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Preparing Prospective Primary Teachers to Teach Science: A Challenge for Teacher Education

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Abstract

Findings from educational research suggest that many primary school teachers admit a lack of science knowledge and confidence to teach it. In addition, attention to the attitudes of primary teachers toward science is of fundamental importance to research on primary science education. The paper reports on the evaluation of a science methods course for future primary science teachers guided by the framework of Pedagogical Content Knowledge (PCK) and also addressing students' motivational orientations according to personal and teaching efficacy in science education. 158 pre-service primary science teachers took part in the study. Quantitative data were gathered from the STEBI-B and a content knowledge test. In addition, a set of qualitative data (portfolio, assignments, lesson plans, and reflection on teaching sequences) was used for answering the research question how the design of the course impacted the development of students' PCK and motivational orientations. Starting with descriptive analyses, analyses of variance, confirmatory factor analyses, cluster analysis, and regression analysis were conducted. However, extensive data analyses reveal a range of alternative conceptions held by the pre-service primary teachers prior to the course. Generally, the pre-service teachers indicate positive self-efficacy beliefs regarding science teaching. In conclusion, no significant relationship between self-efficacy beliefs and achievement could be identified.

Zukünftige Volksschullehrkräfte auf den naturwissenschaftlichen Sachunterricht vorbereiten: eine Herausforderung für die Lehrerbildung

Zusammenfassung

Bei der Evaluierung eines fachdidaktischen Seminars zum naturwissenschaftlichen Sachunterricht konnte kein direkter Zusammenhang zwischen Selbstwirksamkeitserwartungen und Lernergebnissen nachgewiesen werden.

Schlüsselwörter:	*Keywords:*
Naturwissenschaftlicher Sachunterricht	Primary Science
Testinstrument Selbstwirksamkeitserwartung	Science Teaching Efficacy Beliefs Instrument (STEBI-B)
Fachdidaktisches Seminar naturwissenschaftlicher Sachunterricht	Primary Science Methods Course
Lernen im naturwissenschaftlichen Sachunterricht	Primary Science Teaching and Learning

1 Introduction

Obviously, science teaching of primary school teachers is influenced both by their science teaching self-efficacy beliefs and their conceptual understanding of basic science concepts. In consequence, the main aim of a primary science course in teacher education has to focus on helping prospective teachers start to build a set of knowledge that will enable them to teach science effectively. According to Shulman's PCK (Shulman, 1986),

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science teachers have a special kind of knowledge for teaching science that goes beyond knowing science and knowing about teaching and learning in general and includes knowledge of science learners, curriculum, instruction, and assessment. Therefore, a key goal of a science methods course in teacher education is to help future primary teachers develop sufficient PCK for teaching science to enable them to commence teaching science and lay a key foundation for continuing professional development. The author, in her role as teacher educator, believes that learning to teach science involves clarifying, confronting, and expanding students' ideas, beliefs, and values about science teaching and learning. Consequently, course activities should have the potential to possibly help future teachers accommodate new ideas, beliefs, and values about science teaching and learning.

Based on contemporary ideas about the teaching of science mentioned above, prospective primary science teachers should develop a comprehensive science knowledge base, concurrent with a deepening understanding of the links between the content knowledge and the teaching and learning process (Ginns & Watters, 1999). Furthermore, research results identify two factors influencing primary science teaching: (1) teachers' level of understanding about science and (2) their beliefs regarding science (Stevens & Wenner, 1996). However, primary teachers often have negative attitudes towards science and do not have confidence in their ability to teach science (Cakiroglu & Boone, 2002). Furthermore, students come into the classroom with prerequisite knowledge and prior conceptions, which sometimes are incompatible with currently accepted knowledge. Consequently, learning has to be viewed as an interaction between new and prior knowledge. In order to teach science effectively, it is essential that teachers - besides being proficient in regard with the content - can facilitate conceptual change by identifying students' current conceptions about the topic and guiding them to realize the limitations of those misconceptions. In addition, early research suggests that there is a relationship among teacher performance, teacher self-efficacy and student achievement (Ashton, 1984). Beyond that, low self-efficacy towards teaching primary sciences may result in avoidance of teaching science and reduced quality of science instruction. Based on Bandura (1986), Riggs and Enochs (1990) postulated that two factors, personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE), might affect science teaching behaviours. In consequence, Riggs and Enochs developed the Science Teaching Efficacy Belief Instrument for pre-service teachers (STEBI-B).

2 Research Questions

The focus of the present study is on examining the understanding of pre-service primary teachers with respect to specific science concepts (floating and sinking, air is a matter and has weight, states of matter for water, and magnetism) on exploring pre-service teachers' self-efficacy beliefs regarding science teaching and on investigating the relationship between these two issues. Consequently, two broad research questions were addressed:

1. In what way is student prior content knowledge, perception in relation to teaching and learning, and in particular, science teaching self-efficacy beliefs different?
2. Which factors influence teacher student learning outcomes?

