teacher's own effectivity and influence are eventually in the main role concerning the achievement of students (Wright, Horn, & Sanders, 1997). Therefore, it is essential, that teachers are adequately prepared for diversity (Valiandes and Neophytou, 2017). Notably, the achievement levels of students are higher in those classrooms, where the teacher knows them and is able to support them both emotionally and instructionally (Perry et al., 2007). How different teaching practices affect to student achievement is not studied in this thesis. The focus is on the development of science education concerning pre- in-service teachers' needs for support.

2.2 Teaching practices in diverse classrooms

Teachers can handle student diversity in different ways. They can ignore it, try to take most of the students' needs into account or use it as a resource for the entire class. (Gordon et al., 2010) There are various teaching practices such as hands-on activities, field trips (Norman et al., 1998; Kousa et al., 2018), inquiry-based activities (Chen, Wang, Lin, Lawrenz, & Hong, 2014), and group work (Vishnumolakala, Southam, Treagust, Mocerino, & Qureshi, 2017) which can have a positive effect on diverse students' achievement and attitudes towards science as well as STSE-based teaching practices (Bennett et al., 2007). In this thesis, pre- and in-service teachers' beliefs about differentiative science teaching practices in general are discussed and STSE issues concerning school-industry collaboration and visits are used as an example. Other science or chemistry teaching practices for diverse students are not specified more closely.

2.2.1 Definition of diversity

Defining diversity can be a difficult or even an impossible task (Gordon et al., 2010), because there are so many cultural and academic features included (e.g. Richards & Omdal, 2007). For example, cultural, immigrant and socio-economic backgrounds, disabilities, difficulties with learning and/or language, gender and sexual orientation, discipline etc. can be associated with diversity (e.g. Goethe & Colina, 2018; Wassel et al., 2018). Previous studies, concerning diverse students have used comparable terms such as heterogeneity (e.g. Johnson Rothenberg, McDermott, & Martin, 1998) and mixed ability classrooms (e.g. Valiandes, 2015). Furthermore, inclusive teaching has been used in a context with regular students and students with different levels of disabilities in the same school or classroom (e.g. Norman et al., 1998). However, race and/or ethnicity have been linked with diversity most often (Polhan & Aguilar, 2001). In this thesis, the various academic and cultural features of diverse students (Richards & Omdal, 2007) are not categorized in detail.

2.2.2 Differentiated teaching practices

Students' achievement, subject understanding, motivation and engagement can be improved by differentiated teaching practices (e.g. Konstantinou-Katzi et al., 2013) as well as their self-esteem and confidence (Norman et al., 1998). In addition, the differentiative approach to teaching can decrease the achievement gap (Valiandes, 2015), which enhances the equality of students in turn (Lambe & Bones, 2006; Valiandes, 2015). Students' achievement and success depends strongly on a teacher, whose role is to evaluate the teaching practices case-by-case (Morgan, 2014) rather than routinely differentiate the amount of work, materials and methods (Konstantinou-Katzi et al., 2013) or topics that might be too difficult (Sirhan, 2007). Differentiated teaching practices can be implemented for an entire class, a group or a person (Thakur, 2014) and the diverse requirements of students can be taken into account by differentiating the "content, process, product, and learning environment" when needed (Santangelo & Tomlinson, 2012). Furthermore, the content can be supplemented, simplified, or altered (Janney & Snell, 2006). For example, tiered material which includes the same content but different levels of tasks depending on the skills and knowledge of the student can be useful especially for low achieving students (Richards & Omdal, 2007). However, it is important to notice that regular "tracks" for lower levels are not necessarily effective. Differentiated teaching practices should be planned and implemented for an entire class instead. (Johnson Rothenberg et al., 1998)

On the other hand, taking the various needs of all students into account seems an unattainable goal (Lambe & Bones, 2006), because of the vast diversity of students' skills and knowledge. Moreover, students should feel that scientific material has significance and importance in their everyday lives (Southerland & Gess-Newsome, 1999). Although differentiated teaching practices require more time and effort from the teachers (Valiandes, 2015), they can be useful for the entire class (Janney & Snell, 2006). In this thesis, the term differentiation is used with teaching methods that are implemented to all students in diverse classrooms (e.g. Morgan, 2014).

2.2.3 STSE-based teaching practices

The aim of Science, Technology, Society and Environment (STSE) education is to help students to adjust themselves to the constantly changing world (Pedretti & Hodson, 1995), where the cultural, societal, ethical, political, economic and ecologic issues are also present and have an influence on their lives (Hodson, 2003). STSE issues have many benefits for students (e.g. Yager, 2007; Amirshokoohi, 2016), and the issues are widely used and part of a curricula throughout the world. For example, the STSE approach in teaching can improve teachers' and students' positive attitudes towards science, even in diverse classrooms (Caseau & Norman, 1997). Students with different cultural and academic backgrounds and achievement levels can particularly benefit from the STSE approach, because it motivates them to understand, learn

and apply their knowledge into practice (Pedretti & Nazir, 2011). Teaching with STSE approach can also improve achievement in science as well as critical thinking, co-operating skills and classroom behavior (Caseau & Norman, 1997). Moreover, STSE-based issues can enhance personal and societal interests of students (Hodson, 2003) and make topics such as well-being, environment, energy or applications that are based on industries personally meaningful (Chowdhury, 2014). Using examples from students' everyday lives can help students to participate in society as competent and equal citizens (Chowdhury, 2013).

Field trips such as visits to industries and companies are the most preferred teaching practices in spite of students' achievement levels (Kousa et al., 2018). Therefore, they should be considered as noteworthy options when suitable STSE issues are selected for teaching practices (Brunton & Coll, 2005). Field trips are not as preferred as traditional methods, because teachers find them too resource-consuming and complex. However, school-industry collaboration and visits have apparent benefits. (Orion & Hofstein, 1994) Perhaps the most important benefit is better achievement in science (Whitesell, 2016) and more positive attitudes towards scientific issues (Jarvis & Pell, 2005), which can enhance learning in turn (Eshach, 2007). Furthermore, industrial field trips are as fascinating among girls and boys, in spite of the technological characters that they might have (Hofstein & Kesner, 2014).

A teacher has an essential role to familiarize students with STSE issues within the community outside of school. However, there are challenges such as how to fulfill the needs of diverse students. (Lawrence et al., 2001) The problems have been noticed and lots of pre- and in-service support has been given worldwide, but the attempts have not been entirely successful (Chowdhury, 2016). For example, there is still a large gap between students' chemistry skills and working life demands (Overton & McGarvey, 2017). Consequently, more work has to be done in order to find out how to support pre- and in-service teachers with STSE based teaching practices (Pedretti, Bencze, Hewitt, Romkey, & Jivraj 2008). Most of the studies regarding field trips are about science centers and museums (Eshach, 2007) and there are not that many studies about visits that are based on school-industry collaboration (Brunton & Coll, 2005), or how pre-service teachers could be supported to cooperate with smaller companies nearby schools and to learn, how to implement visits that are based on school-industry collaboration and STSE issues into teaching. This is one perspective of this thesis.

