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Learning Communities in Teacher Education: The Impact of e-Competence

Abstract

*The present article reports on the results of the three year programme Biology in Context (*bik*). In this German-wide programme, teachers and science education researchers worked together in 10 learning communities (so-called school sets) with the goal of enhancing the quality of teaching and learning in biology classrooms as mandated by the recently passed National Educational Standard for the lower secondary level. In addition to face-to-face meetings, computers were used as tools for communication and collaboration. Computers enabled the mutual sharing of information among the participants, as well as the planning and documenting of tasks and teaching units. Furthermore, they promoted the reflection of the process and the refinement of the products. Data were collected from questionnaires and structured interviews with teachers, researchers and coordinators. The analysis identified teacher profiles with regard to their attitudes toward implementing the* bik *concept, their use of computers and the change of classroom activities. The results exposed several main tendencies. (i) The participant teachers largely utilised ICT tools for the construction of tasks and units and for collaboration with each other. (ii) These tools were, however, less useful for instructional purposes, learning and knowledge creation. (iii) ICT tools were hardly used for reflection of professional experiences. (iv) Teacher-use of ICT tools increased from the first to the third year. The study concludes that information literacy skills have a strong impact on the persistence of learning communities. Further research on the advancement of the professional development of teachers in learning communities should be conducted which would assist teachers to rely less on classical settings, such as face-to-face meetings, and to adopt a mixed form of learning.*

Keywords: learning communities, information literacy skills, National Educational Standards, competency acquisition, context orientation.

Introduction

In their report ‘Science Education Now: A Renewed Pedagogy for the Future of Europe’, the high-level group on science education of the European Commission recommends:

> Improvements in science education should be brought about through the new forms of pedagogy; the introduction of the inquiry-based approaches in schools, actions for teachers training to inquiry-based science education (IBSE), and the development of teachers’ networks should be actively promoted and supported. Teachers are the key-players in the renewal of science education. Among other methods, being part of a network allows them to improve the quality of their teaching and supports their motivation. (Rocard et al., 2007, p. 3)

The German-wide programme *Biology in Context* (*bik*) (Bayrhuber et al., 2007a, 2007b) is an example for the implementation of the EU recommendations. *Bik* aims to support teachers as the key-players of school-based reforms by fostering context-based and competency advancing forms of teaching and learning (KMK, 2004). This requires a change of perspective, a moving away from input orientation which is characterised by an accurate specification of the subject content, and a turning toward output orientation. To help teachers abandon established routines, the *bik*-project developed 10 teacher networks. In these networks, the teachers and science educators serve as experts in their respective fields cooperating with and learning from each other. The project was financed by the German Federal Ministry of Education and lasted from September 2005 till May 2008.

In this article, I focus on the implementation of the *bik* programme and the impact of computer literacy skills on the participants. Traditionally, German science education projects operate according to a top-down-strategy, whereby innovation is entirely under the control of the researchers. The goal of such traditional forms of implementation is to spread innovative changes in the way intended by the members. Snyder, Bolin, & Zumwalt (1992) used the expression *fidelity approach* to describe this kind of innovation; teachers are merely executors of ideas which were originated outside the school, their main task being to replicate the innovations as accurately as possible. According to Snyder et al. (1992), the results were unsatisfying; in many cases, either the teachers failed to implement the innovations or they varied considerably from the original innovation.

In contrast to the top-down strategy, the *bik* approach envisions teachers and researchers as equal partners of participation in *learning communities* in which they jointly aim to enhance the quality of teaching and learning. The cooperation of teachers and researchers lies at the core of this *symbiotic approach* (Gräsel & Parchmann, 2004) which is characterized by a reciprocal dependency from which both researchers and practitioners profit (Parchmann, Gräsel, Baer, Demuth, & Ralle, 2006). The implementation is characterized by two important aspects:

- It takes place in a cooperative and social process within a *community of learners* consisting of teachers and science education researchers.
- In addition to face-to-face cooperation, computers are used to foster professional discourse. Technical and social features that facilitate a learning community are elaborated, as well as the use of Information and Communications Technology (ICT) in German schools.

In the following two sections, I want to elaborate on the theoretical framework covering these aspects.

Learning Communities as tools for professional development

The concept of *communities of learners* stems from theories of situated learning which describe the collaboration of teachers with each other and with researchers (Lave & Wenger, 1991; Borko, 2004). The common goals are to improve learning and teaching skills, to share responsibility for the professional growth and development of colleagues and to partake in professionally guided discourse about one's teaching and learning. The discourse and the different views of teachers and researchers serve to enhance the process of reflection about their classroom experiences and to expand their horizons, understandings and capabilities.

Gauging the successfulness of a community is no easy task. However, based on the assumptions associated with cognitive apprenticeship and the 'social constructivist perspective implied by communities of learners', Jonassen (1995) identifies seven qualities of meaningful learning which support the successfulness of a community: active, constructive, collaborative, intentional, conversational, contextual and reflective.

Life cycles of learning communities

Learning communities are groups of individuals who share the same set of concerns, problems and interests in a particular topic. They come together to fulfil both individual and group goals. They focus on sharing experiences, appraising good practices and creating new forms of knowledge. They are dynamic social structures, which require *cultivation* for emergence and growth. Some design the framework for this *cultivation*, while others are responsible for the organisational frame. Together, these persons help foster the formalisation of the community and plan activities for the growth and sustainability of the community. Ultimately, however, it is the members of the community who will define and sustain it over time (Wenger, McDermott, & Snyder, 2002; Zellermeyer & Munthe, 2007).

According to Wenger et al. (2002), communities undergo a life cycle, they emerge, grow and possess a life span. If a community is successful over time, the energy, commitment and visibility of the community will develop until it becomes institutionalized as a value-added capability. Six phases in the life cycle of a community can be distinguished. During the initial *inquiry phase*, the purpose, goals and vision of the community are identified. In the *design phase*, the group defines activities, group processes and roles. In the *pilot phase*, the group seeks to attain commitment, tests assumptions and refines the strategy. Succeeding this is the *launch phase* which is characterized by the expansion of the community to a broader audience. In the *growth phase*, members engage in collaborative activities of learning, shared knowledge and networking. In the core of the *sustain phase*, activities centre on cultivating and assessing the knowledge and the *products* created by the community, as well as on developing strategies, goals, activities and technologies for the future.

According to Wenger et al. (2002), the six phases may serve as a guide for the development of online learning environments in the education sector. In their opinion, developing an online learning community involves more than member access to a range of information and technology tools, such as a threaded discussion forum or a chat room. An online learning community goes beyond this to establish a sense of belonging among members, who can depend on each other to achieve the learning outcomes of the course or intended group goals (Palloff & Pratt, 1999). What are the requirements necessary to support the development of such communities? To address this question I would like to turn to the technical and social features of learning communities.

Technical and social features of learning communities

To facilitate the existence of a learning community, a social architecture, as well as a technical one, is needed (e.g. a joint platform). While the technical architecture *supports* the entire community, the social architecture *enlivens* the roles, processes and approaches that bring people together – whether in face-to-face meetings or via online – in relationship building, collaborative learning, sharing of knowledge and project collaboration.