3 Methods

The data for the study were collected within a combined science content and methods course for prospective primary teachers by utilizing two instruments: (1) a misconception test involving the topics described above administered prior and after the course, and (2) STEBI-B. For the STEBI-B a four point Likert Scale was used (1 = strongly agree; 2 = agree; 3 = disagree; 4 = strongly disagree). Primarily, the course addressed the development of fundamental science content and pedagogical content knowledge of the prospective primary teachers helping them integrate other knowledge bases that are important to teaching. After completing the course, the students should be able to apply fundamental science concepts to everyday situations, demonstrate the appropriate use of science process skills and the nature of science by designing an age appropriate science instructional unit for the primary classroom. In addition, they should also be able to identify effective teacher characteristics and become aware of effective teaching strategies for science instruction.

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158 pre-service primary teachers (8 male, 150 female) participated in the study. Whereas 42% of the teacher students (G1) completed their teacher education in addition to another regular job, 58% were full-time teacher students (G2). Whereas G1 comprised two groups of students with an average age of 30.2 and 31.9 years, the students of three further groups belonging to G2 were significantly younger; their average age was 22.5, 21.9, and 23.4 years. In addition to responding to the previously mentioned test instruments, the teacher students also delivered other data: (1) a portfolio with answers to distinct questions and including reflections on teaching sequences, (2) a lesson plan for a self-chosen topic within the content of the course, and (3) a design of an experiment in regard to floating and sinking with focus on varying guidance and a specific alternative conception (see figure 1).

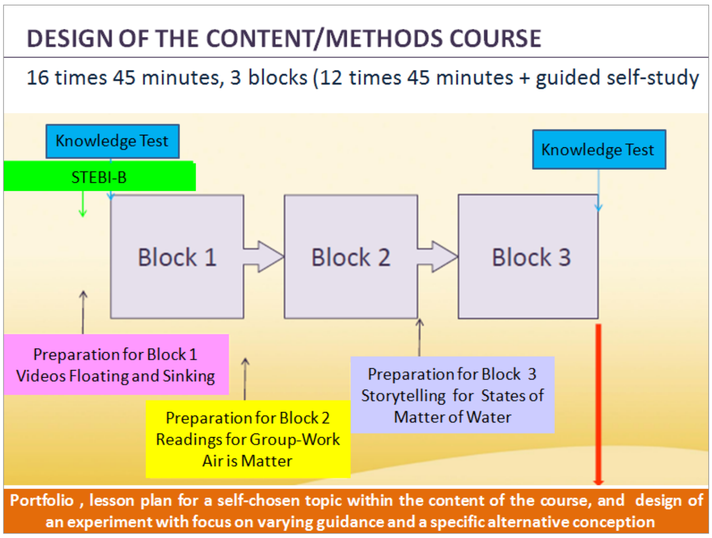

Figure 1: Design of the science content/methods course.

4 Results

Quantitative and qualitative data analyses reveal a range of alternative conceptions held by the pre-service primary teachers prior to the course. Generally, the pre-service teachers indicate positive self-efficacy beliefs regarding science teaching. Looking closer at specific items from STEBI-B, some differences appear according to the social affiliation to one of the two student cohorts. For example, the results illustrated in figure 2 suggest that teacher students belonging to cohort G2 (groups 3, 4, and 5) show significantly higher perceived abilities in regard to their PCK prior to the methods course. Whereas 50 out of 52 students in cohort G1 (groups 1 and 2) disagree or strongly disagree that they already know all the steps necessary to teach science concepts effectively, 32 out of 72 students in cohort G2 (groups 3, 4, and 5) agree or strongly agree to the same question.

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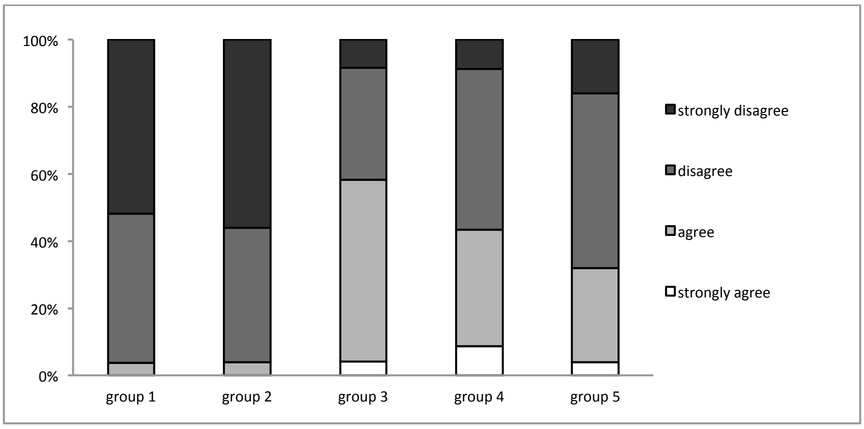

Figure 2: Student perceptions for Item 5 from STEBI-B.