2.3 The relationship between teachers' beliefs and practices

There are many ways in which to explain and categorize teachers' beliefs (Pajares, 1992). According to some studies, teachers' beliefs might be too complex to examine, because there is more than just one belief at a time that has to be taken into account (Cano & Cardelle-Elawar, 2004). A considerable amount of terms is related to teachers' beliefs like attitudes, confidence, motivation, self-concept and self-esteem (Pajares, 1992). Moreover, teachers' knowledge, views, principles and opinions about teaching and learning are also encompassed in a manifold

concept of beliefs (Milner et al., 2012). Generally, teachers' beliefs can be regarded as traditional or modern. When traditional and epistemological beliefs are considered, teachers' classroom practices are often teacher-centered and content-oriented, and learners are passively adapting knowledge from the teacher. On the contrary, modern and constructivistic beliefs are related to student-centered teaching practices where students are able to work more autonomously and for example, choose topics that are meaningful for them. (Markic & Eilks, 2012)

There is a congruence that teachers' beliefs have an influence on their practices (e.g. Nespor, 1987; Pajares, 1992; Van Driel, Verloop, & de Vos, 1998; Bryan, 2012). For example, teachers' positive beliefs are positively related to student outcomes such as with the case of field trips (Jarvis & Pell, 2005). Although teachers' beliefs are mostly positive (e.g. Pedretti et al., 2008), there are still some challenges. First of all, teachers' beliefs tend to stay stable during the years of their career (Marbach-Ad & McGinnis, 2008), although there are some ways to encourage them as well (Bryan, 2012). Secondly, teachers' own beliefs are often obstructing the successful implementation of teaching practices (Hofstein, Eilks, & Bybee, 2011). Thirdly, the whole concept of how beliefs affect practices is not straightforward. For example, according to Kagan (1992), teachers do not always even recognize their beliefs, or they might do similar practices with different causes. Fourthly, pre-service teachers have much more incongruence between their beliefs and practices than in-service teachers (Bryan, 2012). Therefore, the evolvement of teachers' beliefs should be examined during their entire career (Kagan, 1992) in order to support and encourage them with their positive beliefs and practices. Moreover, extra attention should be paid if the beliefs are negative (Lumpe, Haney, & Czerniak, 1998), and more information should be found and about the causes and effects (DeWitt & Storksdieck, 2008). It is essential to be aware of, how teachers' beliefs and practices are related in order to ensure the equity of students in diverse classrooms (Bryan & Atwater, 2002). Additionally, teaching practices should respond to students' needs concerning their readiness, interests and learning profiles (Tomlinson & Moon, 2013).

2.3.1 Teachers' beliefs about diversity and teaching practices in diverse classrooms

Some teachers have negative beliefs, misconceptions and insufficient knowledge about learning difficulties and student diversity. This can have a negative effect on students' achievement and their future possibilities in turn (Norman et al., 1998). Furthermore, teachers' negative beliefs tend to increase with the level of their students' diversity and difficulties. Especially science and mathematics teachers have more negative beliefs about diversity and teaching practices for diverse students compared to other subject teachers. (Avramidis, Bayliss, & Burden, 2000) Teachers' and students' negative beliefs can be a result of unsuitable teaching methods and materials (Lambe & Bones, 2006). However, teachers who regularly use differentiative teaching practices in diverse classrooms, have more positive beliefs about their teaching

abilities (Avramidis et al., 2000; Konstantinou-Katzi et al., 2013).

Pre-service teachers do not necessarily have previous knowledge about student diversity. Usually, their beliefs stay convergent with their own socio-cultural backgrounds even after a diversity-based teacher education program. (Bryan & Atwater, 2002) Consequently, teachers with diverse backgrounds have more positive beliefs about teaching in diverse classrooms than other teachers (Kyles & Olafson, 2008). Therefore, teacher educators and schools should provide practical implications in diverse school environments in order to enhance pre-service teachers' understanding about diversity and what is required to take responsibility in diverse classrooms (Dharan, 2015). For example, if teacher students do not become aware of diversity and its many features during their education, they might face prominent challenges in their future work (Tolsdorf, Kousa, Markic, & Aksela, 2018).

Teachers' personal and professional beliefs about student diversity are not necessarily convergent with each other. For instance, teachers might personally believe that increasing student diversity is a problem but professionally they do not agree that more resources are needed in order to fix the problem. (Pohan & Aguilar, 2001) Furthermore, there is a gap between pre- and in-service teachers' personal and professional beliefs about diversity. Generally, teachers' personal beliefs are more positive than professional ones. However, pre-service teachers' professional beliefs tend to be more positive. In other words, in-service teachers' professional experiences tend to affect negatively to their beliefs about diversity. Since in-service teachers have more positive beliefs about diversity in theory than in practice, their beliefs should be examined carefully, that is, what they think of their reality in diverse classrooms. In-service teachers should also be provided more resources and support in order to tackle with their problems. (Chiner, Cardona-Moltó, & Puerta, 2015)

2.3.2 Teachers' beliefs about STSE-based teaching practices

Pre- and in-service teachers have mainly positive beliefs about teaching STSE issues, although there are some studies about their challenges as well (Pedretti et al. 2008; Mansour, 2010; Bettencourt, Velho, & Almeida, 2011; Halwany, Zouda, Pouliot, & Bencze, 2017). Overall, teaching with the STSE approach is believed to increase motivation and interest towards science (Lumpe et al., 1998; Kisiel, 2005; Bettencourt et al., 2011). There are also beliefs that the STSE issues could help students to learn science and accomplish the knowledge that is needed in order to be an equal citizen in society (Lumpe et al., 1998). Accordingly, the STSE issues could be particularly useful for diverse students with different achievement levels (Bettencourt et al., 2011). Teachers also find that the STSE issues bring versatile, rewarding and enjoyable addition to their work (Kisiel, 2005). In this study, school-industry collaboration and visits are used as an example of STSE-based issues, because they are considered advantageous for students (Brunton & Coll, 2005), and all students prefer them in spite of their achievement levels (Kousa et al., 2018). Actually, a fruitful school-industry collaboration could benefit the entire community. Firstly, it can enhance students' understanding about science as

well as knowledge about careers, services and products. Secondly, industries and companies can have positive publicity and updated knowledge about education and possible future employees in turn. (Brunton & Coll, 2005)

Despite positive beliefs, there are also various challenges that teachers face in their work. For example, STSE-based teaching is considered as being more difficult than the traditional one (Lumpe et al., 1998; Pedretti et al., 2008; Bettencourt et al., 2011). Some teachers have preferred traditional teaching practices even more after STSE-based courses (Halwany et al., 2017). Furthermore, the STSE approach needs more effort, time and other resources according to teachers (Lumpe et al., 1998; Pedretti et al., 2008; Bettencourt et al., 2011; Halwany et al., 2017). Moreover, some teachers believe that STSE-based teaching is not preferred among students (Bettencourt et al., 2011; Halwany et al., 2017) or their parents (Pedretti et al., 2008). Some teachers also believe that STSE issues are too controversial (Lumpe et al., 1998). There are also additional challenges concerning school-industry collaboration such as lack of sufficient communication with company members and problems with funding, time-management, logistical issues and safety regulations (Hofstein & Kesner, 2006). Long-term collaboration and mutual commitment are the greatest challenges in STSE-based school-industry collaboration (Brunton & Coll, 2005).

According to some studies, teaching with the STSE approach has improved pre-service teachers' confidence and willingness to teach those issues although more support and knowledge are still needed (e.g. Pedretti et al., 2008; Kousa, Aksela, & Ferk Savec, 2018). Moreover, pre-service teachers' interest and knowledge have also increased after STSE-based teacher education courses (Amirshokooi, 2016). Therefore, pre-service teachers should have more knowledge about STSE issues and possibilities to practice them regularly. Additionally, it should also be studied how teachers' beliefs affect their practices. (Lawrence et al., 2001)

3 Methodology

This chapter discusses about the mixed methods research approach which is used in this thesis. The descriptions of quantitative and qualitative data collections and analysis are described in more detail along with the studies (I-IV), which are presented in chapter 4.

