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The potential of substantial learning environments for inclusive mathematics – student teachers’ explorations with special needs students

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Although in Germany there exists a long research tradition concerning common instruction and inclusive education, more research is needed concerning the subject-matter specific programs for inclusive teacher education. The paper reports on the project ProViel (‘Professionalisierung für Vielfalt’ – ‘professionalisation for diversity’). Within the project inclusion is pursued as a common objective for all subjects and disciplines. In addition, sub-projects concentrate on selected subjects as ‘Mathematics Inclusive’. For this sub-project concepts and modules for teacher education will be developed, tried out and reflected with respect to inclusive mathematics. The paper presents the mathematics project’s aims and objectives, followed by data concerning the concrete course ‘Learning Mathematics with Substantial Learning Environments (SLEs)’ and primary teacher students’ practical experiences and reflections.

Keywords: Pre-service teacher education, special needs students, inclusive education, substantial learning environments, field studies.

Introduction

In Germany students with special needs either visit special schools for handicapped children or regular schools in inclusive settings (cf. Klemm, 2015). According to the realization of the UN conventions (see UN, 2006), the proportion of students with special needs in inclusive settings has increased continuously over the years. In Germany, for the school year 2013/14 about 50 % of the students with special needs on the primary level visited regular schools (Klemm, 2015). But actually a decrease or stagnations can be observed in some states (Klemm, 2018). Inclusive settings show extremely heterogeneous groups in classrooms, so that a high degree of differentiation is needed.

Teacher education programs preparing for an inclusive school system are in the state of development at the moment, and corresponding research is done. As an important field for research the subject-matter specific preparation of teachers has been pointed out (see Heinrich, Urban, & Werning, 2013). The paper presents first results of a study that aims at implementing substantial mathematics for all.

The project ‘Mathematics Inclusive’ within the project ProViel

The project ProViel ‘Professionalisierung für Vielfalt’ (‘Professionalisation for Diversity’; <https://www.uni-due.de/proviel/>) at the University of Duisburg-Essen is funded by the Federal Ministry of Education within the frame of a program for teacher education (1st phase: 2016–2019; 2nd phase: 2019–2023). Numerous university departments are involved to ensure the development

of a coherent conceptual program for teacher education. One field of action is ‘Diversity & Inclusion’, and numerous sub-projects might cover the wide facets and dimensions in this field (cf. Bishop, Tan, & Barkatsas, 2015; Good & Brophy, 2008).

Following a design based research approach, the sub-project ‘Mathematics Inclusive’ aims at implementing subject-specific concepts and modules for inclusive mathematics education. The central research questions are the following:

- (1) How should didactical courses in teacher education be designed to address the topic ‘inclusive mathematics’? (firstly, for the primary BA-/MA-program, later on for the secondary BA-/MA-program)
- (2) What are student teachers’ prerequisites concerning inclusive mathematics?
2a) experiences with mathematics instruction 2b) existing attitudes and beliefs
- (3) Which changes of student teachers’ attitudes and beliefs and competence developments can be identified after they had completed a course that addresses inclusive mathematics?
- (4) Which modifications for the didactical courses arise from experiences and results of the empirical testing (based on research question 1 to 3)?

Research questions 2 and 3 will be answered on the basis of quantitative as well as qualitative data, whereas the questions 1 and 4 concentrate on qualitative data and methods.

Concept and objectives of the course ‘Learning Mathematics with SLEs’

The developmental work to answer research question 1 firstly concentrates on the course ‘Learning Mathematics with Substantial Learning Environments (SLEs)’ (3rd year, BA-program for primary mathematics). The didactical concept of working with SLEs, and by this realizing a natural differentiation is in line with a constructivist understanding of teaching and learning, and has been proved to be suitable for heterogeneous learning groups in primary mathematics (cf. Hirt & Wälti, 2008; Krauthausen & Scherer, 2013; Scherer & Krauthausen, 2010). These projects also focused on the realization in in-service courses whereas the current paper concentrates on pre-service teacher education, especially with regard to inclusive mathematics.

The design process started in 2016, and the first course has been running during the winter semester 2016/17, followed by the second and third one during the winter semester 2017/18 and 2018/19.

Competencies the student teachers should develop within this course, as formulated in the BA-curriculum for primary, are the following:

- The student teachers are able to design a mathematical learning environment on the basis of mathematical und didactical foundation according to a particular focal point.
- The student teachers are able to carry out and analyze an interview with primary students including subject-specific perspectives (according to a particular focal point).

The course concept is as follows: The course contains a weekly 90-minute lecture combined with a weekly 90-minute seminar. The lecture should be attended by the whole cohort of student teachers,

and it covers the theoretical background of SLEs and the concept of natural differentiation in contrast to more traditional concepts of differentiation.

