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Research Based on Learning in Primary Teacher Education

A comparative case study on Continuous Development on Inquiry Based Science Education

ASTRID HUBER

asthub007@gmail.com

Private University College of Education of the Diocese Linz

Abstract

This article shows the results of numerous teacher-training courses at universities in Austria and Germany in nature & science in primary school. The main goal is to find a successful concept that
enables students on university and teachers later in school to plan research-based les-sons in primary schools. Directive instructions – as well as in the university and in the classroom – are institutionalized, but a large number of studies provide unsatisfactory results compared to inquiry-based learning. With this concept, the students work on their own topics according to their own ideas, imagination and creativity. Of course, practical experience in the classroom is absolutely imperative, as well as reflection with the fellow teachers and students.

Key concepts:

Research learning, university course, teacher training, learning in institutions, science lab

Introduction

The multilateral research project *Naturbild* is aimed at devising pedagogical strategies for early exposure of children to natural phenomena and technical problems.

This article shows selected results of an international study involving 215 university students from six EU countries (Knörzer & Grassler, 2011) forming the basis for a further research project about the effectiveness of different concepts of learning in science labs in teacher training. Two different study programs, with the same aim for raising competency in nature and science subjects during teachers' training in two countries Austria and Germany, were compared.

Numerous examples show the efficiency of research workshops in schools (Bauer, 2013). In order to prepare elementary school teachers for methodological and didactic learning with their pupils, it is insufficient to transfer the concept 1: 1 to the university setting.

Approaches such as AuRELIA (Authentic Reflective Exploratory Learning an Interaction Arrangement), OPeRA (Outline-Performance-Reflection-Analysis), CrEEd (Criteria-based Explorations in Education) and TILA (Theory of Inquiry Learning Arrangements) and the latest results about teaching–and learning research (Reitinger et al. 2013), a research group (Knörzer & Huber, 2017) developed a design for self-determined learning in science labs. These are specially equipped science labs for students in teacher training at universities.

After a general introduction to the objective of the EU project *Naturbild*, this article examines the learning processes of students from different perspectives. In doing so, the question will be asked how effective the approach of research learning is, in universities and schools (Bertsch, Unterbrunner & Kapellari, 2011).

1. Objectives and selected results of the project *Naturbild*

The research–and development-project *Naturbild* was promoted as a Lifelong Learning Program by the European Union.

Four to eight-year-old children were observed nature and science lessons dealing with the phenomena "air" and "water", to find out more about their thinking, acting and understanding of phenomena (AG Frühe Bildung, 2010).

These observations formed a pedagogical concept with the aim to develop with children naturally inquiring and technical solutions for their problems, to challenge them with questions and reflecting the experiences.

The educational concept was tested and evaluated with 215 teachers from six different countries of the European Union. A total of 70 institutions - kindergartens, schools and colleges - participated.

A part of the concept is a multi-perspective and integrative approach to nature formation – a network of subjects, contents und methods.

The goal of the training was to accompany the developed and approve concept in the practical implementation and to support the educators in their own further development (Knörzer & Grassler, 2011).

The extensive project evaluation for the assessment of the project and its further education measures took place on the basis of a specially created questionnaire. This questionnaire contained several selected categories based on specific theoretical backgrounds:

- Evaluation and concepts for further education
- Communication and learning support Educational expertise: specialist knowledge, competences in class room management and imagination

The results of the evaluation are based on 215 returned questionnaires. All items were calculated by using a five-level rating scale starting with 1 „does not apply“ and ending with 5 „totally agree “. The questionnaire contained both types of questions - closed and open questions. The first 30 questions contained exclusively quantitative questions. The data analysed by the statistic software programme SPSS. The following figure is an excerpt of the questionnaire. It shows results on the sustainability of teacher training programs[1].