There is not a standard for mixed methods research, since it has many features. As research methods have been traditionally been divided into qualitative and quantitative ones, mixed methods research can be regarded as a third research paradigm of its own (with qualitative and quantitative methods). It can be stated, that there are three approaches to mixed methods research: with qualitative dominant, quantitative dominant or one with an equal amount of qualitative and quantitative approach. (Burke Johnson, Onwuegbuzie, & Turner, 2007) This thesis starts with a quantitative approach (study I and part of the study II) but has a qualitative dominant. The research process is adapted from the model of Burke Johnson & Onwuegbuzie (2004).

A survey (Cohen, Manion, & Morrison, 2007) was used at the first, quantitative step of this thesis (Study I) in order to describe the attitudes and most preferred teaching methods along with a larger group of students in order to generalize the current situation especially amongst low achieving students. However, student achievement was not further examined in this study, rather it was hypothesized that teachers' beliefs have an effect on their practices which can affect students' achievement in turn. Furthermore, a survey was also used in a smaller scale at the second step of the thesis (study II) in order to have cross-cultural information about pre-service teachers' beliefs both before and after the STSE-based course. Survey research can be used successfully also with smaller samples if the aim of the research and expected information from the participants is clear like in this study (Denscombe, 2010) although the generalizability is not so good than in the larger scales (Cohen, 2007).

In order to examine pre- and in-service teachers' beliefs, two case-studies (II and IV) were conducted. The case-study approach was chosen, since it provides a better opportunity to have an insight to an entire process instead of separated facts (Denscombe, 2010). It is also suitable for examining people in real-world environments. In addition, case-study is appropriate, when strengths and weaknesses of different phenomena are looked at. (Cohen et al., 2007) Furthermore, there is at least three different approaches to case-studies (for example, by Yin, Merriam and Stake) as Yazan (2015) points, out. In this thesis, the approach of Merriam (1998) was used. In that approach, focus was on the particular phenomena (pre- and in-service teachers' beliefs about the school-industry collaboration in study II and about their work in diverse classes in study IV). Case-studies were also descriptive (providing a versatile description of the phenomena) and heuristic (aiming at better understanding of the phenomena). In this thesis, pre-service teachers were practicing school-industry collaboration in authentic environments and the benefits and challenges about the collaboration were discussed about. Moreover, features of in-service teachers' work in diverse classrooms were reviewed as a whole process in study IV, and its positive and negative aspects were taken into account as well.

The mixed methods approach in this thesis included elements of triangulation in order to make the results more justifiable. The purpose was, that a stronger method like a survey with many participants, would compensate a weaker one such as a semi-structured interview with fewer participants. Moreover, there was also features of complementarity in the purpose of the process. For example, some results were used to illustrate, improve and supplement the other results from another method. (Greene, Caracelli, & Graham, 1989) In that way, the data that were collected were in line with the purpose of the thesis (Burke Johnson et al., 2007). It can be assumed, that the results of the first study (quantitative), had an effect on how the second study was accomplished (quantitative and qualitative), which in turn, resulted to the fourth study (qualitative). Accordingly, when two or more methods are combined, more versatile picture of the topic can be provided and new insights for the future research given. Most of all, the features of studied topics can be better viewed from the different perspectives. (Denscombe, 2010)

4 Description of the studies

This chapter presents four studies about pre- and in-service science teacher education in order to find more information about the beliefs that influence teachers' practices and student achievement in turn (Studies I-IV). First, the relation between student achievement and teaching practices are discussed in chapter 4.1 (study I) in order to underline the importance of teachers' work in diverse classrooms (RQ1). In study II, which is presented in chapter 4.2, the relationship between pre-service teachers' beliefs and teaching practices with the STSE approach are examined (RQ2). The STSE approach with school-industry collaboration is used as an example, because school visits are one of the most preferred teaching methods in spite of students' achievement levels (previous study I). Report III and study IV in chapter 4.3 concentrate on teachers' beliefs starting with the features of pre-service teacher education for diversity in Finland and Germany (report III). Study IV deepens the discussion towards in-service teachers' beliefs about their work in diverse classrooms (RQ3). Studies I, II and IV and report III answer the main question about how pre- and in-service teachers' beliefs about diversity and differentiated teaching practices influence students' achievement in which science and chemistry. The aim is to find ways how science and chemistry teachers could be professionally supported for diversity and better student achievement during pre- and in-service teacher education. A model for teacher support based on the results of this thesis is presented in Figure 2., p. 29.

4.1 The relationship between student achievement and teaching practices

About 20 % of European children are regarded as low achievers. That can have severe economic and social consequences. (OECD, 2016) Accordingly, people with insufficient skills and knowledge cannot make sustainable daily decisions or participate in society as equal citizens (Sjøberg & Schreiner, 2006). The situation is problematic, since teachers do not have sufficient education to teach students with different achievement levels (Benny & Blonder, 2018), or methods and materials that respond to their various needs (Markic and Abels, 2014). However, students' achievement can be improved by adequate teacher education which enhances teachers' knowledge and skills in diverse classrooms (Valiandes and Neophytou, 2017). In addition, students' positive attitudes can enhance their achievement in chemistry as well (Kan & Akbas, 2006; Brandriet, Xu, Bretza, & Lewis, 2011; Xu, Villafanea, & Lewis, 2013; Kahveci, 2015).

The aim of this study (I) was to find more information about the attitudes of low achieving students and the relationship between achievement levels and most preferred teaching methods.

4.1.1 Data collection and analysis

The survey which was organized by the Finnish National Board of Education, was based on the Finnish curriculum and quantitative methods were used in the data collection and analysis. Empirical data was collected by stratified sampling. Firstly, about 900 students from 13 Finnish or Swedish speaking schools pre-tested the evaluative exams. 2949 15-year-old, 9th grade students with different achievement levels from 133 Finnish or Swedish-speaking schools participated in the actual survey. The students were divided into five achievement groups according to their results from the chemistry-exam which was not explained in detail in this thesis. Those students, who had deficient results from the chemistry-exam were regarded as low achieving students (n=159). Three background variables were chosen from that group: non-native speakers, students with special needs and gender. Other achievement groups were sufficient, satisfactory, good and very good.

The shortened and modified version of Fennema-Sherman attitude test was used in this study. It has also been used in many international tests like TIMMS and PISA and its validity and reliability have been confirmed inclusively in many studies (Kahveci, 2015). In this study, only questions related to chemistry were examined. There were 15 questions about attitudes towards chemistry.

A correlation between students' attitudes and their achievement levels (based on the results of the evaluative exams) was calculated with SPSS and interpreted by using the Spearman's two-item scale correlation. Furthermore, the difference between attitudes within the low achieving group (i.e. non-native and native speakers, students with and without special needs, and girls and boys) was analyzed by the nonparametric Mann-Whitney U test. Both Spearman's two-item scale correlation and the Mann-Whitney U test are appropriate for studying variables in ordinal scale (Cohen et al. 2007) and in this study, the attitude-scale was considered similar than the ordinal scale.

Finally, teaching methods were categorized into three groups: [1] individual, [2] interactive and [3] different learning environments and approaches to teaching. In order to find out the popularity of different teaching methods students answered to 27 multiple-choice questions. The methods were sorted out according to percentages of increased popularity. The reliability of the results (n=2949) is considered similar to the actual survey (Kärnä, Hakonen, & Kuusela, 2012).

4.1.2 Results

Low achieving students had more negative attitudes towards chemistry than students. For instance, 71% of low achieving students thought that chemistry was not an easy subject and 53% agreed that they do not need chemistry-related skills and knowledge in their working life. Furthermore, there was a significant correlation in all results (significance level 0,01, $p = 0$) between students' negative attitudes and low achievement.

