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# **Inter TeTra – Interdisciplinary teacher training with mathematics and physics**

## **Description of a project partnership between Siegen (Germany) and Hanoi National University of Education (Vietnam)**

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*The benefits of interdisciplinary teaching and learning in school have been discussed for some time, but to make it be more than the additive juxtaposition of elements of knowledge from different disciplines, the universities should implement holistic concepts for integrative teacher education. In the first phase of the teacher training should clarify the advantages and tackle the challenges of an interdisciplinary education. The Inter TeTra project is a DAAD subject-related partnership between the University of Siegen (Germany) and the Hanoi National University of Education (HNUE, Vietnam). The primary outcome of this project is the design of a permanent module for the subjects mathematics and physics at the HNUE and to perform interdisciplinary on the job teacher training with the subjects mathematics and physics.*

*Keywords: Developing country project, interdisciplinarity, relationship of physics and mathematics, teacher training curriculum development.*

## **Motivation of the Inter TeTra-project**

A primary goal of the OECD and the educational capacities in Vietnam is to reform their educational policy by developing a more competency-oriented curriculum (Communist Party of Vietnam, 2013). Germany has two decades of experiences with these types of reforms. The adjustments of the curricula since the mediocre results of German students in the TIMSS and PISA study show the opportunities and challenges such reforms can present (KMK, 2004) and the importance of teacher training for the success of school reforms (Hattie & Beywl, 2013). The cooperation between German and Vietnamese educators offers the opportunity to avoid well-known problems in implementing such reforms. In addition, it can generate new knowledge out of the cultural and structural differences between the two societies, allowing the further development and implementation of novel and distinctive curricula. Consequently, the DAAD (German Academic Exchange Service) endorses the Inter Tetra-project (the name of the project is a short form for Interdisciplinary Teacher Training), a subject-related partnership established between the University of Siegen and the Hanoi National University of Education (HNUE). The outcomes of this project are the design of a permanent module for the subjects mathematics and physics at the HNUE and the performance of an interdisciplinary pre-service and in-service teacher training. One of the distinguishing features of this course is the view beyond the subject boundaries of mathematics and physics. Since 2000, the advantages of interdisciplinary work in teaching and learning in schools have been emphasized, mostly in the form of problem-based and cross-disciplinary teaching that is organized in projects (Labudde, 2014 or Moegling, 2010). In order to achieve the greatest educational benefits, numerous

variants of these demanding and complex learning concepts have been developed (Caviola, 2012; Labudde, 2008). The ability to systematically combine, apply and reflect knowledge from different disciplines is the goal of this project. However, in spite of all the educational advantages, interdisciplinary work also reveals many challenges. The combination of different methods of the participating subjects, overcoming communication difficulties, the identification of common research subjects, the handling of prejudices as well as the handling of group dynamic processes are only some of the problems of interdisciplinary cooperation (Defila & Di Giulio, 2002, 24). The didactic potential of subject-linking teaching and learning has been discussed for some time, especially in mathematics, natural sciences and technology (English, 2017; Kelley & Knowles, 2016; La Force, 2016; Michelsen, 1998).

