

# Learning to Teach at Heterogeneous and Diverse Chemistry Classes - Methods for University Chemistry Teacher Training Courses

Yannik Tolsdorf <sup>1</sup>, Päivi Koussa <sup>2</sup>, Silviya Markic <sup>3\*</sup>, Maija Aksela <sup>2</sup>

<sup>1</sup> University of Bremen, Bremen, GERMANY

<sup>2</sup> University of Helsinki, Helsinki, FINLAND

<sup>3</sup> Pädagogische Hochschule Ludwigsburg, Ludwigsburg, GERMANY

Received 17 February 2018 • Revised 29 June 2018 • Accepted 30 June 2018

## ABSTRACT

Circumstances in school change and teachers constantly face different obstacles. One of these includes dealing with heterogeneity and diversity in chemistry classes. Future chemistry teachers need to be aware of the differences in their classrooms. They must be prepared to diagnose and handle differences in order to obtain the best possible learning outcomes for their students. The present paper presents a cooperative project, which develops and evaluates teacher training modules at the University of Bremen (Germany) and the University of Helsinki (Finland). The seminars are based on a 3-step model which will be described as well. This model focuses on the initial sensitization of student teachers for heterogeneous chemistry classes (first step) and qualifying future teachers to diagnose (second step) and deal with heterogeneity and diversity in chemistry classroom (third step). Examples taken from the courses at both universities will be presented and preliminary evaluation results are given and discussed. First successes of the three steps of qualifying student teachers are recognizable in both countries. The courses in both countries show a short section from the teachers training program for the Bachelor and Master degree. All students attend different school in an internship after or during the courses.

**Keywords:** chemistry education courses, chemistry student teachers, heterogeneity, sensitization, teacher training program

## INTRODUCTION

Nowadays chemistry classes are becoming more and more heterogeneous. This is especially true in west European countries like Germany, Finland, France, the United Kingdom and Ireland, where these changes are very noticeable. One explanation lies in the currently high levels of migration from one country to another due to worldwide economic changes (“globalization”). Populations in many countries are becoming increasingly diluted and heterogeneous in the ethnic, linguistic and cultural sense. These factors covering the changes in school populations have also become much more obvious since PISA and TIMMS were published (Lynch, 2001).

Bremen is one of 16 federal states in Germany and consists of two parts (the city-state of Bremen plus Bremerhaven). Bremen is characterized by a high percentage of families with migration backgrounds. Just as in most parts of Germany, these groups tend to be mainly Turkish, Arabic, Russian and Polish. Bremen also has the highest percentage of unemployed people in Germany. Finally, when comparing Bremen federal states in studies like PISA and TIMMS, Bremen always occupies the last place.

Unlike in Germany that has a different curriculum in different states, Finland has only one. At first glance, PISA and TIMMS success does not necessarily give the precise picture of educational equity in Finland. For example, the academic achievement gap between 15-year-old immigrants and native students remains one of the highest in

**Contribution of this paper to the literature**

- The heterogeneity and diversity in schools all over the world increases. This influences university teacher training programs as well. The paper describes how student teachers can be prepared to teaching heterogeneous and diverse chemistry classes.
- For teaching heterogeneous and diverse chemistry classes and implementing individual learning requirements of the pupils in chemistry teaching, the sensitization of the student teachers is particularly important.
- The presented model for university chemistry student teacher education was implemented in two countries. Both universities are different in their educational system and chemistry student teacher programs. Similarities in the developed courses could be identified.

“Organisation for Economic Co-operation and Development” countries (OECD, 2016). Immigrant students experience school burnout at higher levels as compared to native students in Finland (Salmela-Aro et al., 2016). They also have difficulties in reaching higher education after comprehensive school and have higher risks of dropping out of school than native students (Järvinen & Jahnukainen, 2008).

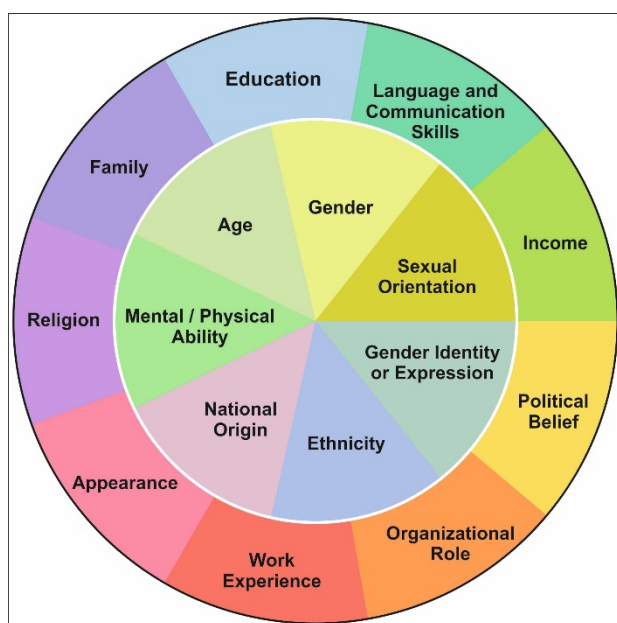
Both countries have different starting points, why the issue of heterogeneity during the teacher training program is an important topic. However, the issues faced by German and Finnish chemistry teachers in both countries are similar. Both German and Finnish teachers in general and chemistry in particular need to know how to deal with the different requirements of students and how to teach each student chemistry according to his or her needs.

Going one step backward, student teachers need to be prepared for the heterogeneous and diverse classes they will meet during their internships and will teach in the future. Thus, the aim of this cooperative project is to develop teacher training courses that prepare future teachers to deal with heterogeneity and diversity in chemistry classes. All of the student teachers in the present project as well German and Finnish were informed and aware of the evaluation of the study and participated the research by choice.

