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Integrated Science Teacher Training at the University Level Using a Student-Student-Interaction Concept

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Abstract

Future teachers for the German high school system (Gymnasium) are traditionally educated in two subjects during their university education. After completion of their degree, they are at the most qualified to teach two scientific subjects at the high school level. In practice, it is becoming more and more common that the subject 'integrated science', in Germany often termed 'Nawi-Unterricht' or 'Science', is offered in lower grades at the Gymnasium [1,2]. In this subject, teachers teach scientific competences although they are typically not prepared for this in their university studies. As a consequence, they have only little didactical and methodical knowledge of the teaching of interdisciplinary classes [3]. However, many of these teachers are interested in teaching science as an integrated subject, but do not feel adequately prepared for the task [4]. For example, most of the teachers feel uncomfortable preparing experiments using physical apparatus, chemical substances or applying teaching methods like 'inquiry-based learning'. In fact, an analysis of German university teacher training curricula revealed that only very few courses for teaching interdisciplinary subjects (e.g. NaWi-Unterricht) are offered in the range of secondary teacher education. In addition to this analysis, the aim of this contribution is to present a design for an interdisciplinary university course in which future teachers learn didactical, methodical and professional knowledge of biology, chemistry and physics. The course is supplemented with expert lectures from the different scientific fields in order to complement and expand on the didactic and methodical foundations. Furthermore, the course is based on student-student-learning arrangements, in which students of the three scientific disciplines learn from each other by preparing teaching units including experiments on topics such as 'How does the sun affect my life?' [5]. Furthermore the paper presents selected examples of teaching units in some detail.

1. Introduction

The German educational system for student teachers at the *Gymnasium* level is divided into three consecutive parts: 1. University studies 2. in service teacher training (*Referendariat* a 18 month student teacher training in schools) and further teacher training programs. The goals of the university education are the acquisition of professional knowledge, didactical knowledge and subject-specific teaching methods. Traditionally, student teachers are educated to teach two subjects. This means that at the end of their studies, teachers have at most gained the necessary didactical, methodical and professional knowledge to teach two of the scientific subjects. During the university phase of the teacher education problems often arise which can cause future deficits in teaching quality. Students often don't recognize their studies as the basis for their future profession since they learn contents whose school relevance is not yet visible, such as taking a mathematics course in order to become a biology teacher [6]. Besides the traditional subjects, the interdisciplinary subject Science (*NaWI*) is especially affected by this. A study investigating German university curricula for future *Gymnasium* teachers reveals that students studying chemistry, biology of physics are less trained in an interdisciplinary manner regarding methodology and didactics since no interdisciplinary science education courses can be found in module descriptions. Especially for *Gymnasium* student teachers there to the best of our knowledge no seminars are offered which convey the fundamental methodical and didactical aspects of science lessons. Hence, student teachers are lacking basic skills for the planning interdisciplinary science classes [6].In the following we will show the problems for school teaching that arise from this type of educational circumstance. In addition, a concept for an interdisciplinary seminar will be presented. This seminar offers student teachers the possibility to learn about the contents of integrated science classes, discover experiments, methods and didactic principals for this type of class.

2. Difficulties and Consequences of the Current Educational Circumstance

Upon entering the second phase of the German teacher education, the *Referendariat*, or upon starting the teaching profession, several diverse problems arise. In the natural science subjects, the tendency for integrated science class is steadily rising. In many federal states (*Bundesländer)*, science classes including topics of biology, chemistry and physics are common. For example, in Lower Saxony and Baden-Württemberg, 30 % of integrated schools and *Gymnasien* are offering the subject science (*NaWi* or *Naturwissenschaft, Phänomene und Technik)* as an additional subject. This integrated subject is taught by teachers who have no specific education in all three sciences and who can often only fall back on limited didactical and methodical knowledge for integrated science class since they did not have the option of learning these skills during their studies [7]. Therefore, they mostly teach in a successive manner in the supposedly integrated lesson (see Fig.1) meaning that the chemistry lesson is followed by a physical and then biological one rather than actually integrating the three sciences into one lesson.

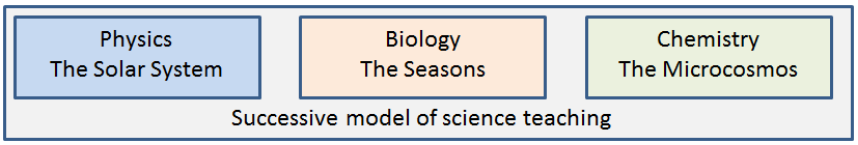

Fig.1: *Structure of the successive model of science teaching.*

One of the research goals in chemical didactics is the pupils' acquisition of scientific literacy or in other words scientific understanding, is therefore accomplished [8]. Furthermore, through successive science teaching the advantages of integrated science lessons cannot be exploited in depth. These concern the pupils a general understanding of their natural surroundings working with natural phenomenon and using the acquired learning methods to further that understanding. In order for students to achieve this scientific understanding, the individual science lessons have to be combined in an integrated model of science teaching (see Fig.2) [9].