Items	N	M	SD
3. The course has high practical relevance	215	4.77	.55
9. The trainers respond to questions and requests of the trainees	214	4.83	.46
16. I can perceive and promote children in their questions, interests, as well as in their motivation and their research urge	214	4.39	.74
18. I now know how to improve the learning environment for students	214	4.66	.64
19. I can accompany students in conversations and in their reflection on phenomena	214	4.50	.72
22. When dealing with natural phenomena, it is particularly important that students do not make mistakes	209	2.97	1.64
25. I feel more confident to create stimulating learning arrangements for pupils even with simple materials	214	4.64	.68
27. The multi-perspective approach of *Naturbild* corresponds to the student's different learning requirements	212	4.65	.61

[1] Further details in Knörzer & Grassler (2011). Various methods were used to evaluate the data set. Mean values and standard deviations were calculated for interval-scaled values and descriptive statistics for nominal-scaled values. A mono-factorial analysis of variance (ANOVA) was conducted to investigate the country-to-country variation in the evaluation of individual training

28. The approach arouses students' curiosity and interest.	214	4.79	.47
30. The pupils have learnt a lot.	214	4.72	.58

Figure 1: Selected results of the evaluation of the training programe

It should be noted that Item 9 "The contact persons respond to questions / wishes of the participants" has the highest value (M = 4.83), followed by Item 28 "The approach arouses the curiosity and interest of the children" (M = 4.79) and Item 3 "The event is practice-oriented" (M = 4.77). The lowest approval value lies with the (control) item 22 "When dealing with natural phenomena, it is important that the children do not make any mistakes" (M = 2.97). These results were verified with significance tests.

It should also be noted that the approval values for the results selected here and also for the overall assessment of the further training data (Knörzer & Grassler, 2011, pp.196-197) are between 2.97 and 4.83, i.e. the values are above the theoretical average of 3, with one exception. This can be interpreted as meaning that the training measures and the educational concept were rated very positively by the participants on average.

All in all, the results of the project evaluation showed that the training measures and the pedagogical concept were rated very positively in the individual countries and that the educators could profit for their own further development and the promotion of the children. This is how two participants reflected:

"I have become open to engaging with the children on the respective priorities of each child and to withhold my existing knowledge and the knowledge of children" (QNR 5, Item 39 in Knörzer & Grassler, 2011, p. 204).

"I am now more concerned with suggestions which the children can determine themselves." (QNR 11, Item 39 in Knörzer & Grassler, 2011, p. 205).

The multi-perspective approach of the education strategy was confirmed, the pedagogical expertise of the educators was extended and the practical relevance of the project proved. The image of the self-active and creative child could be confirmed and was increasingly taken into account in the preparing of pedagogical learning processes. The focus is on the promotion of childlike creativity, constructivity and the intersubjective co-construction of world knowledge.

The main objective of the project was to develop a pedagogical strategy to unlock natural phenomena and technical problems for children in the educational phase of four to eight years. This child-oriented and

multi-perspective strategy relies on the self-active creative power of children to creatively and constructively create, exchange and critically develop worldviews. Theoretical backgrounds are moderately constructivistic approaches and pedagogical approaches that emphasize the educational value of free children's play (Schäfer, 2005).

In this learning process, the adult companion plays a significant role: as an impulse giver, observer, organizer of learning arrangements and as a constantly self-reflecting educator, who starts with the children's thinking and learning processes and motivates them further. In addition, opportunities for the promotion and perception as well as the interpretation of child-world knowledge and problem-solving are developed (training of the perception and diagnostic competence). In this regard, the project also pursued the goal of professionalising educators, students and teachers as part of the described training measures. Ultimately, this pedagogical strategy should become the general standard and standard for the professionalization of early childhood educators and contribute to the promotion of key scientific literacy skills (see ibid).

2. Science labs in teacher training

From different approaches such as AuRELIA (Authentic Reflective Exploratory Learning to Interaction Arrangement), OPeRA (Outline / Performance / Reflection / (Process) Anal-ysis), CrEEd (Criteria-based Explorations in Education) and TILA (Theory of Inquiry Learning Arrangements) and the latest findings from teaching-learning research (Reitinger et al., 2013) have developed a concept for self-determination-oriented learning in research workshops for the training of teachers was developed.

On the basis of the findings from the EU project "Naturbild" (AG Naturbild, 2011), the concept of self-determination-oriented research learning (Reitinger, 2013) was further developed and applied in teaching studies.

In order to check the effectiveness of the concept, data from the students of the primary school teacher course in the 5th semester of the University of Education Linz and the Dresden University of Technology in two waves at the beginning and end of the technical courses with questionnaires (220). Of these, a random sample (N = 31) was drawn and interviewed. Furthermore, group discussions were recorded by the seminar leaders of the nine seminar groups and interviews were conducted with lecturers (7) from both institutions - the University of Teacher Education Linz and the Technical University of

Dresden. First data from the interviews and group discussions are already presented in this article.