## THEORETICAL BACKGROUND

### Heterogeneity and Diversity

Students bring many different prerequisites to the classroom and teachers need to cope with each one. The differences are multifaceted and often overlap. In the literature in the USA, these differences are summarized using eight main dimensions. The so-called “Big 8” are age, gender, ethnicity, religion, race, sexual orientation, functional role, and mental/physical ability (Krell et al., 2007). Another common representation employed is the diversity wheel, which is mostly used for diversity management in organizations. It distinguishes between internal (permanent and visible) and external (change over the life time) dimensions ([Figure 1](#)).



**Figure 1.** Diversity Wheel (see Abels & Markic, 2016)

There are different approaches for dealing with differences in the classroom. The spectrum of approaches is wide. It is possible that the teacher ignoring the heterogeneity (passive reaction). The lesson can be adapted to the students (substitutive and active reaction). But also, the teacher fosters all students individually with specifically differentiated lessons (proactive reaction) (Weinert, 1997).

These different approaches can be associated with "heterogeneity" and "diversity". "Whereas the paradigm of heterogeneity perceives difference as a challenge to be dealt with actively, diversity as a systemic paradigm perceives difference as an asset" and a resource for learning" (Sliwka, 2010, p. 213).

Differences in the classroom are often connected with under-achievers (Kousa, Kavonius & Aksela, 2018). There are various ways to define low achievement. According to EU-report (2016), low achievement in science is often a temporary situation where a child does not reach the basic level of skills required at school. Under-achievement is not necessarily the same thing as learning difficulties, although those categories can overlap each other. In addition, there are other categories of students who can also be considered low-achievers. These include who have migrant family backgrounds, socio-economic disadvantages, low achievement in literacy or other additional needs in education. Although there are specific risk factors such as low socio-economic conditions or an immigration background, low achievement can also be found in all families, regardless of socio-economic status. In the present paper under-achiever considered to belong to multilateral parts of the diversity wheel (Kousa et al., 2018; see [Figure 1](#)). In some parts of Germany, new courses have already been anchored in the teacher training program. The changes started at the political level. In all courses of the teacher training program, a language and multilingualism in school is the important point for inclusive teaching. Additionally, student teachers for primary and lower secondary school have a more special need education content in the teacher training program (Stellbrink, 2012). In the field of multilingualism in schools, new master's programs in educational linguistics are offered with more educational and didactical orientation, e.g. Institute of Education at the University of London with the program bilingual learners in urban educational settings. Heidinger and other (2018) described, that the professional development does not teach only the inclusive pedagogies content, furthermore a reflection and sensitization of beliefs in inclusive scenes teaching are important. But also other researcher reported that in the chemistry teacher training program the belief needs to be reflected and more positive regards to the heterogeneity and inclusive teaching (Mumba Banda, Chabalengula, 2015; Haq & Mundia, 2012). At the University of Dortmund, the chemistry education cooperate with the special needs institute. This cooperation project uses the "Universal Design of Learning" from Rose and Meyer and integrate this model step by step in the teacher training program. Vitoriano and other say that visualizations need to be considered more in chemistry teaching and the future chemistry teacher have to be prepared during the study for this with examples. These examples show that often only further courses offered for an inclusive teaching at the universities.

At last, one of the competencies and knowledge domains that student teachers need to gain during their university teacher training is focusing on the diagnosis and support of their future students. In schools, the implementation of these competencies can be structured in different steps. At the beginning, the teacher should define the aim of the diagnosis. This preparation is called the Pre-Actional phase. Regarding the goal, special methods and instruments need to be selected. This is followed by the Actional phase, in which the collection of information is the focus. A solution is developed and implemented with the help of the collected information. This is described as the Post-Actional phase (Klug et al., 2013). To use a diagnosis profitable in chemistry teaching, the teachers' attitudes and beliefs about pedagogical diagnosis are important (Ohle & McElvany, 2015). Thus, the teachers need to be sensitized to individual problems of students, so that they recognize the effects of different heterogeneity dimensions on learning chemistry. Further, a teacher needs varying knowledge in each of these different steps. For the development of our university modules, a knowledge of the range of diagnostic possibilities, the types of different instruments available (Pre- and Actional phases), and the many methods of changing detected behavior or steering personal experiences are especially important (Post-Actional phase). Klug and other (2013) also emphasize the cyclical nature of the process in order to review the support provided to the learner.

## STARTING IDEA OF THE COURSES

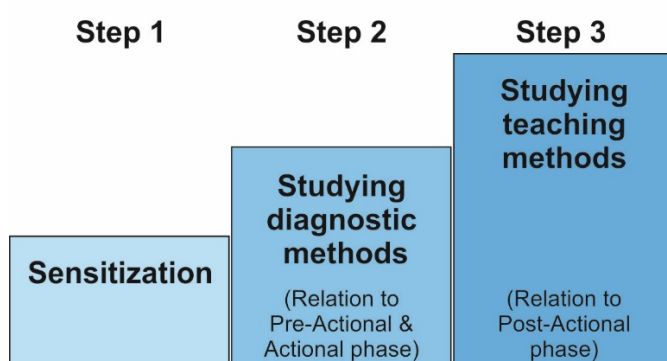
Starting from the issues and obstacles named above and the concept of diagnosis, the overarching goal of the current cooperative project was to aid future chemistry teachers in both countries in dealing with diverse groups in their future chemistry classes. In a participatory action research project for the university level (Tolsdorf & Markic, in review), the teacher training program in both countries is developed. These two chemistry education researcher teams have developed ideas separately from each other and in exchange with adjoining sciences (mathematics education, pedagogy or German as a second language). In order to use the most varied and different perspectives on the topic, the action research model was used for the development process. This model has already tried and tested on the school level in chemistry. As participating researchers, we can contribute our ideas in a cooperative interaction of action and reflection. In the different meeting, visits, and observations of each other seminars, different methods, and tools were discussed and – if needed – adopted from the other university.