Teachers must have appropriate knowledge, along with the technical and social skills to participate creatively and critically in learning communities. These skills are summarized in so-called ICT (Information and Communications Technology) competencies. UNESCO (2002) proposed a model that organizes ICT competencies into four groups. One, *pedagogy* focuses on teachers' instructional practices and their knowledge of the curriculum. This means that teachers should develop applications for their disciplines which make effective use of ICTs and which support and extend teaching and learning. The second group of competencies, *collaboration and networking*, acknowledges that the communicative potential of ICTs is in its ability to extend learning beyond the classroom walls. This carries with it the implication for the development of new forms of knowledge and skills by the teachers. The third area of ICT competency regards *social issues*, since new technology brings with it new rights and responsibilities, including equal access to technology resources, individual health care and respect for intellectual property. Finally, the fourth area of competency concerns *technology issues* and is one aspect of the Lifelong Learning theme through which teachers update skills with hardware and software as new generations of technology emerge (UNESCO, 2002).

Are German teachers well prepared to meet such tasks? Do they have the necessary ICT skills? To better address these topics, we must look deeper into the German school system and assess the current level of computer literacy in schools and teacher training courses.

The use of ICT in German schools

In general, Germany has made considerable advances in the distribution and use of ICT in schools in recent years. According to the OECD report 'Are Students Ready for a

Technology-rich World?' (OECD, 2006), the use of computers for student learning has reached a level comparable to that of other European countries. The overall picture that emerges from this report is that German students are generally experienced and confident in using computers but that access to computers and their use is more limited at school than at home. Yet, even in schools which are equipped with computers, students do not necessarily have the same degree of access from one country to another. The number of 15-year-old students in German schools who must share a computer is twice as high as the OECD average.

In Germany, 71% of the computers at school are connected to the Internet (OECD average 78%) and 45% are part of a local area network (OECD average 68%).

The 15 year-old German students who are established computer users tend to perform better in key school subjects than those with limited experience. Half of all students surveyed report that they frequently use word processing software and the Internet as a research tool. In contrast, at 23%, Germany has the lowest percentage of 15 year-olds using computers several times each week at school, which is just slightly more than half of the OECD average level (44%).

These results clearly show that the distribution and use of ICT in schools is an on-going process and must be supported on multiple levels. Therefore, teacher training was established simultaneously with the introduction of computers in German schools. Results from the international IEA-study, 'Computers In Education' (Pelgrum & Plomp, 1989), show that teacher attitudes toward learning about computer use are positive; the desire for training is strong, and the self-confidence required to learn is relatively high. Support for teachers is provided by formal in-service courses. However, the provision in teacher training is limited and inadequately directed at specific subjects. It is mainly left to the teacher to decide how he or she acquires specific ICT skills and tools. As a consequence, the use of computers in school practice depends largely on individual engagement.

The integration of computers in the daily work of teachers is seen as an important requirement for the successful use of computer tools in implementation projects. What is known about the use of computers by German teachers? In German schools, about 10% of all computers are exclusively reserved for the use by teachers, which is quite low by European standards. Furthermore, Germany (along with half of all European countries) does not include education in ICT as a compulsory component in teacher education. Although in some German states, the universities, as institutions of teacher training, are obliged to include ICT in their course offerings, but 'it is left to the trainees to decide whether or not to include it in their overall course of education' (Eurydice, 2004, 44). To enhance ICT-related knowledge, continuous professional development in the form of additional training is essential. In Germany, this training is generally not compulsory; teachers decide themselves if the training is suitable for them. There is no evaluation to determine whether a teacher's ability to use ICT meets with certain standards. ICT is not systematically integrated in teacher education, neither in the universities nor in vocational teacher training. Thus, it cannot be taken for granted that the computer literacy skills of teachers are sufficient for ICT use in learning communities. The question thus arises, are the teachers sufficiently prepared to use computers in implementation projects?

The German programme *Biology in Context*

Biology in Context (*bik*) aims to implement new forms of teaching and learning in schools by using an approach based on close cooperation and mutual exchange between researchers and practitioners. In the following sub-section, I report on the goals and content of *bik* by providing an illustrative example for the development of a task. I will then describe the *bik* learning communities and report on the use of computer tools in the *bik*-project.

Goals and contents of the **bik**-*project*

Biology in Context (*bik*) is a German-wide programme funded by the Federal Ministry of Education to promote student competencies and to support teacher professional development (Bayrhuber et al., 2007a, 2007b; Elster, 2007) in context-based and advanced competency teaching.

> Competencies are defined as the cognitive capabilities and skills which individuals have or with which they can learn to solve certain problems, in addition to capabilities concerning motivation, volition and social willingness permitting one to successfully and responsibly apply solutions to problems in variable situations. (Weinert, 2001, 7)

The competency approach is based on the concept of *scientific literacy* (Gräber, Nentwig, Kobella, & Evans, 2002); the science subjects should enable the students to actively participate in social communication and opinion forming concerning technological developments and scientific research. Further goals of basic scientific literacy are the development of scientific thinking and working, as well as the critical discussion about the limitations of scientific methods.

- *Fostering student competencies according to new educational standards*

The German National Educational Standards (KMK, 2004) assign competencies into four areas (see Table 1): subject knowledge, epistemological skills and knowledge acquisition, subject related communication and decision making, including valuing and moral judgment. The competency area of subject knowledge encompasses three basic concepts: system, structure and function, as well as development and evolution. Table 1 offers an overview of the four areas of competency and gives examples of standards which students should achieve.

[Insert Table 1 here – Competence areas]

- *Fostering student interest through authentic contexts*

To promote interest in biology education, the *bik* tasks should be embedded in student-relevant contexts. Based on the theory of motivation (Deci & Ryan, 1993), the relevance of science could be promoted by a variety of authentic science questions. These should enable students to integrate their own ideas and activities and also should invite them to participate in a problem-solving process. The aspect of social embedding is covered by group learning activities, by the integration of out-of-school environments and by the application of that which was learned outside of school (e.g. by being able to participate in discussions and decision making processes).

In the view of the *bik*-group, subject-contents should be introduced to the students in such a way that they can be linked to everyday experiences. This broadens the area of scientific application and has been termed 'sense - making' by Muckenfuss (1995). Additionally, the contexts should be oriented according to the guidelines of the PISA consortium (Prenzel, Baumert, Blum, Lehmann, Leutner, Neubrand, Pekrun, et al., 2004). Therefore, it should be possible to allocate the contexts to the following areas: life and health, earth and environment, technology and the genesis of knowledge. It was assumed that these areas represented the core context fields of current science education.

- *Structure and design of* bik *tasks*

Bik tasks and units are based on subject matter that is relevant to students, and they are intended to foster the development of competency at the student level. The contexts can be either learning tasks or used to diagnose student competencies. They are characterised by criteria based on the following key questions:

1. *Context:* In which context can the biological content be placed? Does the context have interest and relevance for students? Does it provide exposure to advanced scientific fields?
2. *Basic concepts:* What kind of knowledge should students apply in task solving? What is the underlying basic concept or principle?
3. *Competencies:* Which competencies (according to the National Educational Standards) are needed to cope with the task and to solve it?
4. *Affective dimension:* Is the task motivating and interesting?