There was a small difference between attitudes within the low achieving group. Non-native speakers and students with special needs found chemistry more important, liked it and studied it more willingly than others in that group. Furthermore, low achieving girls had more negative attitudes towards chemistry than boys, and girls did not think that chemistry-related skills and knowledge would be useful in their future life.

The low achieving students as well as students from other achievement levels preferred teaching methods that were all in a group [3] which included the following activities: visiting companies, institutes, museums and exhibitions (i.e. scientific field trips) and non-traditional methods such as computers, videos, magazines and books. Second most preferred methods belonged to the group [2] which consisted mostly of student-centered and teaching methods such as discussion and group work. The least preferred methods were all in group [1] which included traditional and teacher-based methods such as reading, writing and listening.

4.1.3 Summary

The aim of this study was to find out more information about the attitudes of low achieving students, and the relationship between achievement levels and most preferred teaching methods. The study showed clearly that there is a correlation between students' negative attitudes and low achievement in chemistry. The results are generally in line with the previous findings about students' attitudes in science, but there are also new findings about the differences between low achieving students and their attitudes. Notably, students prefer similar teaching practices in spite of their achievement levels and that is a significant piece of information to teachers and teacher educators, in order to be able to develop supportive teaching practices to diverse students.

4.2 The relationship between pre-service teachers' beliefs and STSE-based teaching practices

Science, technology, society and environment (STSE) issues have many benefits (e.g. Yager, 2007; Amirshokoochi, 2016) also to students in diverse classes (Caseau & Norman, 1997). However, there are many challenges that can prevent the successful implementation of those issues. Firstly, teaching practices with the STSE approach might not fulfil the needs of students with different achievement levels. Secondly, teachers' negative beliefs can obstruct the successful connections between STSE-based examples and subject knowledge (Hofstein et al., 2011). Thirdly, both positive and negative beliefs tend to be stable during teachers' careers (Marbach-Ad & McGinnis, 2008). Significantly, teachers' beliefs affect to their practices in the classroom (e.g. Nespor, 1987; Pajares, 1992; Van Driel et al., 1998), and positive beliefs have a positive effect on STSE-based teaching practices like in the case of scientific field trips (Jarvis & Pell, 2005). Consequently, teaching with STSE issues can improve students' achievement in

turn (Caseau & Norman, 1997; Pedretti & Nazir, 2011; Whitesell, 2016).

Teacher educators have not sufficiently succeeded with offering support for STSE issues (Chowdhury, 2016). Since beliefs have an effect on teachers' practices, the positive ones should be encouraged (Lumpe et al., 1998) and reasons for negative beliefs should be examined (DeWitt & Storksdieck, 2008) already during pre-service teacher education (Lumpe et al., 1998). The aim of this study (II) was to find out ways with which to support and encourage pre-service teachers in order to have better outcomes and to be successful in their future practices with STSE issues. The field trips were used as an example, since they have many benefits (e.g. Orion & Hofstein, 1994), they are the most preferred teaching practices by students with different achievement levels (Kousa et al., 2018) and there are not that many studies concerning school-industry collaboration and visits (Brunton & Coll, 2005).

4.2.1 Data collection and analysis

This was a case-study with a mixed methods approach (Cohen et al., 2007) including pre- and post-survey (part I), open-ended post-questionnaires and reflective writing (part II). The study was about two correspondent school-industry collaboration science teacher education courses with the STSE approach in Finland and in Slovenia. The Finnish course "Science and Mathematics in Society" (5 ECTS) was carried out by the Unit of Teacher Education at the University of Helsinki. Concurrently, in Slovenia, the course was part of the course "Project-based Learning" (9 ECTS) which took place at the University of Ljubljana, Faculty of Education.

The two courses were based on a previous research and the curriculum. During the courses, pre-service teachers practiced collaboration with local schools and companies and made teaching material about school-industry collaboration for schools. The course included three parts. The aim of the first, theoretical part was to improve teachers' skills and confidence with STSE issues (Hofstein et al., 2011). The second part included a company visit that pre-service teachers organized for themselves. Afterwards, students chose local schools that were interested in cooperation. The following companies were chosen by students' interests: a communal wastewater treatment plant, a supplier organization of lab equipment and services, a chemical industry group (oil and minerals), a producer of local fruit beverages, food manufacturers, a producer of organic fertilizers, a local institute of agriculture, cosmetics manufacturer and an ecological dry-cleaning company. Finnish pre-service teachers formed three and Slovenian counterparts ten groups with the chosen companies and schools (one collaborating company and school per group). The third part included the development of learning material about school-industry collaboration which had three parts the pre-visit, the actual visit and post-visit part (Hofstein & Kesner, 2006).

Eight Finnish and thirty-four Slovenian pre-service chemistry teachers participated voluntarily in the first part of the study. A survey in part I, was adapted from Pedretti et al. (2008), and it included 10 claims with interval 5-point Likert scales about teachers' STSE

related beliefs. The paired samples t-test was calculated with SPSS Statistics in order to compare the results of pre- and post- measurements. Eight Finnish pre-service teachers participated in the next part (II). In that part, there were four, open-ended questionnaires with four topics: collaboration with industry, collaboration with school, collaboration with group members and developing teaching material. At the end of the course, there was reflective writing based on a question about the believed benefits for the future practices. All topics and questions were based on previous courses in Helsinki and studies about school-industry collaboration (e.g. Hofstein & Kesner, 2006). All answers were carried out in written form and they were analyzed through content analysis with open-coding technique by two researchers (Cohen et al., 2007).

4.2.2 Results

The first results were from the pre- and post-survey, where 8 Finnish and 34 Slovenian pre-service teachers filled out the surveys (part I). There was a significant ($p < .05$) improvement in pre-service teachers' beliefs about their confidence and readiness to teach STSE issues in their future work after the course. Interdisciplinarity of STSE issues was also considered significantly important. Furthermore, there were other beliefs that were more positive after the course, although the results were not significant. There was a higher agreement about connections between scientific issues and values in education and the importance of STSE education in general. Pre-service teachers were also less concerned about the resources after the course.

Other results were from four open-ended post questionnaires and reflective writing. This part was completed by 8 Finnish pre-service teachers (part II). The questionnaire data set had four categories.

1. *Collaboration with industry*: The company representatives were mostly supportive and had positive attitudes towards the collaboration. The general information and material were also given promptly. However, collaboration was not very fluent. Additionally, more profound information was needed about the industry and its products and vocations in order to connect it to the science subjects, everyday life and future careers.
2. *Collaboration with school*: School teachers had positive attitudes towards school-industry collaboration in general according to pre-service teachers. However, the collaboration had many challenges. Accordingly, the school teachers were passive, and they had no ideas or opinions for the visits or teaching material.
3. *Collaboration with group members*: Almost all group members of pre-service teachers were active and had ideas for the visits and teaching materials. There were also disagreements and some students suffered from lack of time and passivity of student colleagues.
4. *Developing industry-based material*: The material was considered very beneficial, interdisciplinary, versatile and multi-purpose. According to pre-service teachers, the best parts had connections to everyday life and included versatile teaching methods that

could increase the interests of students. It was also found out that students with different achievement levels could benefit from the materials. The materials also had some challenging features. For example, some of the pre-service teachers did not like open tasks with multiple answer possibilities. There were also beliefs that school teachers would regard the material too modern since it focuses too much on industry-based issues and too little on science subjects and the curriculum.

According to the results of reflective writing, the STSE-based school-industry collaboration course was found beneficial for pre-service science teachers' future practices. Teacher students felt readier and more confident to implement those issues into teaching. They especially valued smaller local companies and believed that the representatives would be easier to contact and collaborate with. Pre-service teachers believed that they would need team support as well as an opportunity to practice teaching skills with the STSE approach in the future. They also highlighted the importance of sufficient quality requirements of teaching material that should include interesting and encouraging ideas and vocational knowledge for the students.