SLEs can be defined by the following four constituting demands (Wittmann, 2001; Krauthausen & Scherer, 2013; Scherer & Krauthausen, 2010): (1) They represent central objectives, contents and principles of teaching mathematics at a certain level. (2) They are related to significant mathematical contents, processes and procedures beyond this level, and so they are a rich source of mathematical activities. (3) They are flexible and easily adaptable to special conditions of a classroom. (4) They integrate mathematical, psychological and pedagogical aspects of teaching mathematics, and so they form a rich field for empirical research.

In addition, the constituent characteristics of the concept of natural differentiation are: All students get the same learning offer, and this offer must be holistic, and may not fall below a specific extent of complexity and mathematical substance. Holistic contexts in that sense by nature contain various levels of demands which must not be determined in advance. In addition to the level the students decide to work on, they can freely make their own decisions concerning the ways of solution, use of manipulatives and facilities, kinds of notation, etc. The postulate of social learning from and with each other is fulfilled in a natural way as well (cf. Wittmann, 2001; Krauthausen & Scherer, 2013; Scherer & Krauthausen, 2010).

During the lecture not only the theoretical background is given, but also examples for planning and designing concrete learning arrangements as well the analyses of concrete interview or classroom situations for various SLEs and various mathematical contents, for example taken from former studies (see Scherer & Krauthausen, 2010).

For the corresponding seminars, the cohort is distributed in groups of about 15 student teachers. The seminars are related to different focal points like *differentiation*, *difficulties in language* or *inclusive mathematics*. The latter one is part of the sub-project 'Mathematics Inclusive'. During the whole semester, in the seminars the student teachers have to work in small groups up to four persons. They have to design and carry out clinical interviews with pupils from primary school working on selected SLEs. For the seminar focusing on 'inclusive mathematics' each student teacher has to interview two or more children with and without special needs. The student teachers should offer one and the same substantial learning environment and tasks to the different pupils and videotape the interviews. Within their small group as well as in the seminar group they have to analyze and reflect on the interviews in general, the concrete learning processes and pupils' existing competences as well as existing difficulties.

The course should enable student teachers to design common learning situations and learning within a common topic and mathematical content. The course concept cannot cover all dimensions of effective instruction but focuses on the dimensions *teacher*, *students* and *teaching approaches* (cf. Hattie, 2009).

Questionnaire and interviews with student teachers

Pre-post questionnaire: To answer research questions 2 and 3 a standardized questionnaire was used in a pre-post-design. The initial questionnaire contains items concerning experiences as well

attitudes and beliefs with respect to inclusion and inclusive mathematics (cf. Meyer, 2011). The latter ones are also included in the post-test. The relevance of beliefs and attitudes can be assumed (cf. Sullivan, Clarke, & Clarke, 2013, p. 18 f.), and with the pre-post-design one of the questions will be, if and how student teachers' attitudes and beliefs changed after completing the course.

Retrospective self-assessment: Moreover, to answer research question 3 for the post-test six items for a retrospective self-assessment for the development of individual competencies were added (cf. Nimon, Zigarmi, & Allen, 2011), and the student teachers had to rate their competencies before the course and at the end of the course. These items were designed according to the curriculum objectives focusing on substantial learning environments, clinical interviews and analyses of students' thinking and learning processes (see section 2.1). The student teachers had to rate their competencies for these three aspects on the one hand in general, on the other hand concerning the relevance for inclusive mathematics. For example, the two statements referring to clinical interviews were (see section 3):

General: *I know the relevance of clinical interviews for mathematics teaching.*

Relevance for inclusive mathematics: *The use of of clinical interviews seems relevant to me to support special needs students in inclusive classrooms.*

Additional interviews: For deeper analyses, additional interviews with selected student teachers were carried out. The interviews comprised selected items of the questionnaire (attitudes and beliefs), and asked for more detailed explanations of the student teachers' experiences before the course. Moreover, the interview focused on the concrete experiences the student teachers had made during the course (example: *In what way could you gain experiences for inclusive mathematics?*) as well as perspectives for their future teaching (example: *In what way can you imagine to use your insights for your future teaching of mathematics?*).

Results

In the following section exemplary results will be reported. Firstly, student teachers' pre-experiences with inclusive mathematics (data from pre-test), and secondly, the retrospective self-assessment for the development of individual competencies with respect to substantial learning environments (data from post-test and selected interviews).

Pre-experiences: For detailed results concerning student teachers' individual pre-experiences with inclusive mathematics (research question 2a; open item: *Which experiences have you made so far with inclusion in mathematics instruction?*) see Scherer (2019). For the here reported course, the following results are relevant: Although the participating student teachers had completed in their BA-program at least one or two practical phases at school of about 5 weeks in total before, it showed that only about 50 % of the student teachers have made school-related-experiences whereas the others had no experiences or made experiences out of school or in other fields. The school-related-experiences cover a wide spectrum of aspects: Apart from organizational or personal requirements of inclusive settings, the statements could be specific for mathematics education or be more general.