To support the construction of *bik* tasks, a task format can be used as a reflection instrument (see http://bik.ipn.uni-kiel.de). An exemplary *bik* task is given in Table 2.

[Please insert Table 2 here- Exemplary bik task]

Learning Communities within the **bik**-*project*

Based on the framework that was derived from the German National Educational Standards (KMK, 2004) and on theories of context-based teaching and learning of science (Gilbert, 2006; Bennett, Gräsel, Parchmann, & Waddington, 2005; Muckenfuss, 1995), teachers and researchers work together in *learning communities* (so-called school-sets) to transform these theoretically based competency models into actual teaching and learning tasks and units. This transformation should take place in a process mutually constructed by teachers and researchers.

> Co-construction is the discursive process between partners, who share their individual knowledge regarding a concrete task and develop together new knowledge or solutions for task or problem solving. (Little, 1990, 15)

Co-construction requires agreement about the working process and shared goals of researchers and teachers, as well as a critical re-thinking of one's own practice which can lead to a change in the routine of action.

Furthermore, it is assumed that the professional development of teachers is dependent on teachers' culture of reflection about their own work (Altrichter, Posch, & Somekh 1993; Elliott, 1991). Action research is expected to support teachers to establish a research relationship to their own practice. It should increase their professional knowledge, enhance the effectiveness of teaching and learning and broaden their autonomous scope. It should empower teachers as 'reflective practitioners' (Schön, 1983) to develop 'tacit knowledge' (knowledge in action) by 'reflection on action'.

> Teaching is a highly skilled activity which above all requires classroom teachers to exercise judgment in deciding how to act. Reflective teaching is seen as process through

which the capacity to make such professional judgments can be developed and managed. (Schön, 1987, 7)

- *Organizational structure*

The organizational structure of *bik* involved the construction of school-sets in the nine participating German federal states. In each school-set, 8-16 teachers worked together who came from different schools, such as Gymnasium, Realschule and Hauptschule (corresponding to High School, Middle School and Integrated Comprehensive Schools, respectively?). From 2005 to 2008, 144 teachers and 1689 students (aged 10 to 17 years old; in average 15 years) participated in *bik*. Each set was chaired by a coordinator and was scientifically supported by a science education researcher from the Universities in Kiel, Duisburg-Essen, Giessen, Göttingen, Münster or Oldenburg. Coordination and evaluation tasks were performed at the Leibniz-Institute for Science Education (IPN) in Kiel by Markus Lücken and the author.

The school sets differed in their specific focus. Each set chose one competency domain of the National Educational Standards to develop materials. Two sets chose the domain subject knowledge, two sets the domain subject communication, three sets jointly worked on the development of inquiry based teaching materials, and four sets focused on the domain moral judgment in the context of sustainable development or bioethics. The set researchers and coordinators discussed together with the teachers their theoretically based competency models and supported the teachers with subject specific materials. An overview about the focus of research within the different *bik* learning communities is given in Table 3.

[Please insert Table 3 here – Overview LCs]

- *Processes within the set-meetings*

Teachers and science education researchers met regularly at face-to-face meetings (120 hours across three years) permitting all to benefit from the various forms of expertise. During the meetings the participants discussed the conceptual framework of *bik* (such as competency models or theories about context orientation), collaborated on the development of tasks and teaching units and shared their successful or less successful classroom experiences. Their joint reflections led to a refinement of the conceptual frame. During set–meetings, the phases of instruction, construction and reflection should be brought or kept in balance to support the participating teachers on their way to become 'reflective practitioners' (Schön, 1987). The working steps within the learning communities are introduced in Figure 1.

[Please insert Figure 1 here – Working steps in LCs]

Although the working steps were similar, the inner structure of the 10 *bik* learning communities, the transformational strategies (relationship building, collaborative learning), the engaging group processes and their facilitation (collaborative knowledge sharing and project collaboration) were – with regard to the use of technical features – surprisingly varied.

The use of computer tools

A wide variety of computer tools were incorporated into the project. They were used during the set-meetings and the periods in-between.

- *The main* bik *website.*

The project's most important computer tool was the *bik* website. It contained all materials which the learning communities used for teaching. At the beginning of the project, the theoretical competence models, as well as some texts that dealt with the goals and features of *bik*, were made accessible to the teachers. In addition, the website contained tutorials on how to construct materials for *bik*, how to integrate student relevant contexts, how to reflect on experiences and, additionally, a link to a sample of exemplary teaching tasks and units presented by the KMK (2004).

- *The set-intern forum.*

The second most important computer tool was the set-intern forum, which contained a closed database for each set. There, the teachers could publish their teaching materials by themselves, while allowing other teachers of the set to use and revise the materials. The forum could also be used to post set-intern instruction materials, time-sheets, presentations and other tools, which facilitate the communication and social processes within a set.

- *The* bik-*intern forum.*

The third most important computer tool offered the possibility for group exchange within the whole *bik* community. The forum was open to all teachers, researchers and coordinators. It was not guided by a moderator. The topic was the project itself, e.g. information about the annual *bik* meetings, and experiences and results stemming from the project. The teachers could post self-developed tasks and teaching materials which fulfilled the *bik* criteria.

Research frame

The *bik* programme pursues two major goals: First, it seeks to develop tasks and concepts of biology education that are embedded in authentic contexts and that are relevant and interesting for students. They should foster meaningful learning and instil greater competencies in students. The second goal pays attention to the teachers and supports the enhancement of teacher skills and motivations to implement the innovative conceptions of *bik* in the classrooms. To investigate the processes on the teacher level, a comprehensive evaluation concept was utilised (Lücken & Elster, 2008) which is based on the theory of 'planned behaviour' (Ajzen & Madden, 1968) (see Figure 2).

[Please insert Figure 2 here-Prediction Model]

According to this model, the behaviour of teachers practicing a contextual and competency based approach can be predicted more precisely when specific aspects are considered. The prediction model involves the measurement of *teacher attitude* toward implementing the *bik*-conception. Furthermore, it considers the assessment of the perceived attitudes of important other individuals, such as colleagues and school principals (subjective norm), as well as the teachers' self-efficacy concerning the implementation of the new *bik*-concept (see Figure 2). These three aspects predict *teacher behaviour* which is primarily mediated by influencing the *intention* of the teacher to implement the *bik*-concept (Lücken & Elster, 2008).

The structure of the questionnaires and interview guidelines are based on this prediction model. In this study, I present results of the formative evaluation focussing on teacher professional development.

Research questions

Considering the professional development of teachers in *bik* learning communities, the essential question of the formative evaluation research can be formulated as such:

> Does participation in the *bik*-project foster the professional development of teachers toward acquiring competency-oriented teaching and learning skills within student-relevant contexts?

Information on the *personal level* was collected about the *attitude* and *behaviour* of teachers by focusing on the following questions:

(1) Teacher-attitudes toward implementing the *bik* concept.

Is it possible to identify different teacher profiles which take into account their willingness to implement *bik* and to foster competency-based biology teaching?

(2) Teacher-behaviour and change of practice.

How does the *bik*-project effect daily work in the classroom?

Information on the *system level* was obtained about the *processes* occurring within the learning communities through the following questions:

(3) Instruction, construction, reflection.