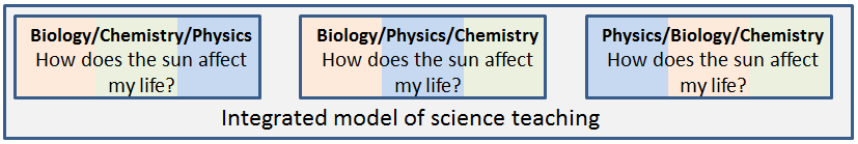

Fig.2: *Structure of the intergrated model of science teaching.*

Although teachers in a survey conducted by BRÖLL (2012) stated an interest and necessity teaching in an integrated manner, they do not feel that they have sufficient relevant skills to do it since they claim to be unaware of the possibilities of combining the different scientific subjects. For example, many teachers are confronted with several problems *e.g.* working with chemicals or physic apparatuses and feel that the necessary preparations for these types of experiments are a too time consuming on top of their already demanding work day. Among the resulting consequences are experimenting according to the procedure of others which make it difficult to work with an investigative inquiry-based teaching method. This hinders the development of the competence *Gaining of Insight*, one of the main four competences that are being developed in schools in Lower Saxony [3, 10]. Overall, BRÖLL's study reveals that there is a demand for workshops and continuing education among teachers who want to develop their skills and increase their knowledge. To prevent these teachers from having to carry the extra burden of workshops or further studies in order to acquire the necessary skills to adequately work in their profession, the structure of the current teacher education program has to be changed. Here, the goal would be to coordinate teacher education with the reality of the profession and modify its structure to better prepare current teacher students for integrated science classes. GOLDHABER and BREWER (1996) have demonstrated that completing 15-20 ECTS-Credits in a third subject could be sufficient in preparing university students to effectively teach the subject later on. Therefore, in the following part, a possible concept for the already mentioned restructuring of the educational system for student teachers will be presented. This concept allows student teachers to adequately prepare themselves both methodically and didactically and acquire the necessary knowledge to teach integrated science classes [11,12].

3. Concept for an Integrated Science Seminar at Universities

The cooperative science seminar will be offered to students either as one of several options within their program or in the form of extra credits. This seminar will be available to all science students independent of their specific subject in order to create a common module. Here, the learning goals for students are the following: development of competences in didactics and methods, recognition of common basic patterns in all three sciences, practice of ways of planning integrated lessons as well as the increase of confidence with regard to experiments. During each class, one or two topics are presented by mixed groups of students made up of at least one student from each of the scientific subjects. For their presentations, students plan a sequence of lessons for their topic for which they develop lesson plans including experiments and teaching methods. Moreover, they will provide didactical justification for their plans. An example of a topic would be “How does the sun affect my life?” [5].

The topic is planned in the student groups so that the respective content and time shares of each subject in the integrated lesson are left open. The module is geared towards students in higher semesters since knowledge of methods and didactics is necessary to plan the lessons which are meant to give students a general overview of other scientific subjects (see Fig. 3). For teachers who are teaching subjects for which they have no qualifications it is often difficult to estimate the importance of different contents which makes it harder to plan efficient and coherent lessons. This problem arises because teachers are unaware of which contents and competences are taught and developed at which levels in the other subjects. Furthermore, they do not know which contents and competences of other subjects are pre-requisites for higher levels in the spiral curriculum. Since BRÖLL has shown that problems are especially surfacing in the experimental component of chemistry contents in integrated science classes, the module offers practice in the use of chemicals and apparatuses [3]. Additionally, students also practice using the gestalt law during the presentation of experiments in the classroom.

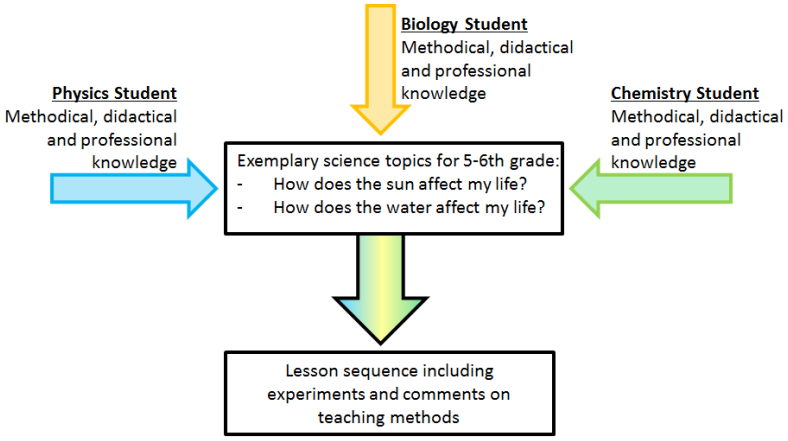

Fig.3: *Basic concept and structure for the seminar on the methods and didactics of integrated science classes.*

After the planning and experimental phases, the experiments and thoughts of all the students are presented. The results of the groups, the experimental procedures, the commentaries on the methods as well as didactical ideas will be collected and summarized. Therefore the integrated science classes of future science teachers have a methodical and didactical structure. For example, students’ teachers will learn different classroom methods, ways of structuring worksheets and options of presenting experiments. Moreover students will learn the fundamental didactics of i.e. context-based-learning or inquiry-based-learning. Furthermore, they will consider students’ misconceptions and their choice of key experiment at the moment of lesson planning. In addition to the group work, professors from educational departments in chemistry, biology and physics will hold lectures on didactical and methodical topics. Therefore, the module does not only allow for practice in lesson planning but also deepens professional knowledge.

4. Conclusion

Future interests of study would be to investigate scientific competences of currents students in the sciences in different semesters to not only legitimate the restructuring of the educational system but also to re-emphasize the current problems. For this, the professional, methodical and didactical

knowledge of students is tested using a questionnaire based on misconcepts. This study is meant to be the basis for the future evaluation of the integrated science module. Furthermore, it is meant to investigate the influence of the module on the lesson planning strategy of teachers teaching subjects they are unqualified for. This allows for a comparison of how these teachers and teachers who have studied the subject plan lessons. Additionally, the consequences on the qualification of teachers as well as the influence of having attended the integrated science module on the quality of classes can be examined.

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