4.2.3 Summary

The aim of this study was to find ways to support pre-service teachers for better outcomes and success in their future practices with STSE issues. Visits that were based on school-industry collaboration were used as an example, since it appeared from the study I, that they are one of the most popular teaching practices in spite of students' achievement levels. This study had some similarities between the previous results of pre-service teachers' beliefs. Pre-service students found it extremely important to have opportunities to practice teaching skills with the STSE approach. Most of all, pre-service teachers' confidence and readiness to teach STSE issues can be significantly improved, if the examples are from real world and preferred also by students like in the case of visits that were based on school-industry collaboration (study I). It can be concluded from the studies I and II that teachers' positive beliefs could have a positive effect on their practices, and if those practices are also preferred by students, this can affect positively to their achievement in turn.

4.3 Pre- and in-service teachers' beliefs about diversity and supportive teaching practices for diverse students

Classroom diversity has been a growing phenomenon all over the world (e.g. Southerland & Gess-Newsome, 1999; Santangelo & Tomlinson, 2012). Accordingly, teachers in all levels find, that they are not sufficiently prepared to teach in diverse classrooms (Norman, Caseau, & Stefanich, 1998). Many studies emphasize that teachers' beliefs have an effect on their classroom practices (Nespor, 1987; Pajares, 1992; Van Driel et al., 1998; Bryan, 2012), and it is well known that positive beliefs are related to students' better achievement (Jarvis & Pell, 2005). However, teachers' negative beliefs tend to increase with students' difficulties and

differences. For instance, science and mathematics teachers have more negative beliefs about those issues than other subject teachers (Avramidis et al., 2000). Nevertheless, teachers who regularly work with diverse students, have more positive beliefs toward them and differentiative teaching practices, as well (Avramidis et al., 2000; Konstantinou-Katzi et al., 2013). Therefore, teachers should be supported during their career in order to encourage them with positive beliefs (Lumpe et al., 1998). This could have an effect on their practices and student achievement in turn.

This chapter concentrates on teachers' beliefs starting with the features of pre-service teacher education for diversity, and how it could be developed (descriptive report III). The original report was about teacher education courses in Finland and in Germany. Here, only the Finnish part is presented, since teacher students in Finland had previous teaching experience contrary to German counterparts. Accordingly, the experiences were more comparable to study IV, which was about Finnish teachers with similar educational backgrounds, yet more teaching experience. In study IV in-service teachers' beliefs about their work in diverse classrooms are reflected comprehensively. The purpose of both studies was to acquire more information in order to develop supportive teaching practices for pre- and in-service teacher education for more successful chemistry teaching in diverse classes.

4.3.1 Data collection and analysis

Descriptive report III

Although the chemistry teacher education course for diversity is discussed here only from the Finnish point of view, there are some joint issues that are presented. Firstly, the courses had been separately developed at first and afterwards, cooperative discussions and visits have been made in order to share background knowledge and practical ideas for the courses. The chemistry teacher education program for diversity was obligatory and significantly longer (24 ECTS) in Germany than the voluntary course in Finland (5 ECTS) which was carried out only two times. The background knowledge for the courses was based on different models by previous studies (e.g. Taber, 2005; Calderhead, 2011; Markic, 2015) and it used a diagnostic process by Klug, Bruder, Kelava, Spiel, & Schmitz (2013). In addition, the model of professional development by Aksela, (2010), which is used in chemistry teacher education at the University of Helsinki, was taken into account in the Finnish course.

Five, voluntary chemistry teacher students participated in the Finnish course (5 ECTS) called "Eriyttäminen kemian opetuksessa" (Differentiation in chemistry teaching). The course was organized and implemented by the researcher from the Unit of Chemistry Teacher Education at the University of Helsinki. At the end of the course, the pre-service teachers participated in a semi-structured interview with five questions about the course and their beliefs. Their answers were also analyzed by content analysis by the researcher in Finland. However, the results are not explained here in detail, since the the purpose of the descriptive report III was to present some general features of pre-service teacher education for diversity and discuss

about pre-service teachers' beliefs concerning those issues.

During the course, student teachers were first familiarized with the dimensions of diversity which have an influence on students' achievement in chemistry. In the first part, pre-service teachers familiarized themselves with simple language, texts and pictures in chemistry books, learning difficulties, gifted students, different cultural backgrounds etc. They also had short lectures as well as different exercises such as role-plays and real stories from the real world. Secondly, student teachers learned how to diagnose individual differences and use diagnostic tools. Short lectures, videos, discussion and debates, presentations, the Finnish language, scientific language, content knowledge, misconceptions, experimental skills, and chemistry teaching were used as topics. Moreover, student teachers visited two randomly-chosen, secondary-school chemistry lessons (90 minutes each) and made careful observations about the topics. After observations, student teachers' experiences were shared and discussed. The observation reports were collected by the researcher for further research and development of chemistry teacher education. Thirdly, student teachers made a lesson plan with differentiated teaching material. The task was open-ended, since the aim was to simulate teachers' work, where ready-made material is often unavailable. The researcher only suggested that pre-service teachers choose a topic from chemistry that was difficult to them in order to concentrate on the subject knowledge, as well. At the end of the course, new material was analyzed by student counterparts, developed further and shared to webpages for other interested teachers.

Study IV

This was a case-study, the aim of which was to focus more deeply on chemistry teachers' work in diverse classes. The studied case was an in-service teacher training program about STSE education and differentiation in chemistry. The program was carried out four times (once per month) at the University of Helsinki, Unit of Chemistry Teacher Education, Faculty of Science by the researcher. Semi-structured interviews were used to collect data from eight, voluntary Finnish secondary-school chemistry teachers, and the data was analyzed with descriptive content analysis. (Cohen et al., 2007) The teachers were chosen by purposive sampling (Denscombe, 2010).

The research process started with a literature review and discussions concerning the topics of this study. The theory and practices from the previous report (III) about pre-service teacher education for diversity (Tolsdorf et al., 2018) also had an influence on this study. Furthermore, 11 questions were developed for the interview, and these were first piloted by a group of student teachers and teacher educators. A sample of teachers who participated in this study were then interviewed, and the verbatim transcripts from the audio-recorded interviews were analyzed. The content analysis was carried out by two researchers, and 264 codes which were related to the interview questions were found from the data. Finally, four categorical distinctions were found from the codes.

4.3.2 Results

Descriptive report III

Pre-service teachers' opinions about the chemistry teacher education course were mainly positive. All teacher students thought that the course met their expectations and cleared the general view concerning diversity and teaching chemistry in diverse classrooms. The experiments in the course were easy to adapt, since they had already familiarized themselves with teaching during pedagogical practices. All pre-service teachers preferred the observation experiment most, since it gave them freedom to observe students' actions and individual differences, and to observe the actual teacher used differentiated teaching methods and materials. In addition, role play activities and development of differentiated teaching material were found also useful. According to the pre-service teachers who had participated in this study, the course helped them to: recognize students' individual differences and needs, create teaching material for different achievement levels, and pay attention on how to use language (when speaking and writing). All in all, pre-service teachers believed that they would be more confident to teach in diverse classrooms after the course, and their pedagogical content knowledge improved as well.