How are these processes conducted within the learning communities? Can successful and impeding elements be identified?

(4) Computer use.

How are computers embedded in instruction, construction and reflection processes?

(5) Social and technical features.

How are ICT tools used in processes of relationship building, learning, knowledge creation and project collaboration?

Methods, participants and data sources

Figure 3 gives an overview about the methods, participants and data sources. Results of the formative evaluation (interviews with teachers, researchers and coordinators; teacher questionnaire after the set meetings) and data of the student survey are reported in this study.

[Please insert Figure 3 here – Overview of the sample]

- *Interviews*

To investigate the process of professional development of teachers, the coordinators and researchers were asked to participate in interviews at the initial part of the *bik*-project, again after one year of working in learning communities and at the end of the *bik*-project. Figure 3 shows the number of interviewees. The methodology of the interviews was identically structured with four persons from each *bik*-set: two teachers from different schools (participation in the interview survey was voluntary), the set-coordinator and the set researcher. In Schleswig-Holstein (focus group), all participating teachers took part in the interview survey.

The interviews followed guidelines rooted in the theory of *planned behaviour* (see Figure 2) and inquired about teacher attitudes (toward the implementation of context-oriented and competency advancing teaching and learning, self-concept of teaching, ICT skills), teacher intention to implement *bik* and teacher behaviour (while constructing tasks and in the classroom). Additionally, questions about processes occurring within the learning communities (phases of instruction, construction and reflection) and the impact of social and technical features were investigated.

Each interview lasted about one hour and was tape-recorded. During the interview, a mind map was developed together with the interviewee. The mind maps and the transcripts of selected parts of the tape-recordings were analysed according to the paradigm of qualitative content analysis (Mayring, 2003). This method allowed the deductive theory-based coding of categories, as well as an inductive coding (of sub-categories). The coding was performed independently by two coders (Lamnek, 2005) and communicatively validated till the inter-relater co-efficient (Kappa value) ranged between 0.85 and 0.95.

- *Student questionnaire*

To assess the classroom activities, the students were asked to fill out a questionnaire each year (see Table 4). The reported scales allowed insight in the daily classroom routines with regard to fostering competencies (subject knowledge, inquiry acquisition, subject-related communication, valuing and decision making), context-orientation and inquiry- orientation, Additionally, the methods of assessment and teacher-steering were investigated. The analysis was conducted with factor analysis and ANOVA.

[Please insert Table 4 here – Student scales]

Results

In this section, the main results of the formative interviews are reported in light of the research questions (coding of the interviews: i1 = initial interview; i2 = follow-up interview; i3 = final interview; LK = teacher, R = researcher, C = coordinator). Additionally, data of the questionnaire survey (student sample) are presented to report the effect of *bik* at the classroom level.

The reported results are aligned according the following research areas:

(1) Teacher-attitude toward implementation the *bik* concept.

(2) Teacher-behaviour and changes.

(3) Instruction, construction and reflection processes within learning communities.

(4) The use of computers.

(5) Social and technical features.

(1) Teacher-attitude toward implementation of the *bik* concept

- *Is it possible to identify different teacher profiles which take into account their willingness to implement* bik *and to foster competency-based and context-oriented biology teaching?*

Based on the qualitative content analysis of the initial interviews (random sample of 37), I identify three separate profiles of teachers which are summarized in Table 5. The profiles are distinguished by several factors. (i) The willingness of teachers to carry out innovations (based on self-appraisal). (ii) The teachers' self-concept of their own teaching and learning (see Figure 4), and (iii) the teachers' self-concept regarding their collaboration and networking (see Table 6). Additionally, the teacher profiles are related to (iv) the teachers' attitude toward fostering student competences (see Figure 5) and (v) the amount of ICT skills possessed by the teachers (see Table 7).

[Please insert Table 5 here – Teacher profiles.]

I would like to discuss in greater detail each of the five factors which make up the teacher profiles.

(i) Willingness of carry out innovations

In the interviews the teachers were asked to report about their openness to carry out innovations. [Interview question: How interested are you in new approaches to teaching and learning?] The resulting data were coded into three categories corresponding to teacher profiles:

- Teacher Profile 1. The *enthusiastic teacher* is one who is interested in nearly all innovations and teaching experiments – whether in subject-related or pedagogical domains.
- Teacher Profile 2. The *open teacher* is one interested in innovations, too. He or she reflects critically on innovation goals and takes part in innovations only if his or her daily work load allows it.
- Teacher Profile 3. The *subject-related teacher* is one mainly interested in domain specific innovation; pedagogical concerns are of less importance.

(ii) Self-concept of teaching and learning

To investigate the teachers' self-concept of teaching, six 5-point-polarity profiles were included in the interviews. The contrasts are contained in polarity profiles and can be formulated as follows:

1. Teacher orientated – Student orientated
2. Subject related – Everyday life related
3. Teacher directed/steering – Fostering pupil self-activity
4. Tasks to test factual knowledge – Complex tasks to foster problem solving
5. Subject-related performance level – Class-related performance level
6. Summative performance monitoring – Formative performance level

The polarity profiles were used in the initial (i1) and final interview (i3). [Interview question: Please, mark that part of the polarity profile which corresponds to the *is-state* in your *bik* class. The 'is-state' is the current way you handle the issue.] The teachers' responses are reported in Figure 4. The results show differences between the teacher profiles. For example, teachers of profile 1 are more student-oriented, whereas teachers of profile 2 are subject-oriented and open to promoting student activities, e.g. by assigning complex tasks. Teachers of profile 3 are performance and subject-oriented.

The data from the final interviews show that teachers of profiles 1 and 2 are open to change whereas the teachers of profile 3 fail to show any changes in performance monitoring (The data of the final interviews are not included in Figure 4).

[Please insert Figure 4 here – Personality profiles] *(iii) Self-concepts of collaboration and networking*

To obtain information about the teachers' self-concepts of their own collaboration and networking, I asked the interviewee 'What do you see as an advantage when collaborating in your *bik* set?' The categories and sub-categories and percentage of answers in the initial (i-1) and final interviews (i-3) are reported in Table 6. I identified two categories of collaboration within the school set between teachers of different school types and between different schools: *subject-related* and *interdisciplinary*. The data documented an increase in joint subject related planning and reflection, an increase in the integration of interdisciplinary contexts, but a decrease in the simple exchange of materials from the first to the third *bik* year.

[Please insert Table 6 here – Collaboration and networking.]

(iv)Attitudes toward fostering competencies

One of the core questions of the interviews concerns the attitudes of the teachers on fostering student competencies in their classroom. The interviewee was asked to score on a four-point-scale their response to the following question: How important is it for you to foster....competencies in your students? The three teacher profiles are related to teacher attitude on fostering student competencies. For teachers of profile 1, it is very important to foster all competence areas; for teachers of profile 2, it is important to foster subject related communication, valuing and decision making, as well as the basic concept *development and evolution*; profile 3 teachers seek to foster subject-content knowledge and the basic concept of *structure and function*. Figure 5 summarises the results of the interviews.

[Please insert Figure 5 here – Foster competencies] *(v) ICT skills of the interviewed teachers*

The computer related abilities of the teachers can be categorised at various levels: excellent, average, low and absence of ICT skills. Each of the categories listed in Table 7 are accompanied by a statement typical for the category.