Despite the many benefits of interdisciplinary teaching and learning at school, the teacher training at German as well as Vietnamese universities is still largely organized in a discipline-oriented manner. The first phase of the teacher training should clarify the advantages and tackle the challenges of an interdisciplinary education. To make interdisciplinary teaching and learning in schools be more than the additive juxtaposition of elements of knowledge from different disciplines (Wellensiek, 2002), the universities should implement holistic concepts for integrative teacher education. The inadequate fit of non-integrated teacher education with the requirements of interdisciplinary teaching (Bröll & Friedrich, 2012) is repeatedly cited by teachers in schools as an objection to integrated instruction (Jürgensen, 2012; Rehm, 2008). If interdisciplinary teaching at school is to succeed, teacher training must also be adequately designed (Brown & Bogiages, 2017; Cormas, 2017). Studies show the importance of the preservice teachers' knowledge of interdisciplinary pedagogy (An, 2017). However, it has become apparent that experienced teachers in particular have reservations about interdisciplinary teaching (Thibaut 2018). For this reason, the Inter TeTra project is planning an interdisciplinary master course and in-service teacher training. Appropriate didactic concepts have already been developed at some universities (Krause & Witzke, 2017; Witzke, 2015). The University of Siegen works currently on interdisciplinary education projects such as MINTUS, FäMaPDi and InForM PLUS (Holten & Witzke, 2017; Krause, 2017). For this purpose, the subjects of mathematics and physics seem to be the most appropriate, since these subjects have numerous epistemological parallels (Krause, 2016). First approaches for establishing subject-linking lessons already exist in Vietnam (Nguyen, 2015). In contrast, the present project does not initially focus on interdisciplinary teaching in Vietnamese schools but starts earlier by adding an interdisciplinary module to teacher education. In this way, the connecting element in the subject-linking lessons of the future is not only the common subject of instruction (which is viewed from the perspective of different subjects) but rather the embedding of lessons in the comparative discussion of didactic theories in the participating subjects from the very beginning, with the goal of concretization and implementation in the Vietnamese curricula. This approach is an innovation especially for Vietnam, where teacher training is currently very isolated and compartmentalized. While the modern application-oriented teaching of mathematics looks to physics didactic concepts for experimentation, modern physics teaching also requires mathematical didactic knowledge to deal with technical problems via mathematics (Schwarz, 2016). Consequently, the repertoire of future teachers will become richer by incorporating the didactics of neighboring subjects. So this project aims to make a meaningful and lasting impact through teacher training, combining classroom teaching with practical instructions. The aim is the

development of a competence-oriented curriculum for teacher training in Hanoi. The Vietnamese partner university is the authoritative body of educational policy reforms within the country, ensuring later dissemination of the developed module. The previously mentioned projects at the University of Siegen have demonstrated that interdisciplinary teaching in teacher education provides a deeper insight into the didactics (Witzke, 2015). The combination of didactical theory and teaching practice is particularly important to our approach.

## **Concept of the courses in the Inter TeTra-project**

### **General information**

The duration of the Inter TeTra-project will be four years. In the first year (2018) the colleagues from Vietnam have joined the referring projects in Siegen - the FäMaPDi and InForM PLUS projects (Krause & Holten, 2018) and both sides discussed the theoretical framework of the project. The courses for the HNUE will be designed in the year 2019 and will take place in Hanoi in 2020 and will be repeated in 2021. The idea is the implementation of an interdisciplinary course for pre-service teachers in the teacher training curriculum at the HNUE and the offering of an interdisciplinary course for in-service teachers with the subjects mathematics and physics. These courses will be composed of a theoretical and a practical part.

### **Theoretical part**

The aim of the courses is to enable students to compare the didactical theories of their own discipline, which they have come to know during their studies, with the didactical theories of the other subject. Since only a limited number of sessions are available for the theoretical part, only a selection of topics can be found that is relevant for both subjects. In order to combine subjects in a meaningful way, one should compare the common “Big Ideas” of the subjects (c.f. Chalmers, 2017). One research desideratum that the Inter TeTra Project focuses on is to explicate topics, which are relevant for mathematics and physics education. For this reason, handbooks and conference-proceedings of mathematics and physics education will be compared systematically to identify intersections. Even if this research is still in process an exemplary selection of topics, which are suitable for an exchange between mathematics and physics education, can be listed:

**Nature of science vs. beliefs of mathematics:** What is physics? What role does the experiment play in physics? To what extent does a physical theory depict reality? Because questions of this kind are crucial for teaching-learning processes, the didactics of physics has been dealing with them for some time under the heading “nature of sciences” (Aydeniz et al., 2013; Dass, 2005, Hötticke & Rieß, 2007; Kahana & Tal, 2014; Kartal et al., 2018). Likewise also the mathematics didactics researches on the different views on mathematics (e.g. Grigutsch et. al, 1998; Witzke & Spieß, 2016), because the individual conceptions determine our concrete activities in science. What similarities can be identified between perceptual research in mathematics didactics and NoS research in physics didactics? What are the differences? Interesting approaches can be found in the literature: Lawson (2008) talks about Nature of Science and mathematics. Rolka and Halverscheid (2011) talk about mathematical worldviews of students.