In spite of positive feedback, pre-service teachers had many needs concerning supportive teacher education and their future practices. To begin with, all students argued that the course was too short. Teacher students would have wanted more information about different achievement levels and disabilities, and how to assist students for example, with laboratory-work. Furthermore, teacher students noticed that differentiated material needed more time and effort than the normal one. Some of the teacher students stated that it would be impossible to make suitable material for everyone. In addition, there were many concerns about pre-service teachers' future practices. First of all, they were concerned with teaching in the right way: choosing correct terms and being clear with the language, taking different achievement levels into account (without oversimplifying the content or ignoring the gifted students), using real-world examples, and finally, making chemistry more interesting.

Study IV

The following four categorial distinctions about teachers' beliefs about the successful implementation of chemistry teaching practices in diverse classes were found from the data: 1) to have more support and resources, 2) to be able to recognize students problems, 3) to use supportive materials and methods, and 4) to connect theory and practice with inspiring and meaningful activities.

Firstly, teachers found that the lack of resources, time, money and possibilities to use versatile learning environments were challenging as well as having too big classes. The most distinctive challenge was the lack of sufficient chemistry teacher education for diversity (one obligatory course with 5 ECTS) and support. Teachers needed more practical examples instead of having only theory-based lectures, peer support from colleagues and special education teachers, consulting, workshops and courses from the university teacher educators, and also

more materials and methods for differentiation.

Secondly, being sufficiently sensitive to recognize students' problems and take their needs into account in diverse classes was found very challenging. However, teachers mentioned about many general problems that they have recognized in their work such as students' negative attitudes and lack of motivation. Many individual differences and challenges were also brought forth such as learning difficulties, cultural aspects concerning language issues, behavioral problems and conflicts between students. Consequently, it was considered to be impossible to find materials and methods that would work for everyone. Furthermore, teachers believed that chemistry itself caused many problems, since it is abstract, hard to understand and has difficult terminology.

Thirdly, it appeared that supportive teaching material is already used in diverse chemistry classes and most of it is self-made or altered. Almost all teachers in this study believed, that variation and alternative teaching practices, examples from everyday life, hands-on activities, peer support and group work were successful and supportive. However, some teachers stated, that the making of differentiated material was time-consuming and challenging. Nevertheless, differentiated material was mostly regarded as beneficial and worth the effort, since it was found suitable for more than one student/group of students. Lastly, some teachers remarked that it was difficult to use differentiative teaching practices, since some of the students and parents had negative attitudes toward some practices and therefore, they did not want them at all or wanted them to be used, but not in public.

Fourthly, teachers claimed that students' abilities to connect theory and practice was generally low. Furthermore, many students did not know why chemistry was studied in the first place. Consequently, the lack of interesting, inspiring and encouraging teaching practices was well identified by most of teachers. There have been challenges on how to connect chemistry into real-world examples, for instance, concerning girls and issues that they would be interested in. However, there were many successful teaching methods according to teachers, such as laboratory and inquiry-based activities, hands-on activities, modelling, using computers, watching videos, modelling, making visits, using real-world examples and presenting exciting chemical reactions. Moreover, teachers were almost unanimous that student-centered activities were most inspiring and rewarding teaching practices in diverse classes.

4.3.3 Summary

The aim of descriptive report III and study IV was to acquire more information in order to develop supportive teaching practices for more successful chemistry teaching in diverse classes. The studies presented two important features concerning chemistry teacher education: what are pre-service teachers' opinions and expectations, and how diversity is handled by more experienced teachers. Many similarities were found between previous studies with report III and study IV, especially about the concerns and challenges about the work with diverse students. Notably, both pre- and in-service teachers found that student-centred teaching

practices with real-world examples would be extremely beneficial for diverse students in order to connect theory and practice as well to inspire students. The popular and supportive practices that in-service teachers emphasized, were surprisingly similar to those practices that students preferred in Study I. It can be concluded from studies I, II, and IV as well as from report III that it is important to ask students' and both pre- and in-service teachers' beliefs about the popular and effective teaching practices in order to find fruitful connections for better success and student achievement in the classroom.

5 Validity and reliability

The validity and reliability of the mixed methods approach (with quantitative and qualitative methods) is reasoned in this chapter. The aim of this chapter is to discuss how well the mixed methods approach corresponded to the main research question and the subquestions. More detailed discussion about the validity and reliability can be found from the original studies and from chapter 4. The mixed methods approach is presented in previous chapter 3.

Reliability has a different meaning concerning quantitative and qualitative research methods. In quantitative research, the aim is in the sustainability and consistence of research settings and results (similar results can be accomplished with similar settings). In qualitative research, there are many features such as trustworthiness, applicability, transferability and inter-rater reliability that has to taken into account. Validity refers to the accuracy of the research: it is important to make sure that the research questions are corresponding to the research methods. External validity implies that the results are generalizable or transferable and internal validity implies that the research is sufficiently reasoned, structured and organized. Although there are no studies that are completely objective or valid, the degree of bias can be minimized by reassuring the reliability and validity by using both qualitative and quantitative research methods. (Cohen et al., 2007)

The mixed methods approach, which included survey and case-study was used in this thesis. The mixed methods approach was qualitative-dominant (Burke Johnson et al., 2007). The approach was chosen, since the possibility to acquire more reliable results increases, if the combination of the methods is used. In addition, the phenomena and its complexity can be understood more fully with mixed methods approach. (Cohen et al., 2007) Moreover, mixed methods approach and sufficient data collection process can even reinforce the results (Noor, 2008). Most of all, it would have been challenging to test the hypothesis and different assumptions, if the qualitative approach had been only used (Burke Johnson & Onwuegbuzie, 2004). Naturally, mixed methods approach has also some weaknesses, as well. For example, there can be ambiguousness with the results. However, when two or more research methods are used in order to examine the same issue (methodological triangulation), it can be also checked if the different methods give the correspondent results. It is also important that methods are linked to each other. (Denscombe, 2010) Along with triangulation, the characteristics of

complementarity which have also been used in this thesis, can enhance the interpretability of the results and decrease the bias-effect, in turn (Greene et al., 1989).

The focus of this thesis was on pre-and in-service teachers' beliefs and there are many ways to examine them. For example, espoused beliefs can be examined by using interviews like in the studies II and IV. It is known that there can be a contradiction between what teachers say and what they do. (Bryan, 2012) It can be assumed, that the results of this thesis gave insights how teachers find they work, not necessarily, what they do in real situations. However, the results were strengthened with pre- and post-survey (study II). All the processes had also careful sampling and appropriate timing as well as reproducibility. In addition, study II had cross-cultural validity, which is justifiable and important when the research is about diversity. The generalizability of the results was not strong, since the sample size was small in studies II and IV. The purposive samplings were, however, considered appropriate for the case-study approach (Merriam, 1998), since each participant presented a unique example of pre- and in-service teachers with different backgrounds. However, the results deepened the understanding of pre- and in-service teachers' beliefs differently than a larger-scale survey.

In summary, it can be presumed that this thesis propounded a connection between teachers' beliefs, practices and student achievement. First large-scale survey (study I) gave a clear and general picture of low achieving students thoughts about chemistry and chemistry teaching practices compared to other students in diverse classrooms. In second case-study (II), the sample sizes were smaller, but triangulation was successfully used in order to clarify the deeper effects of the STSE-based teacher education to pre-service teachers' future practices. Thirdly, pre-service teacher education for diversity was presented in a report (III), and the theoretical background, academic discussions as well as described processes gave validity to the discussion and for the next and final study IV. Although this thesis had its limitations, most of the results were concordant to the previous studies and theories. Most of all, the results of this thesis provide fruitful ideas for corresponding cases as well as give insights for future research.