[Insert Table 7 here-ICT skills]

Most of the interviewed teachers (26 of 37) are ICT users at the average level. They remarked that they make use of the computer at home for the development of materials and information sheets. In addition, they have the possibility to access the internet at home or at school, and they are confident in sending e-mails.

Six of the interviewed teachers are users with excellent skills. They have extensive ICT-related knowledge including the educational use of ICT. They have taken additional computer courses and are sufficiently computer literate.

Four of the interviewed teachers are users at the low level. They have little or no experience in the use of MS Word and/or have no possibility of setting up an internet access without support. Only one of the interviewed teachers admitted to entirely lack ICT competence.

Is there a correlation between teacher profile and computer use? I was able to identify those teachers lacking computer skills or with low computer skills as teachers of profile 1. Teachers with excellent computer skills are mostly of profile 2 (5 of 12 teachers), one teacher with excellent skills belongs to profile 3. Many teachers with excellent computer skills were of profile 2 (5 of 12 teachers), and one teacher who excelled in computer skills belonged to profile 3.

(2) Teacher-behaviour and change of practice

How did the bik*-project effect daily work in the classroom?*

The behaviour of the teacher during the implementation the *bik* approach can be analyzed by examination of their developed tasks and materials (exemplary tasks see Table 2) and the student questionnaires. More than 100 tasks and units were developed in the ten *bik* school-sets. They are available on a CD - ROM which can be ordered from the Leibniz-Institute of Science Education at Kiel University. The *bik* tasks and units stress many domains of subject content. They can be seen as stepping stones for the implementation of a standard based curriculum, but they do not represent a whole curriculum. The analysis of the tasks is still pending.

Change of classroom activities

To obtain data about effects of *bik* and the change in the daily work of the teachers I organized questionnaires on the student level (Lücken & Elster, 2008). The student surveys were conducted yearly (number of participating students: $n = 1689$). The data demonstrate that there was an increase in student awareness ($p<0.001$from the first to the third year) of competence-oriented teaching which can be differentiated into the following competency areas: subject knowledge ($d = 1.89$), inquiry acquisition ($d = 1.76$), communication ($d = 2.34$), and valuing and decision making ($d = 2.47$). Additionally, there was an increase in student awareness (p<0.001 from the first to the third year) in context-oriented teaching (d = 2.47) and inquiry based teaching (d = 2.77), as well as individual performance feedback (d = 0.69). The students commented on the lack of teacher-centred teaching and learning (d = 1.72). The scales (number of items, Cronbach's Alpha, exemplary item) are documented in Table 4. The results are summarized in Figure 6. Reported are the changes from the initial survey (start) to the final survey (follow up 2). They results suggest that change needs time since there was a considerable increase in the last *bik* year.

[Insert Figure 6 here- change of classroom activities]

(3) Processes within the learning communities

How are processes of instruction, construction and reflection conducted within the learning communities?

The *bik* face-to-face-meetings can be characterized by phases of instruction, construction and reflection. The term *instruction* describes all means and tools given to the group by the researchers and coordinators. The instruction phases are embedded in a flat hierarchical structure to allow a mutual exchange between researchers and practitioners.

The term *construction* describes the developmental processes of tasks and units (individual or in groups). One of the major goals in the *bik*-project is to cultivate the phases of shared construction which Little (1990) defined as *co-construction*. Co-construction requires agreement about the working process and goals of researchers and teachers, as well as a critical re-thinking of one's own practice which can lead to a change in the routine of action. The term *reflection* comprises individual processes (such as writing a reflective journal about classroom experiences), as well as group processes (such as discussions within the set meetings about classroom experiences and theories or feedback on recently developed materials).

- *Instruction: Which resources available to the groups supported the* bik *implementation?*

Based on the findings of the interviews with the teachers, researchers and coordinators, the following resources and tools, which were made available to the group, proved supportive (see Figure 7). Quotations from the interviews illustrate this. 'Concrete examples of teaching and tasks' (i1_SK1); 'exchange of teaching experiences…' (i1_SK1; i1_SK2; i1_LK6; i1_LK7); 'It was interesting to hear the high school teachers discussing with each other and with teachers of other school types. Their attitude toward the difficulty of student tasks is very different to middle school teachers....' (I_SK9).

The teachers considered *reflection on theories* to be of minor importance. Sharing with each other 'examples of biology lessons and units', the 'further development of *bik* tasks' and 'reflection on classroom experiences' were more important for teachers than researchers or coordinators. In sum, the use of 'exemplary *bik* tasks' and their 'joint further development' supported the transfer of theoretical competence models into school practice.

[Please insert Figure 7 here – Effectiveness of resources.]

- *Construction: How do* bik *teachers construct tasks and units?*

Table 8 gives an overview about construction processes. It shows that the construction of *bik* tasks was mostly performed at the set meetings (86%), while only 14% of the tasks were constructed between the set meetings. Three subcategories of task development occurred during the set meetings: the simple exchange of materials (40%), synchronisation of task development (22%) and co-construction (24%). In-between the set meetings, the teachers reported that they relied on the exchange of materials via e-mail and the *bik* website (set intern forum) in putting together the tasks. Table 8 summarizes the results and shows a decrease in the simple exchange of materials and an increase in co-construction from the first to the third *bik* year.

[Please insert Table 8 here – Construction processes]

- *Reflection – How often do the teachers engage in reflective processes?*

Based on the results of the interview survey, two categories can be distinguished: *reflection occurs* and *reflection does not occur*. The first category is an umbrella term which encompasses four subcategories. Two of these, *reflection in action* and *written reflection on action*, revolve around individual processes of analyzing classroom experiences. The remaining subcategories, *reflection on classroom experiences* and *reflection on theories*, are processes which occur at the group level. In the category *reflection does not occur*, the teachers comment on their *implicit knowledge of action* (see Table 9).

The core results show an increase of mentioning individual *reflection on action* from the initial interviews (6%) to the final interviews (17%), as well as an increase of *group reflection on classroom experiences* (from 3% to 7%). There is a decrease of the subcategory *implicit knowledge of action* from the initial (25%) to the final interview (8%).

[Please insert Table 9 here – Reflection processes]

(4) Use of computers

- *To what extent are computers used in instruction, construction and reflection processes?*

[Please insert Figure 8 here – use of computer.]

From Figure 8 it is evident that the computer is mostly used during the construction process. We see an increase from the first *bik* year (60%) to the third where 80% of the construction of tasks and units were composed with the help of the computer and internet. What are the reasons for the increased use? One teacher from set 4 describes the process well:

> There was a change from the first two years to the last year: the importance of having internet access during the set-meetings increased considerably. The reason was a change in our team collaboration; we started to exchange materials via the *bik* forum. (i3_LK7)

In several school-sets, the set coordinators supported the teachers in fulfilling requirements necessary for the use of different computer features.

> The teachers have a lot of problems in using the *bik format* for the task development. Therefore, I offered them the possibility to send their tasks per e-mail to me. Then I reformat them and put them into the *bik* forum. (i3_SK4)

Other participants used the *bik* website to access information and materials from other school sets: ‘When will the *bik* tasks of the other *bik* sets be available? Can I use them in my classes?’ (i3_LK23). These reasons given by the teachers explain the increase in visiting the *bik* forum for task construction. Oder: These reasons explain why teachers increasingly visited the *bik* forum for task construction.