One could identify *main categories for mathematics* that are of great importance for the course concept ‘Learning Mathematics with SLEs’, namely *differentiated learning offers* and forms of *inner or outer differentiation*. The student teachers’ school-related-experiences most frequently could be assigned to these categories. Looking in more detail at the category *differentiated learning offers* one could identify a wide range of aspects: offering more time, more/less number of tasks, different worksheets or tasks on different levels of difficulty, different textbooks or mathematical topics, additional materials and manipulatives, additional help, learning step-by-step, more repetitions.

Although a questionnaire does not allow in-depth analyses of the underlying concepts of teaching and learning or of the underlying concept of differentiation, one might assume that the classroom situations the student teachers have experienced did not follow the concept of a natural differentiation and the children did not work on common subjects, problems and tasks, as the student teachers rarely report situations that pupils work on common topics or SLEs. Some of the student teachers’ statements might lead to the conclusion that the teaching and learning setting more or less represents an exclusive setting with separate learning situations than inclusive education (see also Scherer, Beswick, DeBlois, Healy, & Moser Opitz, 2016, p. 640 ff.). In contrast, the course ‘Learning Mathematics with SLEs’ focuses on common learning situations for *all* students, enabling individual as well as cooperative learning situations, for example by realizing the concept of a natural differentiation (cf. Krauthausen & Scherer, 2013; Scherer & Krauthausen, 2010; section 2.1).

Retrospective self-assessment: So one interesting question would be how the student teachers rate the development of their competencies concerning SLEs, especially the relevance for inclusive mathematics (research question 3). On a Likert scale from 1 to 6 (1 = not at all true; 6 = extremely true) the student teachers had to rate the following statements referring to SLEs:

General: *I know the characteristics of substantial learning environments for mathematics teaching.*

Relevance for inclusive mathematics: *The use of substantial learning environments seems relevant to me to support special needs students in inclusive classrooms.*

Figure 1a, b and Figure 2a, b show the results (N = 90, missings in Figure 2a): Before the course, many student teachers already know the characteristics of SLEs (Figure 1a) as about 45 % agree to this statement ($M = 3.32$, $SD = 1.22$). This result is plausible as the topic is touched in different courses in the 1st and 2nd year of the BA-program. Nevertheless, the self-assessed development of competencies is obvious and shows a significant effect (Figure 1b; $M = 4.98$, $SD = .66$), as after the course nearly all student teachers agree to the statement. A similar result occurs with respect to inclusive mathematics (Figure 2a: $M = 3.91$, $SD = 1.06$; Figure 2b: $M = 4.98$, $SD = .85$; significant effects). This shows an important development, as the student teachers’ pre-experiences had shown quite different classroom situations they had observed.

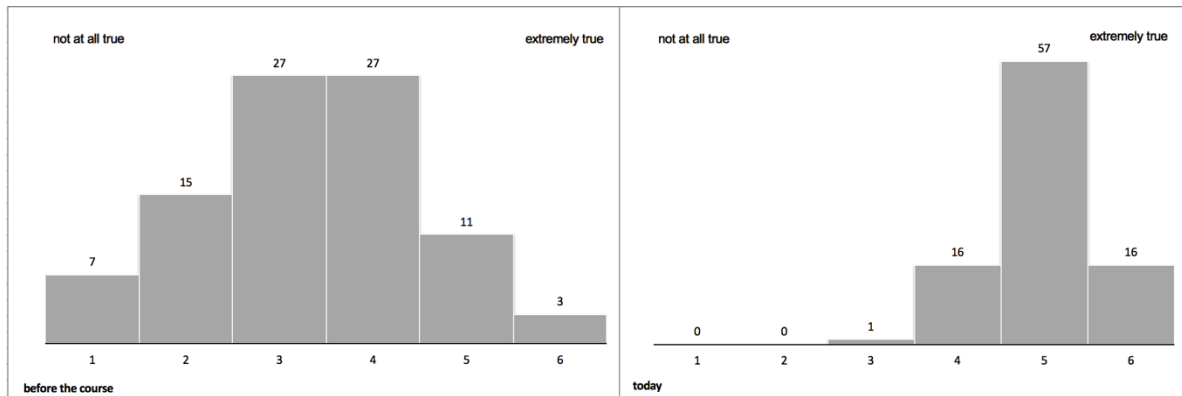


Figure 1a, b: Results for the self-assessment item with respect to SLEs (general)