Starting from the diversity dimensions presented in [Figure 1](#) and to identify the focus of our work discussions, we communicated with different groups of researchers (e.g. chemistry educators, science educator, etc.). Additionally, both chemistry teachers and student teachers were asked in order to reveal which dimensions of the diversity wheel influence teaching and learning in chemistry classrooms the most (Markic, 2018). The results from the discussions pinpointed four dimensions as the most important factors, independent of the country: 1) language and linguistic skills, 2) culture, 3) cognitive differences, including differences in content knowledge, and 4) students with special needs. Thus, the named dimensions will be considered in following joint project and these four dimensions are the focus of the development process. However, the additional dimensions are not to be ignored and will play a minor part in our seminars.

Furthermore, the researchers (authors and further researchers) discussed different ideas for how to carry out seminars and lectures. By studying and discussing different models presented in the literature (e.g. Taber, 2005; Calderhead, 2011; Markic, 2015) and focusing on the description of diagnostic process by Klug and other (2013), we decided to organize student teachers' efforts by following three main steps (see [Figure 2](#)):

1. Sensitizing chemistry student teachers for heterogeneity and diversity
2. Studying different diagnostic methods
3. Dealing with heterogeneity

### **Structuring model of the courses**



**Figure 2.** Developed model for structuring chemistry teacher education modules

Following, the reason of this focus on three steps is based on the above described process of diagnosis. Even to start this process, student teachers need to be sensitive for the differences and the different requirements students could have in their future chemistry classes (Step 1). Step 2 and 3 describe pedagogical diagnosis, which is an assessment of learner information followed by subsequent actions to solve any problems (see for more details above and Tolsdorf & Markic, 2016). This is only a minimal issue in the current module, but it is an integral part of the internship.

In the first step, chemistry student teachers are sensitized to the different dimensions of heterogeneity and diversity. This is the big issue for the chemistry teacher training program because the student teachers cannot imagine the heterogeneity or diversity in chemistry classes due to their own biography in a grammar school (Tolsdorf & Markic, in review). Therefore, they are taught how to recognize the influence of such differences on their teaching in the future, including the influences differences may have on students' overall learning (Step 1).

A further step is helping student teachers study how to recognize and diagnose differences (Tolsdorf & Markic, 2016). Student teachers are given information about the different instruments and tools which are available to analyze the differences in different dimensions of chemistry class (knowledge in Pre-Actional phase). Finally, chemistry students also study how to develop such instruments for their own needs and to match them to the needs of their future classes. This knowledge can or must be used in practice (Actional phase).

Finally, student teachers are become acquainted with different methods and media offerings which can be used to deal with differences in future chemistry classes. The tools are presented with an eye towards issues such as integration and inclusion, as well (Post-Actional phase). The cyclic process of a diagnosis is not only to be taught during the university module. It is particularly important for student teachers to experience this process during their internship. As a part of a development process of chemistry teacher education modules, this structure was developed with the help of the Participatory Action Research (Eilks & Ralle, 2002; Tolsdorf & Markic, accepted). In the following example, modules from both countries will be presented as well as the evaluation results. The focus of the paper is the practical description of the modules.

## METHODOLOGY

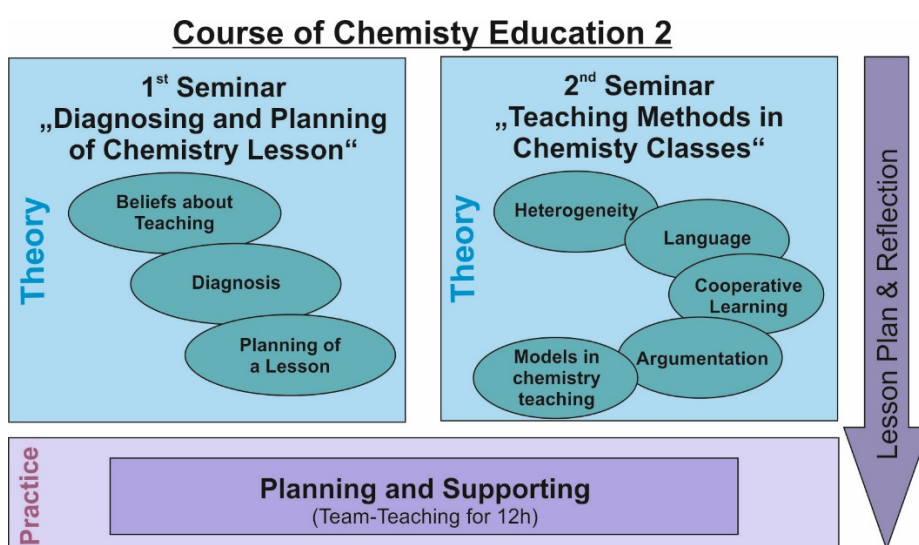
### Courses in Bremen

Chemistry education at the University of Bremen qualifies student teachers to teach at comprehensive schools. The University of Bremen offers different seminars which focus on different dimensions of heterogeneity and diversity. Chemistry student teachers attend four modules in chemistry education for 24 credit points (ECTS) in all. Two modules must be taken during their Bachelor's program and the other two in their Master's program. One module at each level focuses particularly on heterogeneity and diversity in chemistry teaching. Furthermore, it is only in these two modules where the combination of the theory and practical phases is emphasized.

The first module is called Chemistry Education 2 (ChemEd 2). Fifth-semester students visit two different parallel seminars during the semester (see [Figure 3](#)). At the beginning, the focus is on the stimulation and motivation of student teachers' self-reflection on their own beliefs about teaching and learning chemistry. After this, the focus is on building student teachers' diagnostic competence (Jäger, 2009). One of the key aspects is the diagnosis of linguistic heterogeneity in the classroom. After finishing the theoretical phase, chemistry student teachers take part in an internship. Their goal is to diagnose the lessons and the students and to plan their own lessons based on the results. A small group of two student teachers diagnoses students' differences as well as the classroom situation. The student teachers inform themselves about possible diagnostic instruments and develop and use this tool in the teaching unit of the mentor at school. Then the student teachers plan their own lessons, which are only three lessons.