Computers were seldom used during the reflection processes (5% or less). The teachers mentioned that they preferred to reflect privately (with paper and pencil records) or verbally at the set meetings. Any systematic reflection seemed to be ‘lost time’ (i3_LK07), ‘written reflection is only important to change materials if they can be used next year in the school’ (i3_LK23). 'Could you support us with tools or learning programmes – our teachers neglect to reflect systematically' (i2_R03) was the cry for help from some researchers.

The use of computers for instructions (e.g. presentations and demonstrations) was relatively high (from 32% to 45%). The researchers recognized that the teachers increasingly took charge of the instruction processes.

> Besides the regular Power Point presentations of the researchers and the information offered by the coordinators, I recognized that there was an increase of computer input performed by the teachers on their own. They presented their material, e.g. building blocks to foster experimentation, and adopted the instruction processes according their needs. (i3_R01)
>
> Sometimes I thought that the teachers didn't recognize that I am in the room. As they got more and more acquainted with the *bik* concept they mutually instructed themselves in the use of the guidelines to construct competence-oriented tasks by using the electronic *bik* task format. I was asked to participate only as an adjudicator in problem situations. (i3_R06)

From these comments it can be concluded that the 'electronic *bik* task format' was not seen as a steering or instruction tool (which it was in its core). Furthermore, the task format helped teachers to assume responsibility for their own professional development.

In sum, computer-use supported the construction and instruction processes within the learning communities. However, to more fully foster the systematic reflection processes, additional research must be conducted.

(5) Social and technical features

- *How are relationship building, learning and development, knowledge creation and project collaboration conducted within the* bik *learning communities?*

Relationship building, learning, knowledge creation and project collaboration are important social features in learning communities. These features were the core elements of the face-to-face meetings in the *bik*-project. They should be supplemented by technical features such as the use of ICT tools (see Figure 9).

[Please insert Figure 9 here – Social and technical features]

ICT tools are mostly used for project collaboration. Their use increased from the first (20%) to the third year (38%). They were applied for learning (about 24%) and knowledge creation which increased from 18% in the first to 27% in the third year. The computer was seldom put into service to build relationships (about 10%).

Regarding the technical features, which were actually used for collaboration, one teacher claimed:

> In the time between the set-meetings I prefer to send e-mails to my colleagues. It is easier than to collaborate via the on-line forum. If I have materials and pictures to send, then I use the computer platform. But in that case, I write a short e-mail to my colleagues, that I have posted the material in the forum. (i3_T14)

A school team of three teachers was asked to inform other set members about their experiences with collaboration:

> Sorry, we have only little time for collaboration or meetings at school. Sometimes a small chat during the break or the exchange of materials, not more. We collaborate at the set meetings, per phone, or I give my colleagues a CD-ROM with materials.

(i3_LK17)

This comment showed that the use of telephone and e-mail, as well as the exchange of materials via electronic data carrier (CD-ROM or sticks) are the common means of communication within the school teams.

In the opinion of the researchers and coordinators, it is the teachers who need support in task management, project management and time management. Asking one set coordinator about technical features he used for set collaboration, he replied:

> I am responsible for all (technical features in) administrative matters. Additionally, I feel responsible for the task management. Teachers of my set should feel free to ask me for (technical) support. (i3_SK09)

These and similar statements allow us to draw the conclusion that teachers were not (or insufficiently) computer literate to perform the task management by their own.

Which ICT tools are used for *learning* and *knowledge creation*? Examples of technical features that support learning processes and the development of the *bik* set are Power Point presentations about competence models, theoretical considerations about context orientation and exemplary tasks. Several quotations from teachers and researchers should illustrate this.

> Within the set meeting, the set researcher presented a short instruction, e.g. about the ROSE study, a comparative study about students' interests. After the set-meeting, I could find the researcher's presentation in the set forum. That was very helpful for me because later on in the development of the *bik* task I was able to integrate these student-relevant contexts. (i2_LK08)

> It's my opinion that the most important tool for learning and development is the electronic *bik* task format. It supports teachers in task development and fosters the exchange between the school-sets. (i2_R03)

> Exemplary tasks, e.g. 'Anchovies in the Pacific' – a task that we modified again and again to foster selective competencies – are helpful tools to get confident with standard

> oriented tasks. (i3_LK17)

Technical tools to foster *knowledge creation* such as idea and method banks, structured databases and links to further websites are reported in following statements:

> It is important that I can find additional information in the set intern forum such as methods and materials to foster inquiry based learning. (i3_LK15)

> Links to other websites like the context-projects of chemistry and physics brought new ideas with regard to interdisciplinary contexts. (i3_LK10)

The tools for *relationship building* which teachers mostly used were telephones and e-mails. Additionally, the links to school websites available at the *bik* website were taken advantage of. Member profiles would be an important feature to support *relationship building* but they were not used in the *bik* sets.

Conclusions

The findings show that participation in the *bik*-project fostered the professional development of teachers toward competency-oriented teaching and learning in student-relevant contexts. The results of the student sample provide evidence for the effects of the *bik* project on the daily classroom activities. The students noticed that the teachers' form of instruction had changed – according to the conceptual considerations of *bik* – to the advancement of competence via student-relevant contexts and inquiry based methods.

The results of the student sample can be related to the findings of the interview study. I identified three teacher profiles according to their willingness to carry out innovations, self-concepts of teaching and learning, self-concept of collaboration, networking and reflection. The three teacher profiles are related to teacher attitudes toward fostering student competencies and show differences in their willingness to foster the competence areas *inquiry acquisition*, *subject related communication*, *valuing and decision making*, as well as the basic concepts of *system* and *development and evolution*, as well as *structure and function*.

The daily work of the teachers is principally altered by the *bik* tasks which were developed, tested and reflected upon in the *bik* sets. The group helps not only to develop new tasks and units, but moreover to create new ways of teaching. The teachers receive strong support when reflecting on the success or lack of success of particular practices and when discussing common experiences. Concrete *bik* tasks (and their joint further development) were successful starting points for exchange and reflection processes between teachers and researchers. Shared work is reported to be the most effective factor which supports the teachers. More than 90% of the answers stress the basic function of teamwork. The close partnership with researchers was a motivational factor for teacher professional development.

Regarding the computer literacy of the teachers, the main findings show that only a few teachers (6 from 37) were computer literate at a high level. The participant teachers mainly used ICT tools when constructing tasks and units and when collaborating, but less so for instructional purposes, learning and knowledge creation. They seldom used ICT tools for reflection on professional experiences, and teacher use of ICT tools increased from the first to the third year.

It is assumed that computer literacy skills have a strong impact on the persistence of learning communities. Bearing this in mind, the question arises what are the implications for the support of professional development of teachers in the learning communities as the teachers gradually turn from classical settings of learning, such as face-to-face meetings, to mixed forms.