**Modelling:** Modeling is considered in some publications to be a linking element between disciplines. (Blum & Niss, 1991; English, 2009; Michelsen, 2006). In physics, models (such as atomic models)

are an integral part of the theory canon. Accordingly physics education has to clarify how to deal with models in the teaching-learning process (Gilbert, 2004; Oh & Oh, 2017). It is not so common to stress that models should not just be taken over, but rather to emphasize the process of creating models. In mathematics education modeling has been discussed for many years (Burkhardt, 2006; Frejd & Bergsten, 2016; Guerro-Ortiz et al., 2018; Kaiser & Schwarz, 2006). Several models for modeling - so-called modeling cycles - have been developed. So it seems that physics education focuses on the general product while mathematics education is more interested in the process of individual modelling. It is obvious that both sides can learn from each other in this matter, even if it is more laborious than it seems (Neumann et. al, 2011).

**Preconceptions:** In physics didactics preconceptions are treated to different physical contents. They are often negatively connoted as misconceptions. In mathematics education one rarely speaks about misconceptions, trying to highlight positive pre-theories among learners. The term "Grundvorstellung" (vom Hofe, 1992) is certainly prominent in this context in Germany. At the same time, mathematics educators have developed more general theories on context-related learning, which can also be applied to other subjects. For example, the approach of Heinrich Bauersfeld to "Subjektive Erfahrungsbereiche" should be mentioned (Bauersfeld, 1983). Krause has sketched the transfer of this theory to physics and discussed the question of how on the other hand mathematical didactics can be fertilized by approaches of physics didactics (Krause, 2015).

### **Practical part**

In addition to the theoretical sections the courses mentioned and planned in this project will also include lessons at schools. The fact that the didactics of a neighboring subject can be relevant to one's own subject should be clarified by the conception, implementation, and reflection of lessons that try to combine school mathematics and physics in a meaningful way. For this purpose, the interdisciplinary comparison of theories on learning and teaching mathematics and physics in schools will be used to develop research questions in the seminar, which will be examined in the course of the lesson designs developed in the seminar and tested at the cooperation school. These lessons will be videotaped and incorporated into the previously discussed theory. This combination of theoretical lessons and review is established in North Rhine-Westphalia during the practical semester in teacher training (Hoffart & Helmerich, 2016). Such a theory-based classroom reflection research is not yet part of teacher education in Vietnam. However, evaluation criteria do not refer primarily to how the lessons themselves succeeded, but to how the teaching process can be analyzed and classified on the basis of the theoretical sessions. At this stage of the seminar, students should be able to evaluate and justify didactic decisions based on theory.

### **Research**

#### **Explication of relevant content**

The selection of topics in the theoretical part should not be made ad hoc but should reflect the intersection of mathematics and physics education research in terms of content and points of contact. The contents presented in Chapter 2 were determined by the lecturers themselves during the pilot phase in Germany. For the realization of the teaching interventions in Vietnam (which is to take place for the first time in 2020), the theoretical topics are to be systematically selected. For this

purpose, the project participants will carry out a qualitative content analysis (Mayring, 2010) of current manuals and proceedings with the question: *Which contents are relevant for an interdisciplinary exchange of mathematics and physics didactics?* Results of this analysis are still pending.

### **Evaluation of the teaching interventions**

The evaluation of the Master's course and the teacher training should contribute to answering the following research question: How aware are the participants of the relevance of didactic theory of the other subject for their subject? Especially in Vietnam, where teachers are only trained in one subject, it is important to raise the awareness that mathematics didactics is important for physics teaching and that physics didactics is also important for teaching mathematics. The participants will be interviewed at the beginning and end of the theoretical part with an open questionnaire (which is still in the conception phase). What is special about the Inter TeTra project is, that in the practical part the participants are to hold a lesson which will be evaluated video-based. This evaluation also takes place exclusively under the question at which points of the lesson the didactics of the other subject are relevant. This approach was also used in the pilot implementation in Germany. First results may be found in Holten and Krause (2018).

### **Conclusion**

The project's research goals are to clarify relevant topics for an interdisciplinary exchange between mathematics and physics didactics, to design and implement a corresponding course in the teacher training curriculum and a course for in-service teachers at HNUE. The performance of the courses will be evaluated in order to assess the effectiveness of interdisciplinary teaching in the subjects mathematics and physics during the training of preservice teachers.

In this project, an intellectual exchange between four institutes is taking place. Each institute will be focusing primarily on the mathematics and physics disciplines in Hanoi and Siegen as well as four components of teacher training and further education, hence the derivation of the name Inter-Tetra from the Latin "Inter" (between) and Greek "Tetra" (four) and its dual connotation for Interdisciplinary Teacher Training.

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