Before going into more detail about these courses, the potential of research workshops, as we understand them, for the professionalisation process will first be described.

2.1 Science Labs in Higher Education

The research workshop does not see itself here as a learning workshop in which materials are created for teaching. In this place ideas are spun, concepts developed, objects made and materials are tested. This is an area of the university where innovative pedagogy 'out there' at the schools does not refer to traditional concepts of higher education (Wedekind, 2013, p. 21).

In the research workshop, students, accompanied by their teachers, acquire the most varied skills, deal with alternative forms of learning cultures, and test and reflect on what they have developed. Instead, teachers see themselves as learning supervisors for their students. Not only the changed role of the teachers, but also the basic conditions and places of learning and experience - such as excursions or school internships - enable first-rate learning in the university workshops.

These workshops are understood here as "spaces" in a figurative sense. Freedom is created here in rigid university structures, in which research-based learning can find favorable framework conditions (Schude, Bosse & Klusemeyer, 2016, p. 129).

In order to enable self-determined research learning, it is necessary to have flexible time arrangements, the integration of learning venues outside the campus, cooperation with experts and institutions and organizations.

2.2. Science Labs in Teacher training on University College – A Comparative Case Study

Both at the University of Education in Linz (semester 5) and at the Dresden University of Technology (from semester 4), courses in science and technology are only offered or recommended in the advanced phase of the training.

A large majority of students in science and technology disciplines values it’s knowledge and skills in the planning and prepareing lessons higher in comparison to other subjects. In developing the structure of the course, consideration was given to the self-judgement and negative previous experiences in the science-technically oriented subjects

of the past school years, as well as a mostly gender-sensitive education. In doing so, students are provided with a comprehensive range of literature in different levels, sufficient time to exchange ideas with the tutors and fellow students as well as various materials for experimenting. In the practical phase, students can work with their team partners in small groups with pupils on science and technology topics. The entire internship will be accompanied by the seminar leaders. The experiences gained at school are then reflected on at the university and their own actions are questioned. Subjectively experienced successful situations are stored in the portfolio and, for less successful experiences, new action plans are developed which ideally can be tested in the next practical phase (Altrichter & Posch, 2006).

For a better understanding, the concept of the course is briefly presented here.

Each of the two course last one semester.

The following figure illustrates the key features of the course, which contributes to the development of research behavior among students.

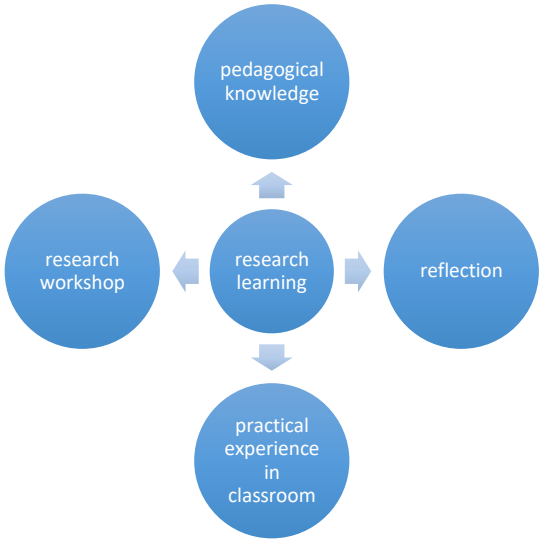

Figure 2: Diagram of research learning and its classroom framework

After a brief introduction to the concept of research learning and the design of the course by the seminar instructors, students choose their personally preferred topic from the natural science and technology domain of the subject teaching. Before working on the topic, the individual level of learning and interest in the topic is recorded, questions are formulated on the topic, and possible goals are noted that the students want to achieve with their pupils in the practical work.

In the next two phases, the personal expertise will be developed and

methodical concepts developed for implementation with children. Especially in these phases, in addition to the support provided by the teachers, a well-equipped research workshop can provide significant support to the students. In brief presentations, students present their concept to their fellow students, offer opportunities to test the materials, but also present difficulties in the entire work process. In the subsequent phase, the concepts are implemented with elementary school pupils during the internship. The experiences from the entire learning cycle are reflected intensively in the teams as well as in the plenum in the seminar. The entire personal learning process is also stored in the portfolio (Huber, 2011, p. 42).