6 Discussion and conclusions

The main research question of this thesis was: *What is the relationship between student achievement and teachers' beliefs about diversity and science teaching practices for diverse students?* As stated previously, increasing student diversity can have manifold consequences (UNESCO, 2004; Subban, 2006; Santangelo & Tomlinson, 2012; OECD, 2013). For instance, deficient skills and knowledge can obstruct students' possibilities to make rational choices later in life, be qualified for a job or equally participate in society (Sjøberg & Schreiner, 2006). The situation is challenging, since teachers are not sufficiently prepared for diversity during their education (Knight & Wiseman, 2005; Mumba et al., 2015). Therefore, they should have more opportunities to have knowledge about the features of diversity and also practice teaching skills

in diverse classrooms (Dixon, Yssel, McConnell, & Hardin, 2014), since well-structured teacher education can enhance teachers' skills and knowledge which can improve student achievement in turn (Knight & Wiseman, 2015; Valiandes and Neophytou, 2017).

Mixed methods approach was used in order to examine following issues behind the main problem: low achieving students' thoughts about chemistry and chemistry teaching practices compared to other students in diverse classrooms (RQ1), STSE-based school-industry collaboration and its affect to pre-service science teachers' beliefs about their future practices (RQ2), and pre- and in-service teachers' beliefs about teaching chemistry in diverse classrooms (RQ3). The results are in line with the hypothesis that teachers' positive beliefs can have a positive effect on their practices in diverse classrooms, and if those practices are also preferred by students, it affects positively to their achievement in turn. A deeper discussion of the results is divided into three parts according to the research questions. A model for teacher support based on the main results of this thesis is presented in Figure 2., p. 29.

6.1 The relationship between student achievement and teaching practices

The purpose of the first research question: "*What do low achieving students think about chemistry and chemistry teaching practices compared to other students in diverse classrooms?*" was to find out more information about the attitudes of low achieving students and the relationship between achievement levels and most preferred teaching methods. Students' negative attitudes correlated significantly with their low achievement in chemistry. That is in line with the previous studies (Gilleece et al., 2010; Brigham et al., 2011) although previous studies have concerned mostly science subjects in general, not only chemistry (Kan & Akbas, 2006; Brandriet et al., 2011; Xu et al., 2013; Kahveci, 2015).

Some differences were found within a group of low achieving students concerning their attitudes towards chemistry. Non-native speakers and students with learning difficulties had more positive attitudes than other low achieving students. Non-native students' positive attitudes have been shown before concerning science subjects (Kärnä et al. 2015), but there are no previous results that low achieving students with special needs could have positive attitudes towards chemistry. Moreover, low achieving boys had more positive attitudes than girls. The results are concordant with other studies (e.g. Brandriet et al., 2011; Desy, Peterson & Brockman, 2011), although the relationship between gender and attitudes towards science is not straightforward (Kahveci, 2015). Actually, it can be assumed, that negative attitudes and their correlation with low achievement is not straightforward at all, since there are so many differences within that group. Consequently, teachers should take those differences into account, find more information about students' attitudes, and encourage them especially with the positive ones.

Scientific field trips, using internet and videos and having student-centered teaching

practices were mostly preferred. The results are similar to in some other studies concerning science and physics (Juuti, Lavonen, Uitto, Bryman, & Meisalo, 2010; Fowler, 2012; Fan, Heads, Tran, & Elechi, 2015). Notably, all students in this study (n=2949) were almost unanimous about the most preferred teaching methods in spite of their achievement levels. The result is significant especially for those teachers who try to find materials and methods that would be suitable for students in diverse classes. Accordingly, this study suggests that students' attitudes and even achievement could be affected by providing methods and materials that students prefer. It is, therefore, important that teacher knows more about the students' attitudes and how to adapt different teaching practices for all students in spite of their achievement levels. Collaboration with different members of community could help teachers to improve their knowledge about different learning environments that are outside schools. For example, field trips to companies could be a fruitful way to combine school subjects to real-world examples of services, products and careers that are related to chemistry and science.

6.2 The relationship between pre-service teachers' beliefs and STSE-based teaching practices

The second research question was: "*How does STSE-based school-industry collaboration affect to pre-service science teachers' beliefs about their future practices?*" In the case-study, mixed methods were used to examine the STSE beliefs of Finnish and Slovenian pre-service teachers. Furthermore, the benefits and challenges of school-industry collaboration and practices were examined. Visits to industries and companies were used as an example since they have many benefits (e.g. Orion & Hofstein, 1994), they are the most popular teaching practices (Kousa et al., 2018), and there not many studies about them (Brunton & Coll, 2005).

The pre-service teacher education course and school-industry collaboration had many benefits. Firstly, the confidence and readiness to teach STSE issues were significantly improved after a course. Corresponding results have been acquired from the STSE-based multi-media course by Pedretti et al. (2008) as well. Secondly, the teacher students found that the materials that they developed, had many benefits such as versatility and multipurposeness. As proven earlier, STSE issues are considered versatile, rewarding and enjoyable (Kisiel, 2005). The material was also regarded as suitable and beneficial for students with different achievement levels. That is in line with the study of Bettencourt et al. (2011). Pre-service teachers also believed that the materials were interesting and had connections to students' lives. Accordingly, STSE issues can improve students' understanding of scientific issues and help them to become more responsible and capable citizens in society (Lumpe et al., 1998). It can be suggested, that materials that are based on school-industry collaboration as well as visits could help students to understand what kind of connections there are between science subjects and their daily lives concerning for example, different careers, materials and products. That can enhance the meaningfulness of science subjects and make students more interested in them, and most of all,

improve their achievement in science as well.

Notably, there were some challenges with the school-industry collaboration and few of the challenges were new. To begin with, students found the collaboration with company representatives uneasy. Similar difficulties with communication have been noticed also before (Hofstein & Kesner, 2006). Furthermore, the collaborating school teachers gave no support or ideas to the pre-service teachers and were passive before and during the visit. Teachers' passive role concerning field trips has been identified previously as well (Tal & Morag, 2009). Development of the teaching material had a few challenges such as disagreements, the lack of time and passivity of student colleagues. It is known, that implementing STSE issues to teaching takes time and effort (e.g. Halwany et al., 2017). In this study, the material was found too modern according to some student teachers. The non-traditional features of STSE issues have been discovered challenging before (Bettencourt et al., 2011). Finally, pre-service teachers hoped that they would have opportunities to practice their STSE skills in the future. Concordant suggestions for more practice with STSE issues are also previously presented (Hofstein & Kesner, 2006).

In summary, school-industry collaboration and visits can improve pre-service teachers' confidence and readiness to teach with the STSE approach. To accomplish better skills and knowledge, the teachers should have regular opportunities to practice those skills. Accordingly, this study suggests that pre-service teachers' beliefs can be affected positively by sufficient teacher education which includes collaboration with local schools and companies within a community. This, in turn, can have a long-term influence on their future practices.

6.3 Pre- and in-service teachers' beliefs about diversity and supportive teaching practices for diverse students

The third research question was: *"What kind of beliefs pre- and in-service teachers have about about teaching chemistry in diverse classrooms?"* To begin with, pre-service teachers had many concerns such as how to take students' individual needs into account in diverse classrooms (report III). In-service teachers were remarkably concerned about the same thing (study IV), which is also one of the biggest concerns in education (Konstantinou-Katzi et al., 2013). Consequently, in-service teachers found that they are not sufficiently educated for diversity. That is also a well-known problem (e.g. Mumba et al., 2015) According to Woollacott et al., (2014) teachers are unable to respond to students' needs, since they do not know their students well enough. However, teachers do have general knowledge about diversity and supportive teaching methods as study IV pointed out. In spite of that, lack of time, resources, materials and knowledge were regarded insufficient. These are also well recognized needs from the previous studies (Norman et al., 1998; Konstantinou-Katzi et al., 2013; Markic & Abels, 2014; Mumba et al., 2015; Benny & Blonder, 2018).