Implications

In the EU report, Science Education Now – A Renewed Pedagogy for the Future of Europe, Rocard et al. (2007) point out that teachers are the key-players in the renewal of science education. The authors of the report suggest several methods to ensure this, among them *networking*. They argue that networks can be used as an effective component for the professional development of teachers, and that they are complementary to the more traditional forms of in-service training. In short, participation in a network allows the teachers to improve the quality of their teaching. Furthermore, it stimulates morale and rouses their motivation.

The *bik*-project successfully promotes such components for the renewal of science education. These educational standards should be brought about through new forms of pedagogy; by introducing inquiry-based approaches to schools; by fostering contexts which are relevant to students and by promoting subject-based knowledge and science competencies (KMK, 2004).

According to Rocard et al. (2007), one goal of the *bik*-project is that teachers should become members of a professional network that provides them with opportunities to enrich their practice. This can be accomplished through collaboration within the school and between schools, by collaborative reflection, refinement of instructions, exchange of materials and experiences and by other forms of support. Can the *bik*-project help us attain this goal?

One of the core results of the *bik*-project which I want to underline is that the *bik* learning communities are to be seen as an effective component of the professional development of teachers. They promote both co-construction and reflection processes. It is evident that the ICT skilfulness of the participating teachers is one of the major requirements for the establishment and the sustainability of learning communities (Borko, 2004). The use of computer tools should not be restricted entirely to coordinators who provide the information to the website which is accessed by the learning communities. Furthermore, teachers should be trained to use both technical and communication tools.

To reach this goal, we must renew our concepts of pre-service and in-service. It should be clear that the present requirements for teachers are insufficient when it comes to computer literacy and ICT skills. I would argue that these should form an integral part of the professional development of teachers. In addition, virtual forms of communication should be more systematically integrated into teacher education programmes. Communication via computer platforms and on-line forums must become a daily instrument in teacher work. We expect that simply providing these tools will not suffice; furthermore, their use should be prepared according to the individual requirements of each learning community.

Inevitably, there are several stumbling blocks which hinder the teachers from acquiring computer literacy, as well as those which threaten the sustainability of *bik*-projects. This study concludes that e-competence and the ability of teachers to cooperate in web-based communities have a strong impact on the sustainability of learning communities. This is of general interest in many other countries where learning communities are used in implementation processes. To further investigate the impact, e.g. in Austria there will be conducted a follow-up project, *biokomp* (teaching and learning biology with a competency-oriented approach) (see http//www.doriselster.at/biokomp). The project will focus on the development of web-based comparative diagnostic tasks which should provide teachers and their students an environment in which they can diagnose, compare and evaluate their advanced competency teaching and learning. A new challenge for the researchers is to promote the professional development of teachers in the learning communities as the teachers move beyond their reliance on classical settings of learning, such as face-to-face meetings, toward a blended form of learning.

In sum, we must be aware that learning communities simply do not happen by themselves. They require a defined purpose and cannot thrive without ICT skills and technical equipment at schools and home. Learning communities must be cultivated, nursed and fostered with professional support and, at times, they need much encouragement.

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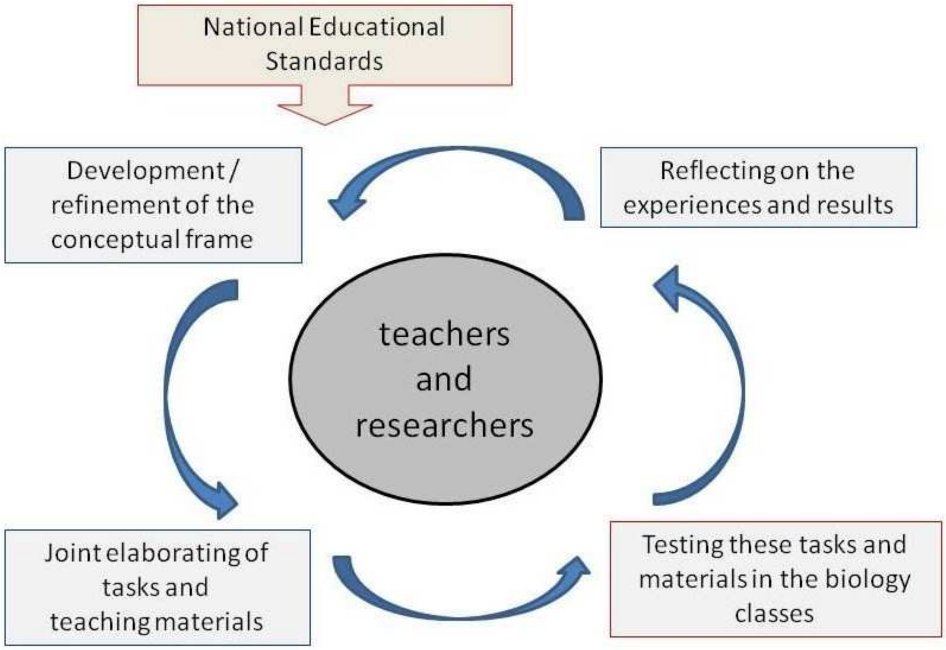

Figure 1. Working steps in bik learning communities.

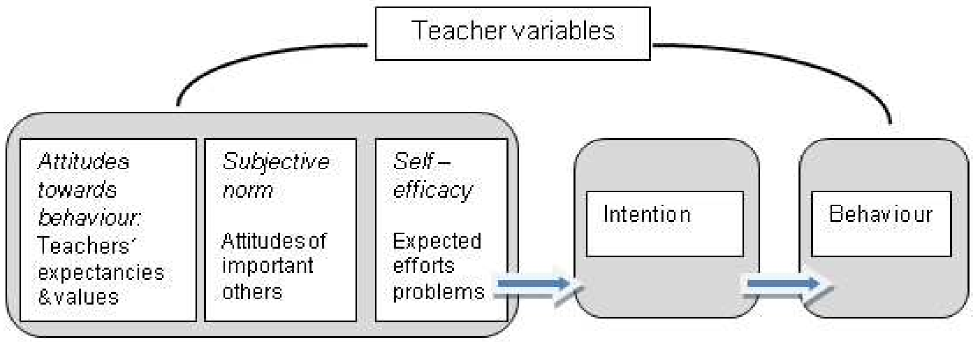

Figure 2. Prediction model according to the theory of 'planned behaviour' (modified after Ajzen und Madden, 1968).
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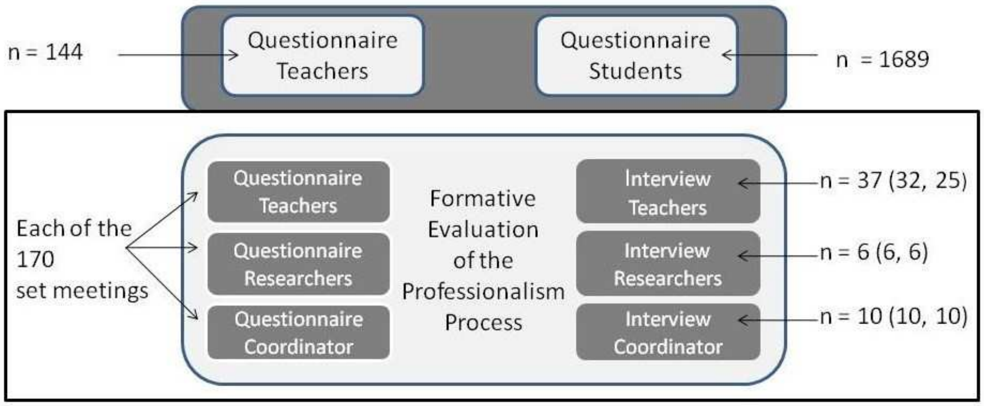

Figure 3. Overview of the sample and participants.