The second university module regarding heterogeneity is called Chemistry Education 4 (ChemEd 4). In the theoretical phase, seventh-semester student teachers amplify their diagnostic competence. After this semester student teachers have a final internship for about four months (see [Figure 4](#)). The length of the internship depends on the school holidays. During this time, they visit three full-day seminars, so the module finished after two semesters.

Most of the student teachers in our seminars experienced schools (including their own time as students) with very low levels of heterogeneity. Based on short interviews about diagnosis and support in chemistry teaching (Tolsdorf & Markic, in review) we know that student teachers link heterogeneity solely with achievement. The student teachers rarely see any other dimensions which also exist in chemistry lessons. This perceived dimension also includes into their own planning of chemistry teaching, for example, culture, migration or students with special needs. During the first half of their internship, student teachers diagnose students' needs and preconditions in their mentor's class. Based on the results, they plan the lessons for the second half of their internship. During their teaching, student teachers continually diagnose their students' needs and preconditions to adapt the lesson to the state and changes in the class. Each student teacher has the support of the mentor at school. The planning is already a big challenge for some student teachers, thus, they were supported by the university staff in the implementation of the diagnostic into chemistry teaching.



**Figure 3.** Overview of the university module ChemEd 2



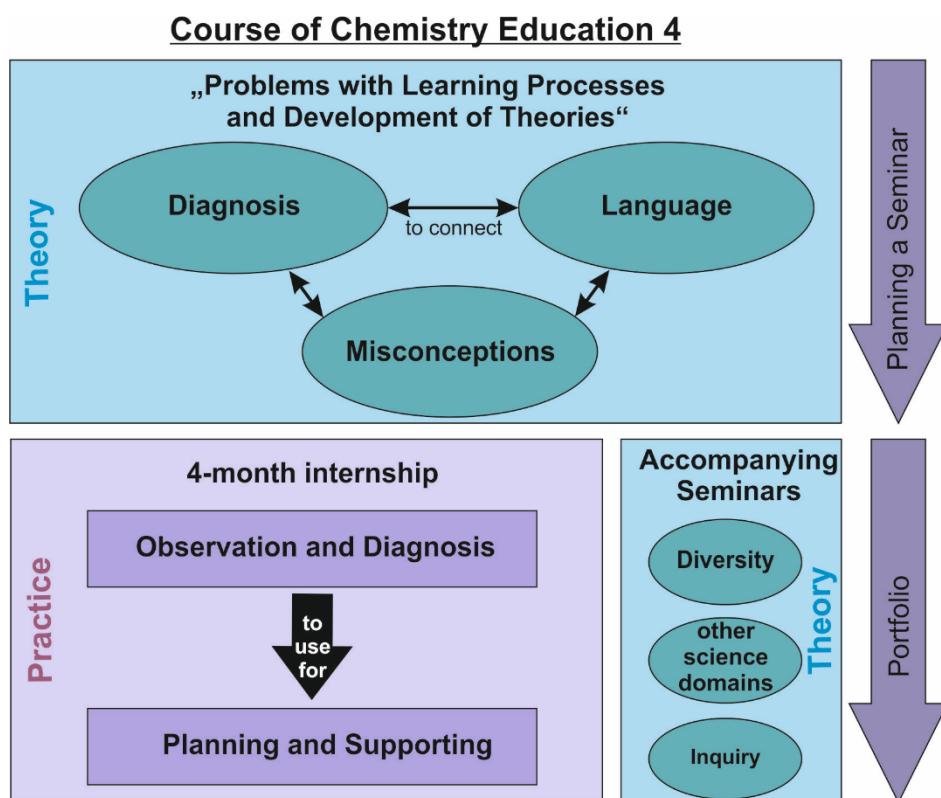


Figure 4. Overview of the university module ChemEd 4

### *Methods used for sensitization to heterogeneity and diversity*

As already mentioned, the student teachers rarely know more than one dimension of the heterogeneity and diversity in chemistry classrooms. Therefore, they must be sensitized at the beginning and they need to recognize the effects or influences on teaching. The sensitization of the student teachers about individual dimensions of the heterogeneity or diversity is repeatedly done during the teacher training program in chemistry education. To sensitize future chemistry teachers to the different dimensions of the diversity wheel, the seminar starts with a role-playing exercise. Student teachers take the role of different students in a regular, fictional school class. The role-playing considers several dimensions, the role-playing was performed at the beginning of the long internship.

The roles include a student with special needs, a young refugee, an average student and gifted student. After finding themselves in the roles student teachers are then led to role-play a chemistry lesson situation with the topic "Working like a scientist". They need to work in groups, conduct experiments and make notes on their work-sheet. The lecturer tries not to interfere in the role-playing exercise. He or she will intervene if necessary, for example, the student teachers cannot adapt the given role. Thus, student teachers need to solve the problem in their own groups playing their given role.

After the role-playing game chemistry student teachers reflect upon it. Important questions in this phase are:

1. Which dimension of heterogeneity and diversity did you notice in the exercise?
2. How did you perceive the heterogeneity and diversity?
3. How did you learn from your role and experience the lesson?
4. How was your role influenced by other students?
5. How did heterogeneity impact or influence the lessons?
6. How did you feel in the game? Did your feelings and impressions change during the lesson?

Particularly interesting are questions 3-6, which are intended to highlight (non-)consideration of heterogeneity and diversity in chemistry teaching. This helps to sensitize the students to this topic so that heterogeneity becomes a natural part of the lesson planning. Furthermore, it is important that student teachers experience how they feel in heterogeneous classes in order to understand their behavior. It is possible, that student teachers have already experienced these roles in their internship. This experience can be included in the reflection.