("I know the steps necessary to teach science concepts effectively.")

Furthermore, the responses to the questions how well the prospective teachers understand science concepts to be effective in teaching primary science also suggest particular differences between the two student cohorts (see figure 3). Whereas none of the persons in group 1 or 2 agrees to the question, 50% or more of the student teachers out of the groups 3 to 5 do so.

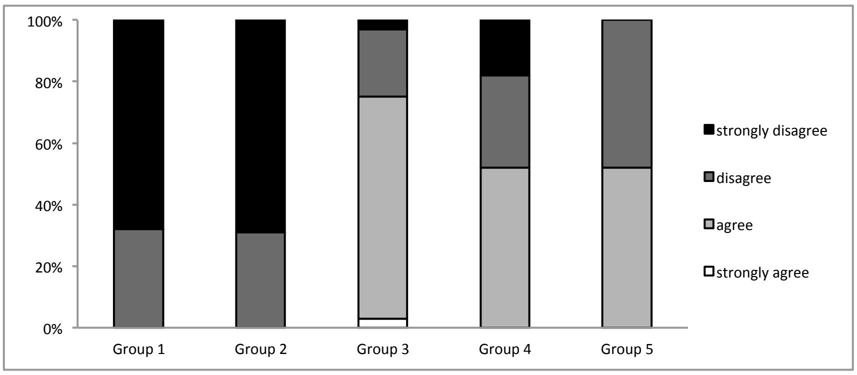

Figure 3: Student perceptions for Item 11 from STEBI-B.

("I understand science concepts well enough to be effective in teaching primary science.")

On the other hand, there are no significant differences between the students of the five groups in relation to their perception if the low science achievement of students generally can be blamed on their teachers (see figure 4). The majority of teacher students in all groups believe that the low science achievement of students generally can be blamed on their teachers.

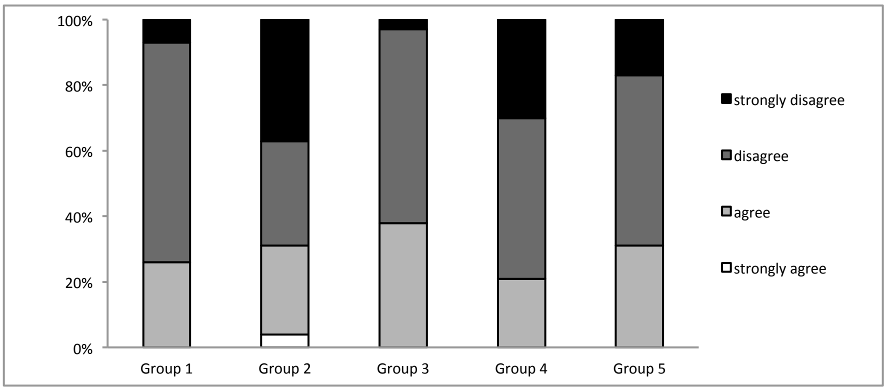

Figure 4: Student perceptions for Item 18 from STEBI-B.

("The low science achievement of students cannot generally be blamed on their teachers.")

With the help of a factor analysis four components (see figure 5) could be identified from STEBI-B: CK = content knowledge, PCK = pedagogical content knowledge, PSTE = personal science teaching efficacy and STOE = science teaching outcome expectancy. Taking a closer look at the results ranging from 1 (strongly agree) to 4 (strongly disagree) the estimations of the two cohorts only differ according to their CK and most to their PCK.

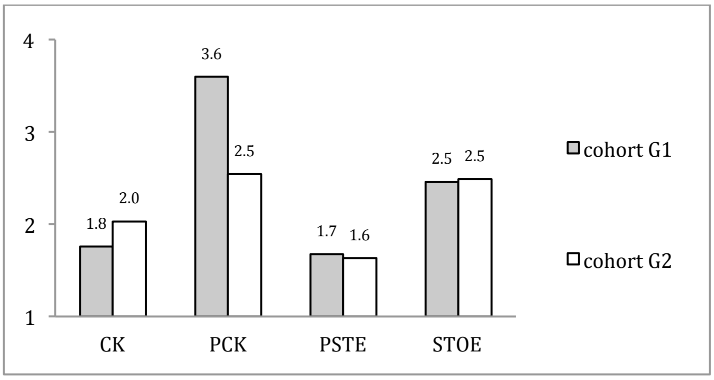

Figure 5: Student estimations of knowledge components and beliefs.