Pre-service teachers were concerned about their abilities to teach in diverse classrooms

and find ways to connect real-world examples in order to make chemistry more interesting. To be able to connect theory and practice was also considered important by in-service teachers in this and previous studies, as well (e.g. Santangelo & Tomlinson, 2012). Furthermore, in-service teachers were aware of what kinds of teaching practices would support their students' attitudes and achievement, although they stated that connecting theory and practice was challenging. Nevertheless, teaching practices such as real-world examples, visits, using computers and videos that were mentioned beneficial in study IV, were similar practices than all students would prefer in spite of their achievement levels according to study I. STSE related topics have been advantageous for diverse students before (Bennett et al., 2007) as well as student-centered teaching practices (Markic & Eilks, 2012). It is essential that the connections between theory and practice are made meaningful for students. Familiar contexts from students' lives or methods that they prefer can be inspiring, interesting and have a positive effect on their achievement as well.

There were some challenges with differentiative teaching practices, although in-service teachers agreed that they are essential in diverse classes. However, to be able to support everyone was seen difficult and even unrealistic according to both pre- and in-service teachers. Previous studies have also presented corresponding results (Southerland & Gess-Newsome, 1999; Lambe & Bones, 2006). Furthermore, some teachers were worried about the resistance that the usage of differentiation could cause within some students and parents. Differentiative teaching practices could, however, improve the equity of students (Lambe & Bones, 2006; Valiandes, 2015) and therefore, it is very important. Both pre- and in-service teachers regarded that planning and implementing differentiated teaching material acquires more time and effort contrary to traditional one. In-service teachers also thought, that teaching is not effective if the lessons are not properly planned. However, differentiated teaching material was considered worthy and advantageous for the entire class like Janney & Snell (2008) have pointed out earlier. In summary, differentiation should be a normal part of teaching in diverse classes although they usually require more time and effort than normal ones. Nevertheless, when the material is once carefully developed, it can be applied for an individual, group or the entire class.

All in all, these studies suggest that adequate teacher support should be provided regularly during teachers' careers and sufficient support and resources are essentially important in order to teach successfully in diverse classes. Firstly, pre-service teachers' beliefs, needs and concerns should be taken into account during their education. Pre-service teachers could benefit from experiences such as classroom observation and thus, get familiarized with diversity in authentic environments. This could be arranged by collaboration between schools and teacher educators. For example, a tutoring network of more experienced subject and special education teachers could have a major role concerning pre-service teachers support with diverse students. If pre-service teachers have more knowledge about diversity and differentiative teaching practices they would not necessarily be so concerned or worried about their future as science teachers in diverse classrooms. Furthermore, teacher support should be continued after pre-service

education. Notably, teachers' own expertise as well as practical skills and knowledge should be taken into account and their opinions should be heard more often. It is worth noticing that both pre- and in-service teachers need opportunities with practical activities along with theoretical information. It is also important that additional support from colleagues, special education teachers and teacher educators should be available when needed. This could be done by expanding the collaboration and tutoring network to teacher educators, school principals and more and less experienced subject and special education teachers who could share their experiences and knowledge of supportive teaching practices. In addition, students in diverse classrooms should also be involved with the network at least in the classroom-level, since their achievement is depending on their attitudes that could be improved for example by using classroom activities that they prefer. In summary, pre- and in-service teacher support can be seen as a wide network of novices and experts who cannot reach the aim of better student achievement without regular collaboration.

6.4 Implications

There is not much national or international research about the topic of this thesis. Therefore, it can be stated that this thesis has proposed prominent insights and ideas for science teachers and teacher educators about diversity and teaching practices for diverse classrooms. According to the results of this thesis, there are three parts in teacher education which are clearly connected together: teachers' beliefs, practices and student achievement. It can be supposed that teachers' beliefs affect their practices and practices, in turn, can affect students' achievement. Since teachers generally recognize students' needs and use a considerable amount of effort in order to support them, it can be also assumed, that students' achievement has a significant effect on teachers' practices as well. Accordingly, there are many possibilities to examine those relations and find ways in which to improve classroom practices for diverse students. Since it was not studied in this thesis, how different teaching practices affect to student achievement, that would be the next step for the research of this topic. Secondly, since the focus of this thesis was on the development of science education concerning pre- in-service teachers' needs for support, it would be essential to find more information about the supportive methods and how they could be utilized during teachers' career. In addition, more knowledge is needed about learning difficulties and disabilities and how they could be alleviated in regular chemistry classes.

Since student diversity and especially low achievement is an increasing concern throughout the world, science and chemistry teacher education should be focusing strongly to those concerns and take them seriously. It is essential, that sufficient teacher education is regularly provided during teachers' entire careers. For that, more effective collaboration between teacher educators, teachers, parents, students and community members such as companies is needed. The collaboration should be also cross-cultural in order to better understand student diversity. The aim was to find ways how science and chemistry teachers

could be professionally supported for diversity and better student achievement during pre- and in-service teacher education. A model for teacher support based on the main characteristics (Figure 1., p. 3) and results of this thesis is presented in Figure 2.

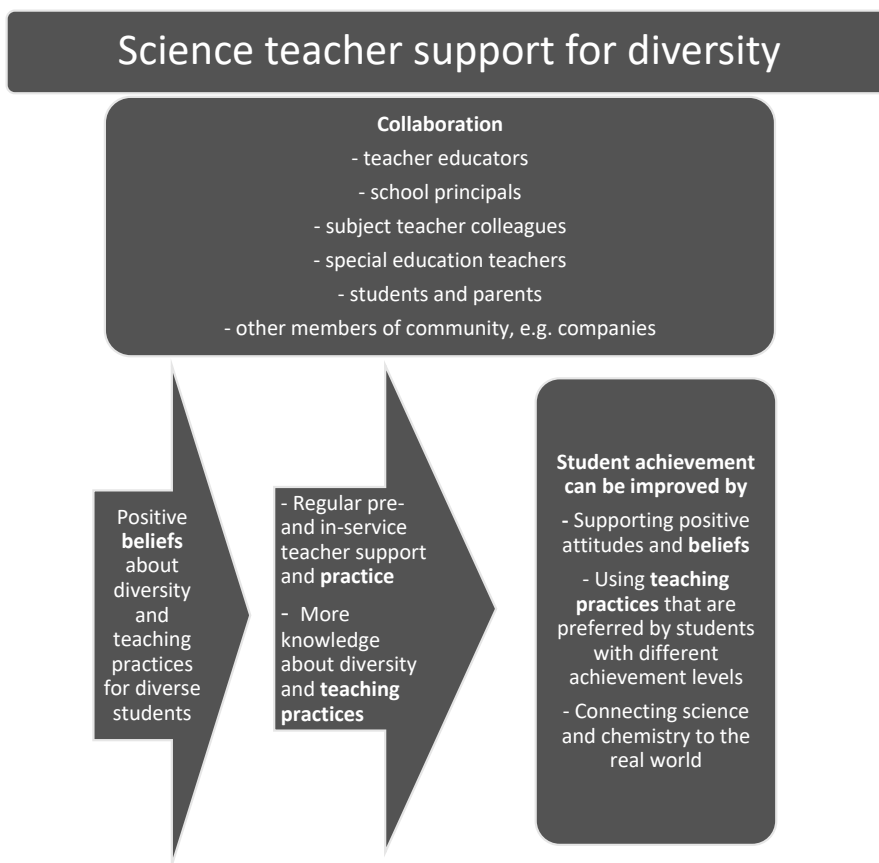


Figure 2. Regular support for diversity during pre- and in-service education affects teachers' beliefs, practices and student achievement in turn.

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