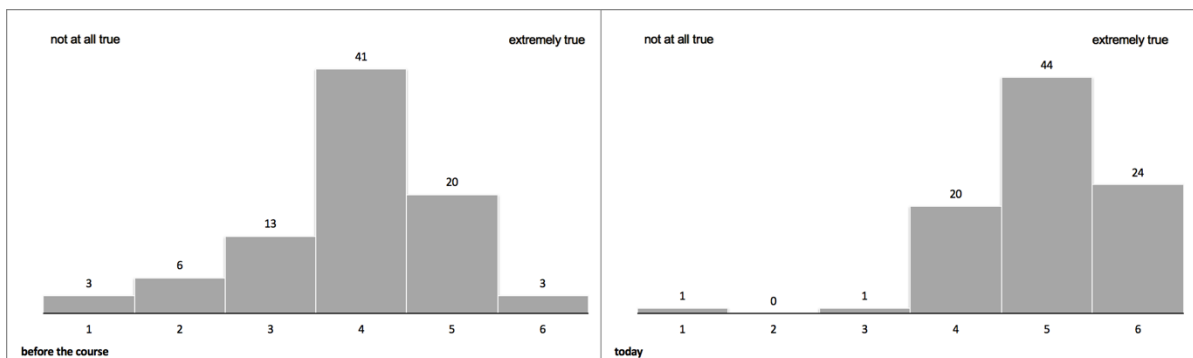


Figure 2a, b: Results for the self-assessment item with respect to SLEs (relevance for inclusive mathematics)

Interviews: For a deeper analysis of these outcomes, one can refer to the interviews, and two exemplary statements are cited:

Transcript 1 (student teacher 1 – ST1):

54 ST1: Well. What I knew before, just as a term and not put into action, were the substantial learning environments. And, well, what I didn't know either before, that you meet the needs of all students with these substantial learning environments. ... I did not know that you can find a task format that students work on for oneself and that differentiation takes place in a natural way. That became clear in my mind by the course. Before, I was aware that you have to work individually but not that you can work with the students on a common topic.

Transcript 2 (student teacher 2 – ST2):

32 ST2: Well, to be honest, before, I had no idea how inclusive education in mathematics should look like. And, well, it did help me that the different learning environments were presented and that it was also said what a learning environment should contain that I can use them for inclusive classrooms.

Whereas ST1 refers strongly to the potential of SLEs concerning inclusive settings, ST2 also links this relevance to the design of SLEs and their characteristics. Both statements focus on the constituting demand of didactical flexibility (see section 2.1), and the mathematical substance or

central objectives or principles for teaching and learning mathematics are not named explicitly. It might be that this is too obvious for the student teachers and that the own planning, the fact that those SLEs might fit for all students and the practical experience dominate and might be impressive. Nevertheless, the content related objectives will be stressed in further courses.

Conclusions

The first results of the course show that the underlying didactical concept of using SLEs and realizing a natural differentiation, is suitable for inclusive classrooms. Moreover, the course concept with the combination of theoretical elements, concrete video examples and pupils' documents (lecture) and practical experiences (interviews at school) with a common reflection (seminar) could reach the above mentioned project objectives. As a consequence, for the overall structure and concept of the course no changes were necessary. But setting SLEs into practice of this more or less new field of inclusive mathematics is a great challenge for student teachers. However, the value of SLEs became obvious.

Analyses and reflections on videos, materials and examples given in the lecture have a high value. Extended by the student teachers' own experiences and common reflections in a seminar can increase their knowledge and teaching repertoire for the future. The above mentioned aspects are important for all kind of teaching situations, but seem to be more challenging in inclusive settings. On the one hand, student teachers have to cope with the mathematical content and be flexible in reacting to different students with their variety of strategies and ways of thinking. On the other hand, student teachers have to be aware of a variety of difficulties. When being confronted with those difficulties, a tendency of reproducing some of the patterns they experienced at school could be observed, for example more traditional forms of differentiation that special needs students need different learning offers, different tasks and materials on different levels or a prescribed program. These concrete experiences have to be made a subject of discussion to widen the repertoire of student teachers (cf. Scherer & Steinbring, 2006). This was already done when repeating the course, and will be strengthened in the future running of the course.

Moreover, the student teachers' pre-experiences have to be considered. As reported, many of their observed classroom situations did not represent common learning situations but exclusive settings with the separation of students with special needs. Those experiences have to be discussed and reflected in the lecture as well as in the seminars and practical experiences.

The next steps in the project will be the data analyses concerning the specific focal points of the seminars. One of the questions is whether the specific focal point 'inclusive mathematics' shows specific results concerning attitudes and beliefs as well as competence development. In the long-term the connection of mathematics education modules – like 'Learning Mathematics with SLEs' – with mathematics modules will be addressed, so that a coherent program will be developed, as terms and theoretical aspects have to be put into action.

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