As a summary of this phase, the students prepare a presentation about heterogeneity and diversity to complete the role-playing part of the unit. The focus is on the influences of heterogeneity and diversity on chemistry teaching. Following this, examples from the practice called vignettes (Campbell, 1996) are presented to the participants and reflected upon. The vignettes in the presentations describe scenes in which a student has misunderstood (misinterpreted) a word in a sentence, for example, synonyms found in both scientific language and everyday language. The student teachers work on two main topics: (i) What is the problem with the presented situation? and (ii) What caused this problem? Thus, the intention is to promote student teachers' diagnostic abilities. In the example above, student teachers must recognize that the vignettes describe students' linguistic difficulties while learning chemistry (Markic et al., 2013). Thus, they experience the effect of linguistic influences on chemistry learning, with an emphasis on the meaning of diagnosis for (the German) language and science language.

### ***Methods for learning about different diagnostic tools***

In the second step of the module in a seminar, the student teachers study different diagnostic tools, regarding to the dimensions in the sensitisation. These diagnostic instruments are present detail: structures, goals, (dis-)advantages, uses and analyses. Examples taken from actual practice are also given to support student teachers' understanding. Before the module (ChemEd 2) starts, the student teachers have almost no knowledge about diagnostic instruments (Tolsdorf & Markic, 2017). For this purpose, we have developed a learning-at-stations module where the different instruments are presented. Furthermore, these examples illustrate that the content or topics of the lessons should not be separated by the instruments. Thus, it is possible for teachers to integrate the instruments into the planning of their lessons. The stations were integrated in the presentation software PREZI which allows for modern and flexible use. On the one hand, some diagnostic instruments stem from the literature, e.g. Multiple-Choice-Test by Chandrasegaran and other (2007) is translated and these tests are described in more detail. On the other hand, some instruments are adapted from other subjects to individual domains of the diversity wheel (e.g. linguistic skills), e.g. the idea of C-Test from German language education is adapted to diagnose scientific language. Summarized, all instruments were divided into six main areas: (i) German language, (ii) scientific language, (iii) content knowledge, (iv) misconceptions, (v) experimental skills and (vi) chemistry teaching. Thus, student teachers learned about several instruments from these six areas. On the one hand, student teachers see the structure and conception of different diagnostic instrument for chemistry teaching. On the other hand, the possibilities of use and the integration into the lessons are described. The instruments are specific for the context or the topic in chemistry. From there, the described instruments are easy (for the student teachers) to adapt to other topics. The main question of the learning-at-stations is: How can teachers perceive/recognize the different dimensions of the diversity wheel while teaching chemistry? This part of the seminar is intended to show the existence and diversity of the various instruments for diagnosis in chemistry teaching, which can be used for their own teaching. The reflection of the instruments is important to identify (dis-)advantages or the implementation for own teaching but also to reflect on combining the instruments (and diagnostic of their own language in the classroom) with their own role as a future teacher. The reflection aims to help student teachers' decide which instruments they would use for own teaching. In subsequent sessions, the student teachers are guided to develop their own instruments for the internship.

### ***Methods for learning about dealing with heterogeneity and diversity in chemistry classrooms***

In the sense of a diagnostic process (Jäger, 2009), results obtained must be considered when planning chemistry teaching. The student teachers must learn to adapt their teaching and materials to the learning preconditions of their future students.

The focus is on dealing with heterogeneity and diversity in chemistry lessons. The lecture presents different experiments which are found in German secondary school curricula. Student teachers need to develop teaching materials which consider the four dimensions of the diversity wheel (see above), as the important factors of teaching (language, culture chemistry and special needs). To attain this goal, teachers work on different examples of good practices taken from the literature. They must discuss in group the question of what makes up the characteristics of the different methods and how they can be adapted to teaching. This method follows two goals: (i) On the one hand the student teachers learn about published materials, which were often developed for the field of science education. (ii) On the other hand, the students have to profitably employ the developed materials and research results in their own lessons. Finally, the students tailor the presented methods to different experiments which they have chosen. At the end, each group presents its modified experiments to the whole group. A discussion and ideas for further development are included during the presentation, so that the learners can recheck their materials. In this way, all students receive quality examples which help them to plan the lessons during the long internship. Guiding questions help the student teachers to orient on two questions for their reflection: i) Are all the experiments

suitable for all dimensions of heterogeneity? ii) How can I use different dimensions of heterogeneity in one experiment?

At the end of the day, it is particularly important to reflect upon the separate phases and the development of teaching materials. For example, the questions for reflection include: Are all the teaching units suitable for dealing with different heterogeneity dimensions? How can the developed materials be integrated into a teaching unit? Could the whole seminar help you to plan your lessons in chemistry with regard to heterogeneity and diversity? Does structuring the subject (contents) of a teaching unit help in the further development of the lessons with regard to heterogeneity?

The Chemistry Education workshop at the University of Bremen before the long internship was able to be further developed over three years with the help of the Participatory Action Research approach (Tolsdorf & Markic, accepted) in cooperation with student teachers. During this process, two researchers worked together intensely and evaluated the seminars. After each semester Likert-type questionnaire, as well as interview with group of student teachers, were collected and analyzed. Furthermore, a questionnaire about student teachers' diagnostic competence was analyzed as well (Tolsdorf & Markic, 2017, 2018).

### **Modul in Helsinki**

The Unit of Chemistry Teacher Education at the University of Helsinki generally uses a professional development model which has implementations like evidence-based teacher training courses and workshops (Aksela, 2010). Teachers with chemistry as a major subject at the Master's level will be qualified to teach chemistry at all school levels: mandatory comprehensive school (grades 1-9), voluntary vocational or upper secondary school (grades 10-12) and at the higher level, except for university. The students have only one obligatory course (4 ECTS) that deals with heterogeneity and diversity during their pedagogical studies in Country 2. The basic course is similar for all student teachers regardless of their teaching subject.

However, teachers face a challenge when they try to take all students' needs into account (Konstantinou-Katzi *et al.*, 2013). They should be able to develop material that is suitable for students with different achievement-levels (Hall, 2002), but there is a lack of information and training for that (Benny & Blonder, 2017; Markic & Abels, 2014). There is also a shortage of materials and methods (Markic & Abels, 2014).