Figure 6 shows the distribution of results for the student learning outcome, comprised of three components of qualitative data described above. On each part the students could reach a maximum of 4 points and in consequence a whole maximum of 12 points. Whereas only 6 out of 73 students from cohort G2 reach more than 6 points, the percentage of students in G1 who reach more than 6 points is 82.4%.

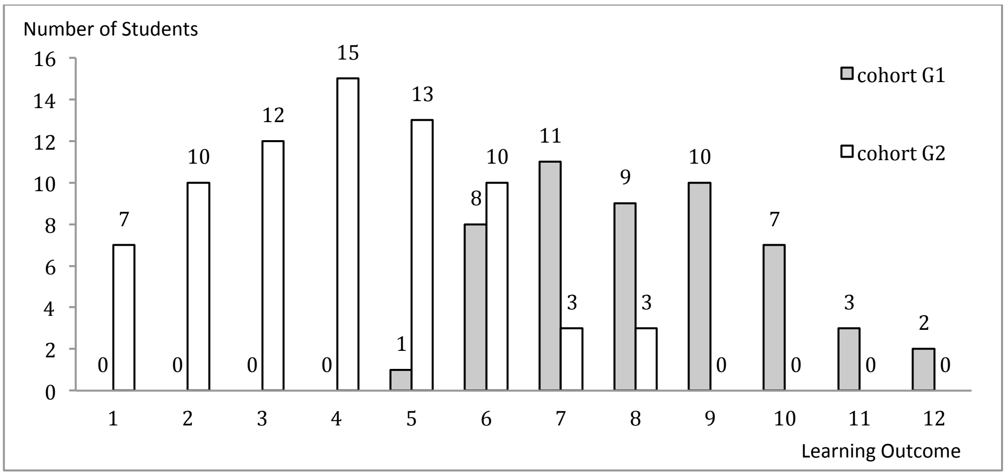

Figure 6: Distribution of results for the student learning outcome.

Finally, regression analyses could support models to predict student learning outcomes as demonstrated in table 1.

Table 1: Regression models for predicting learning outcomes.

Model	Equation for Learning Outcome (LO)	R^2
1	LO = 12.42 – 4.20 · cohort[1]	.576
2	LO = 14.30 – 4.17 · cohort – 1.84 · gender[2]	.597
3	LO = 13.44 – 3.97 · cohort – 1.96 · gender + 0.025 · age	.603

In conclusion, the results suggest that teacher students belonging to cohort G1 show significantly higher learning gains in the conceptual post-test and easily outperform their colleagues from group G2 in regard to their professional development and the quality of their assignments.

5 Discussion and Conclusion

Interestingly, the results of the study do not support a significant and direct relationship between self-efficacy beliefs and achievement of prospective primary science teachers. On the other hand teacher student outcomes are highly influenced by their affiliation to a distinct group which is also correlated to the age of the future primary teachers. First, prospective primary science teachers who complete their teacher education in addition to another regular job are older than their colleagues who are so called full-time students. Secondly, the students in group G1 seem to be more aware of the fact that they have to learn a lot to become a successful teacher and in consequence they approach their study more seriously. Therefore, in the current study factors like age and experience of life overlapped the influence on self-efficacy beliefs on student learning and achievement.

In fact, it is crucial for teacher educators to understand their methods in order to facilitate individual student learning in the best way. Learning to teach science is not simply a matter of learning a script to follow. By getting to know students' ideas about science and science teaching and learning, teacher educators can more effectively plan instruction to meet their diverse needs, interests, and abilities. As little shared formal knowledge about teaching future primary science teachers exists in a comprehensive form, and as an effective primary science teacher educator needs to understand students as learners, more research is needed to uncover the relationships between different components of science teaching and learning.

References

Ashton, P. (1984). Teacher efficacy: A motivational paradigm for effective teacher education. Journal of Teacher Education. 35 (5), p. 28-32.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice Hall.

Cakiroglu, J. & Boone, W. J. (2002). Preservice Elementary Teachers' Self-Efficacy Beliefs and Their Conceptions of Photosynthesis and Inheritance. Journal of Elementary Science Education, 14, 1, p. 1-14.

Enochs, L.G. & Riggs, I.M. (1990). Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale. School Science and Mathematics, 90(8), p. 694-706.

Ginns, I. S., & Watters, J. J. (1999). Beginning elementary school teachers and the effective teaching of science. Journal of Science Teacher Education, 10(4), p. 287–313.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. Educational Researcher, 15(2), p. 4-14.

Stevens, C. & Wenner, G. (1996). Elementary pre-service teachers' knowledge and beliefs regarding science and mathematics. School Science and Mathematics, 96, p. 2-9.

Yin, Y.; Tomita, M. K. & Shavelson, R. J. (2008). Diagnosing and Dealing with Student Misconceptions: Floating and Sinking. Science Scope. April/May 2008. p. 35-39.

[1] 1 for G1 and 2 for G2
[2] 1 for male and 2 for female