Supplemented by interviews and group discussions with the students, those elements of the course were to be identified that contributed significantly to an increase in competence, higher self-assessment and thus leading to greater learning success. The data from the written survey, the interviews and the group discussions were evaluated according to the concept of the Mixed Method (Mayring, Huber & Guertler, 2007).

3. Results

Initial fears and uncertainties regarding the requirements for this course could be largely dispelled during the first session, as the following statement by a participant shows.

I suspected a continuation of the chemistry, physics and biology lessons from high-school, but was then quite positively surprised how interesting you can make the topics for elementary school (M.K./22).

From this it can be deduced that the organizational structure, contents and objectives of the course should be clarified in the first session.

During my chemistry lessons from high school I had negative experiences in my chemistry lessons at high school. It was just too theoretical for me. I did not know what to do that, but you're inevitably confronted with nutrition. My fellow student and I were given interesting material from our seminar instructor... (Ms. p./14).

From this it can be deduced that students have different previous knowledge and previous experience. For successful learning support, supportive materials are needed for differentiation in the researcher's workshop. Foundational work and textbooks of secondary levels 1 and 2 have proven to be especially helpful here.

I was able to contact my seminar director outside of class hours if something was unclear to me (p. H / 24).

I really appreciate the opportunity to use the learning workshop outside the seminar. So I was able to continue working on our topic at the university with ... [team partner] (L.D./6).

It can be deduced that students need sufficient time to explore and experiment with the materials of the researcher's workshop. Extended opening times with support staff also allow students to use the learning opportunities in small groups.

The seminar leader encouraged us to contact the pedagogical director of the technical museum [science lab in a technical museum]. We were able to obtain interesting suggestions and varous of material for our topic (P.H./23).

We spent a lot of time in the SLUB [library] at first, before I could really work on the topic with ... [Kom-militonin] (p. 24).

The researcher's workshop cannot be reduced to the university learning workshop. Research learning can take place in many places both at and outside the university - with the help of experts.

It is quite different when one learns that we can also work on our topic with children (B.M./2).

From then on, it has a very different meaning for me. I was very excited because I did not know exactly how the pupils [and students] will pick up on [bionics]. I did not know exactly what was in it and how to write it correctly (V.L./31).

In all 31 interviews the possibility of practical testing of the contents of the seminar was especially welcomed. The practical phase was given a particularly high priority in the question of personal competence.

Rarely could I speak so frankly about my deficits, as in this seminar.

In the first session of the presentation I was fascinated by the sentence "error desired" (B.J./3).

Afterwards [after the internship] we discussed everything in great detail - also things that did not work so well.

I was very surprised by the openness of my classmates in the reflection round at the university. In our last internship we were told what was good and bad. We had to record that in the minutes. This time we were allowed to choose what [practical situations] we would like to talk about. That almost irritated me at the beginning (K.L./9).

Finally: A trusting climate is the basic prerequisite for the disclosure of one's own learning pathways. Professional knowledge can primarily be based on subjective, significantly experienced situations in the classroom. The team (teachers and fellow students) supports each

other mutually. All materials developed in the seminar will be uploaded to a learning platform for exchange and to be available for further processing.

4. Conclusion

From an academic didactic point of view, the researcher's workshop has a special significance. Researchers' workshops offer particularly favorable conditions for professional networking. Thanks to the stimulating equipment, these workshops also promote communication among all participants - learners and lecturers from the university and the schools as well as experts. However, research workshops cannot replace the real situation in the classroom. They support students in their preparatory work for research-based learning with children. However, successful implementation can only take place in the classroom.

Only when students are sufficiently offered the opportunity to question and interpret their own learning and understanding processes, can prospective teachers become involved in research-based learning in the classroom.

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Curricular note

Astrid Huber is a teacher trainer and post-doctoral researcher at the Private University College of Education of the Diocese Linz. Her current research focus is on Inquiry Learning in primary science education. She researches on the gap between Inquiry Learning in technical subjects and gender in teacher training at the University College in Austria and a sample of German Universities. She points out in research projects that one of the main problems are the strict separation between theoretical university courses and practical experience in classroom, but also the gender socialisation in family and society.