The teacher is able to enhance students' success in mixed-ability classrooms if a proper support and training which improves both skills and knowledge are given (Valiandes & Neophytou, 2017). Professional development and skills to differentiate instructions and teach in mixed ability classrooms could be achieved if student teacher had more time to learn and practice those skills during their teacher training. That could also affect teachers' beliefs about their skills. (Dixon *et al.*, 2014)

Trying to support pre- and in-service teachers in their responses especially to low-achieving students' needs (Kousa *et al.*, 2018), the voluntary, intensive Master's level course called Eriyttäminen kemian opetuksessa (Differentiation in chemistry teaching) was held in the Unit of Chemistry Teacher Education at the University of Helsinki in 2016 for the first time. The second course was held next year. The course is worth 5 ECTS and includes 13 lessons that last about two and a half hours each. Most of the students have already done their internship before the course. Because of the novelty of this kind of course in Finland, the course is still in a process of development. The course is presented in more detail in this paper.

### ***Methods used for sensitization to heterogeneity and diversity in the course differentiation in chemistry teaching***

At first, student teachers are familiarized with the four dimensions of diversity (i-iv, see above), which influence teaching and learning in chemistry. This is done by taking lectures and carrying out exercises which include issues like simple language, texts and pictures in chemistry books, learning difficulties, gifted students and different cultural backgrounds. A role-playing exercise called "Explaining chemistry" is performed in pairs: one partner is a chemistry teacher and the other is a student who either possesses an immigrant background, has learning difficulties, or is gifted. The "teacher" first reads a chemistry-based text alone, they must explain it to the "student". The "student" can ask questions requiring clarification from the "teacher". After one round, students swap roles so that everyone plays as many roles as possible. The following reflection is then performed via a discussion of heterogeneity and diversity in the classroom. The students answer the applied questions (1-6), similar to the situation in Bremen during the reflection phase.

The sensitization phase is completed using real-life stories about a few, anonymous students and their challenges at school. Each group has its own case, such as a very impulsive girl whose achievement level and attitudes in chemistry are poor. The aim is to improve students' diagnostic abilities in order to recognize what is the problem and what might be the cause. After familiarizing themselves with the case, the group proposes a small



plan of how they would help the student if they were full teachers. All cases are presented in a plenum and the solutions that groups propose are shared and discussed.

### *Methods for learning about different diagnostic tools*

After the sensitization phase, different diagnostic instruments are presented for the six topics: (i) Finnish language, (ii) scientific language, (iii) content knowledge, (iv) misconceptions, (v) experimental skills, and (vi) chemistry teaching. Short lectures, videos, discussion and debates, short presentations of student teachers are used to represent those topics. In addition, student teachers make a visit to two randomly-chosen, secondary-school chemistry lessons (90 minutes each) and make careful observations about the issues that are concerned by the six topics by writing everything down. For example, the following issues are observed:

- the structure, contents, and aim of the lesson,
- the methods and tools that are used,
- the teacher's and students role and behavior and
- the communication and collaboration.

The student teachers share their experiences after the visit with each other and their lecturer. The reports are afterward collected for a later research and development of the following courses.

### *Methods for learning about dealing with heterogeneity and diversity in chemistry classrooms*

One of the aims of the course is to develop the suitable teacher supporting material for diverse students. Because there is a connection between students' attitudes and their achievement it is important for a teacher to find out about the teaching methods that could help students to succeed better in the mixed-ability classroom. Students prefer similar student-centered learning activities that are connected to their everyday lives despite their achievement levels (Kousa et al., 2018). Because student teachers have already had an internship and made quite a few lesson plans, they are familiar with chemistry materials, so there is no need to specify or rehearse the planning process itself. However, the participants are not familiar with materials concerning the four, named dimensions of the diversity wheel. They do not know where to find or how to make such materials.

To make a lesson plan for the mixed-ability classroom was an open-ended task. The aim was to simulate a real-life situation where the teacher has to make a lesson plan because the chemistry schoolbook is not suitable for everyone and there is no extra material available. The lecturer only suggested that the student teachers would pick up a topic which they think is difficult to learn in chemistry. Teacher students chose topics like electrochemistry, atomic model, periodic table and chemical bond. After the topic was chosen, the student teachers decided their target group and started to develop their material.

At the end of the course, the new teaching materials are presented and evaluated by the lecturer and the other student teachers. Suggested development of the materials is given after the evaluation, which includes observing the presentation, reading the materials, then discussing each item. The materials are disseminated to anyone interested and can be located on several web pages. The aim is to develop both materials which includes theory and experiments like hands-on activities suitable for the different dimensions of heterogeneity. This must take place in a way that takes the Finnish curriculum into account.

After the course, the student teachers were interviewed. The aim was to get feedback and find out how to further develop teacher training and research about heterogeneity and diversity in Finnish chemistry classes. The following questions were asked: 1) How did the course meet your expectations? 2) What were the most important things you learned about heterogeneity and diversity? 3) What do you still want to learn about those issues? 4) What kind of effect did the course have on your readiness to teach diverse groups of students? 5) What are your strengths/weaknesses and upcoming challenges as a future teacher facing diverse student groups? All teacher students' found that the course fulfilled their needs and expectations well. Many teacher students stated that the course "opened their eyes" and the "picture of mixed-ability classroom became more clear".

The new things that almost all teacher students mentioned that they learned were how to pay attention to the language that they use in the classroom when they write or speak, how to differentiate chemistry material for different achievement levels and how to recognize the different needs in the classroom. One teacher student's opinion about the most popular activity (observation) was that "you see all the things that happened in the classroom like in real life and differently than a teacher does".

Some of the teacher students would have wanted to learn more about how to deal with students who have such disabling conditions that acquire extra assistance for example while doing laboratory activities in chemistry. All students would have wanted a longer course.

Most of the teacher students felt that they would be more ready to teach diverse groups in the future. Many students mentioned good subject knowledge and positive attitudes towards teaching as their strengths.

There were, however many who were uncertain about how to get students interested in chemistry and how to make all of them learn. The classroom management was also one of the concerns as well as the constant lack of time. A few teacher students wondered how much effort it would take to develop material that is suitable for the whole class. One of the teacher students described her feelings like this: "I think I will never accomplish the knowledge and skills that are needed when teaching in a mixed-ability classroom. I don't know how to deal with those who behave badly and I have no previous experience with children."

## EXPERIENCES

These presented courses were developed with the participatory action research by Eilks and Ralle (2002). A groups of chemistry educators of both universities are working together to develop the own courses in chemistry education. Furthermore, persons from other subjects are involved in the development process, for example, science educators, mathematics educators, researchers from a language department. In the courses, a person observes the student teachers and he or she notes comments and statements of the student teachers. Because this person was involved in the development process this section is called experiences (and not results). During the observation, no personal data was collected. Additionally, further studies were conducted, but these studies are not mentioned in this article in detail because the focus is the practical description of the courses. The work of both universities was in a cooperative and participative exchange. The University of Bremen began little bit earlier with the development. So, first ideas have already been developed. Researcher from the Finnish University accompanied the development process at the German University over a semester. In this phase, practical impressions of the courses and experiences could be experienced, the concepts and ideas of the person from the Finnish University could be used for the development. At the end of this phase, the model and some smaller methods are developed, which are helpful at the German University. In the second phase, these concepts and ideas are adapted to the study structure and the teacher training program of the Finnish University. It becomes clear that the cooperation was equal, but the work or the development process of each courses was individual, depending on different curricula. However, the same methods and main structure are to be found in both seminars. The benefits were particularly in new ideas. The combination of the three steps of the model was only created by the strong cooperation. Here it turned out that the University of Bremen focusses on step one and three, and at the University of Helsinki it more step 2. For reasoning and substantiation of the argumentation, references are used in the text to further studies. The benefits of the participants in the development process is to learn from each other. On the one hand, we were able to learn new ideas and further research approaches. On the other hand, it was focused on individual dimensions by the own biography, that the cooperation opened the view again. We demand these open attitudes from our students, and we should ask ourselves again and again how far this will be reflected in the courses itself. The importance of the attitude of the lectures arose especially through the cooperation.

### Experiences in Bremen

First, some student teachers were unenthusiastic about the role-playing situation. It seems that student teachers feel that such things are unnecessary. Only a few students have this opinion after they have empathized into their roles and reflected on them. It seems that some student teachers are not sensitive to such differences in the dimensions of the diversity wheel before role-playing begins. This shows that most student teachers are prepared to step into the role of a student. Furthermore, very few of the participants had problems exactly understanding the behavior of the person in their role.

The emotions and attitudes of the students during the role-playing time were important for the reflection. Participants reported both positive and negative feelings and effects. One student said: "My role was that of an average student. I felt very good that I could share my knowledge with other students. But the other students made me slow down all the time" (translated from German by the authors). The description of the feelings of and effects on this student teacher represents the normal feelings of a pupil in the average classroom. In the first step, the discussion remained on this level. All of the groups over the years came to the general conclusion that "average" students are the most disadvantaged students in the classroom, but this contradicts new research literature (Mittler, 2015; Schlueter & Melle, 2018; Stellbrink, 2012). This "provisional" realization of the student teachers provides a basis for the reflection. Furthermore, many student teachers already recognize during the reflection, that the materials or the lesson in the role-playing were not designed for heterogeneous or diverse class. This was the moment when the student teachers noticed the different needs and roles in their classroom. Most of the student teacher experiences that they (and their mentors) had at school ignored "good" or "average" students. Mainly they focused their attention on lower achievers or students with special needs.

Finally, this kind of reflection is very important because it mentions the emotions about the different diversity and heterogeneity dimensions. On their own, our student teachers were not able to recognize heterogeneity and didn't know about it based on their own school experiences.

The practical vignettes proved helpful to reveal the effects of heterogeneity for chemistry teaching and learning to the student teachers. The vignettes seem to offer good examples, which present teacher trainees with practical insights into the influence of heterogeneity on chemistry teaching. Many student teachers wanted to guess the problem at the beginning, however, they could rarely predict it accurately. Furthermore, the vignettes initiated discussion between the participants. Some student teachers showed behavior resembling a "eureka effect". Either the students knew the similar situation from their everyday life or they were confused about the reaction of the student. Therefore, we can assume that such difficulties in chemistry classes remain unknown to the average student teacher. Thus, it is to assume that they do not recognize the effect on chemistry teaching and learning. At last, the work on the vignettes gave student teachers the opportunity to discuss the methods and instruments for diagnosis they would use in such a situation. It was interesting to see how different student teacher thinks about the applicability of the instruments. First ideas about the support were discussed as well.

Before discussing the experiences gained from this part of the seminar, we do need to clarify that the student teachers were not yet experienced in developing their own teaching materials at this stage of their training.

Generally, it was interesting to see the engagement of the student teachers in the whole workshop. The materials developed were tested during the internship, which supports the relationship between theory and practice. Thus, the development of teaching materials regarding the different dimensions of the heterogeneity and diversity increased the motivation of the participants.

In summary, most of the chemistry student teachers were sensitized for heterogeneity and diversity (see Tolsdorf & Markic, accepted), which means to know about the individuality of pupils in chemistry and the influences for teaching. This is not limited to content knowledge. However, they mainly focused their attention on their students' linguistic heterogeneity and on content knowledge (compare also Tolsdorf & Markic, in review). It is to assume that student teachers who have a high sensitivity on heterogeneity and diversity have also high knowledge about its influences. By interlinking the aspects of sensitization, diagnosis, and support, we could provide the student teachers with ideas for dealing with the different dimensions of heterogeneity, which could then be used in the subsequent internship. The reports from the student teachers during the internship showed that most of them are used these ideas, but few were overtaxed in the preparation and analyzing of some diagnostic tools. Here, awareness by the student teachers could be developed, benefit the heterogeneity in the classroom for the planning of the lessons. This means that the student teachers learned basics strategies for addressing the needs of all learners. Especially, a heterogeneity among the student teachers are also perceptible and it must be considered in the teacher training program so that the university lecturer works as a good example.

### **Experiences in Helsinki**

The observations about the methods for learning about different diagnostic tools was the most popular part of the course. Many future chemistry teachers stated that the observation really "opened their eyes" to see all the dimensions of diversity that are present in the classroom. They also found it easier to find the different characteristics of students when they did not have to teach, but could rather observe from the sidelines. Such observations could serve as a tool for becoming familiar with heterogeneity and diversity in the classroom. It should be used more often.

Because the students were already familiar with making lesson plans, the focus was to develop skills and knowledge about heterogeneity and diversity and how to adapt that knowledge to teaching materials. Student teachers found it difficult to take all the dimensions into account so that the content was not oversimplified and the material remained suitable for more gifted students. Students found that making this kind of materials took much more time than making the ordinary material.

Role play method was also successful during the course. The students were familiar with the role-playing method and had already used it in their teacher training and during their internship. Student teachers liked the exercise called "Explaining chemistry" and found it useful. However, they found it very difficult to speak and explain things slowly and clearly enough to people who did not understand Finnish well. In addition, some of the student teachers found it frustrating to have to think carefully about what to say and how to choose the correct terms. This experiment helped our future teachers to think about the way in which they talk. Often, the speaking pace was too fast in their opinion. They also had to confront how to take different students into account when explaining chemical phenomena. The students also started considering other ways of making explanations. Most of the students found the roles easy to adopt, because they had already practiced teaching in different schools. For the same reason, they were already familiar with the challenges that students might face at school. However, diagnosing what the problem was and what the root cause was proved difficult. Our chemistry students found the

group work and discussion useful and they hoped to have support in the future as well. It is very important that beginning teachers get sufficient support when starting their career, for example, from more experienced subject teachers and special education teachers as well.

All in all, the students find the course necessary but remarked that it was too short. They also wanted more imitations of real-life situations, for example how to deal with students who have low levels of achievement in chemistry. Because of the time limitations in one course, small examples of heterogeneity and diversity could be presented and practiced in other Finnish chemistry teacher training courses, too. That could help the readiness of future teachers when dealing with different students. It can also help them to find and create suitable teaching materials and thus enhance their own pedagogical content knowledge. There is also a need to provide in-service courses for those who have had only basic courses in their pedagogical studies.

## DISCUSSION, CONCLUSION AND FUTURE IMPLICATIONS

The seminars in the present paper were from different countries, had different starting points, different school systems, and organization. However, the two programs faced the same problems and were following the same goal in their seminars: empower and qualify chemistry teachers to deal with heterogeneity and diversity in their classes.

Two different ways following the same scheme were presented here. The methods used in the seminars are similar, but also different in some aspects when meeting the curriculum requirements of the respective universities. Both countries assumed success in sensitizing chemistry student teachers to heterogeneity and diversity in chemistry classes, what is recognizable in the reactions of the student teachers in the courses. Similar results about the sensitizing and awareness of pedagogical diagnosis also evident in the parallel (and broader) studies during the development process in Germany (see Tolsdorf & Markic, 2017; Tolsdorf & Markic, in review) and in Finland based on the preliminary results of the present study. Already Haq and Mundia (2012) reported that the individual dimensions must be experienced during the teacher training program. So the future teachers are not ignore these dimensions in the classroom. During the teacher training program, more positive attitudes toward heterogeneity, diversity and inclusive teaching should be developed. In both countries, it became clear that student teachers were not explicitly aware of the factors that could influence their future work in the chemistry classroom. But this is the basis for the student teachers to see the variety of heterogeneity and to realize the importance of this topic (step 1) for their future work as a chemistry teacher (see also Subban & Sharma, 2006). Before the student teachers really teach in a diverse class, they can think about the diversity and individuality. Starting from here, the student teachers think about how to diagnose their future classes and how to deal with any problems they might encounter (step 2). It seems that our chemistry student teachers have learned how to deal with heterogeneity and diversity in their future classes (step 3). Thus, the discussion of the above-mentioned model and the implementation of it in our seminar succeeded. However, at this point, we cannot say how much this knowledge will influence the participants' future practices, or if they will be able to transform this knowledge into practice, possibly without the support of a supervisor or mentor. Some further studies in this direction are needed.

This model differs from other ideas of chemistry teachers' education (e.g. the development of diagnostic instruments) in that student teachers must always sensitive to each heterogeneity dimension at the beginning. Subsequently, the recognition or sensitizing about these dimensions and the support can be theoretically addressed before the student teachers apply in school. Student teachers cannot be prepared for all dimensions of heterogeneity during their studies, but it seems to make sense to thematize frequent dimensions already in teacher education. Starting from the presented project and keeping in mind the differences between German and Finnish settings, we see this step as essential and extremely important if focusing on this topic in seminar and lecturers. Thus, from our experience, we would recommend such methods and tools as mentioned above to be used in the seminars. Since differences in German and Finnish settings, we believe that named methods are possible to implement in different countries as well.

Thinking also from the other side of the equation, it would be interesting to conduct studies asking in schools for opinions about the planned chemistry lessons considering heterogeneity and diversity. It would be interesting to see how different groups of students feel about those lessons and if they see the advantages.

Additionally, further development of chemistry teacher training is needed. This will ensure more opportunities for future teachers to acquire the necessary knowledge of and practices for dealing with heterogeneous chemistry classes. Starting from this point, more workshops for in-service chemistry teachers should also be developed and offered. One example includes how to support different heterogeneous groups such as girls in science. A possible idea here is to involve chemistry teachers more strongly in student teachers' internships and seek a stronger cooperation between both groups while they provide feedback to each other in this topic.

## ACKNOWLEDGEMENTS

For the German part of the project, we gratefully acknowledge the funding and support of the Deutsche Telekomstiftung (German Telekom Foundation).

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