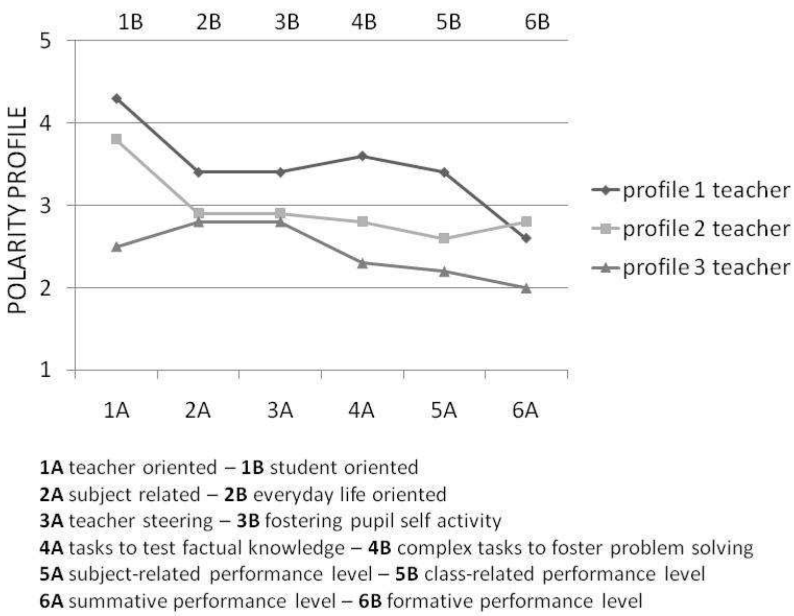

Figure 4. Polarity profiles of teachers (n = 37); reported are means of 5-point-scales
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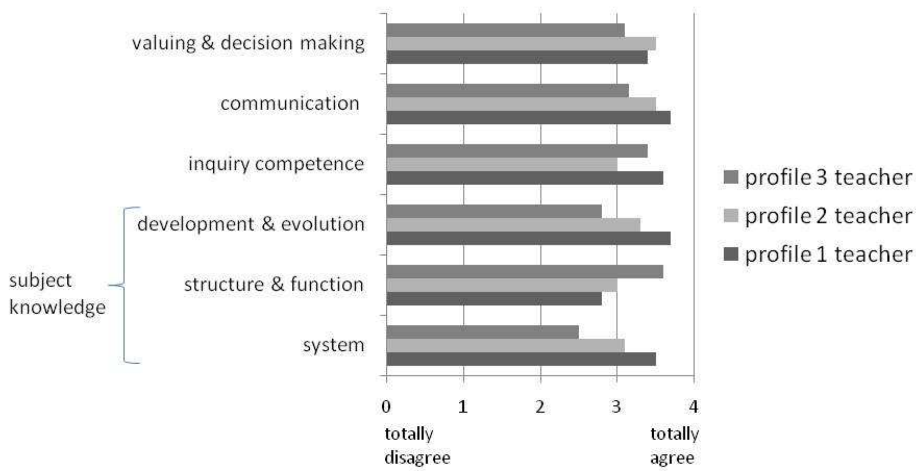

Attitude of teachers to foster competences (n = 144; means of 4-point-Likert scales).
254x190mm (96 x 96 DPI)

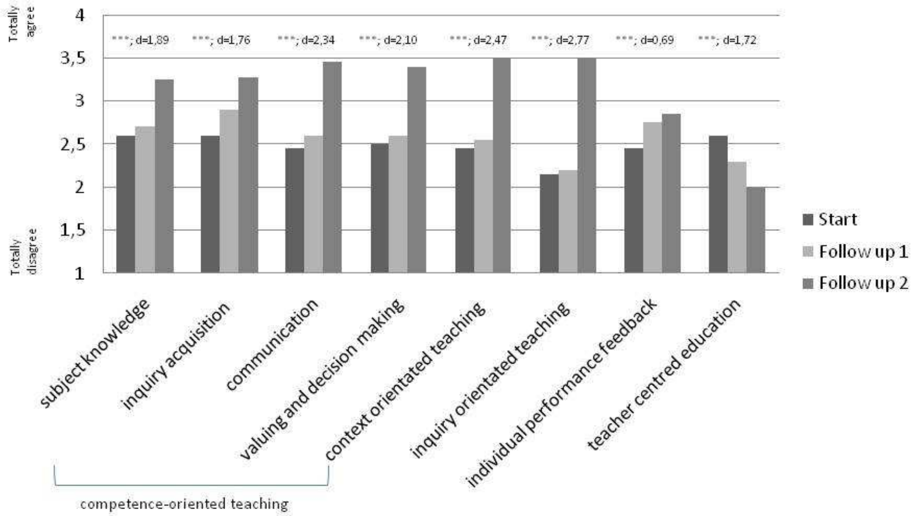

Figure 6. Change of classroom activities (student sample; n = 1689); ANOVA; ***p<0.001.Lücken & Elster, 2008.
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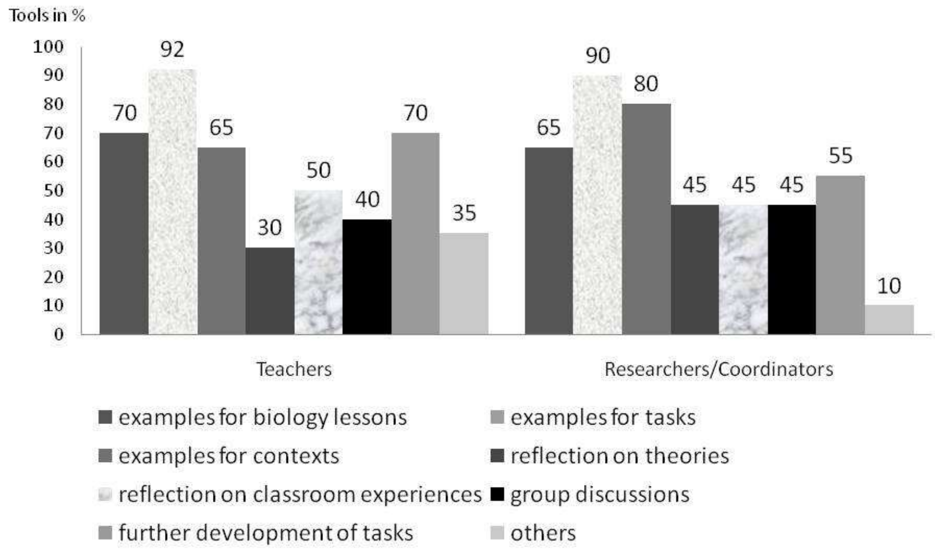

Figure 7. Effectiveness of the means provided to the groups to support the bik implementation. Result of the interview study with teachers (n = 37), researchers (n = 6) and set-coordinators (n = 10). The usefulness of the particular tools is given in %.
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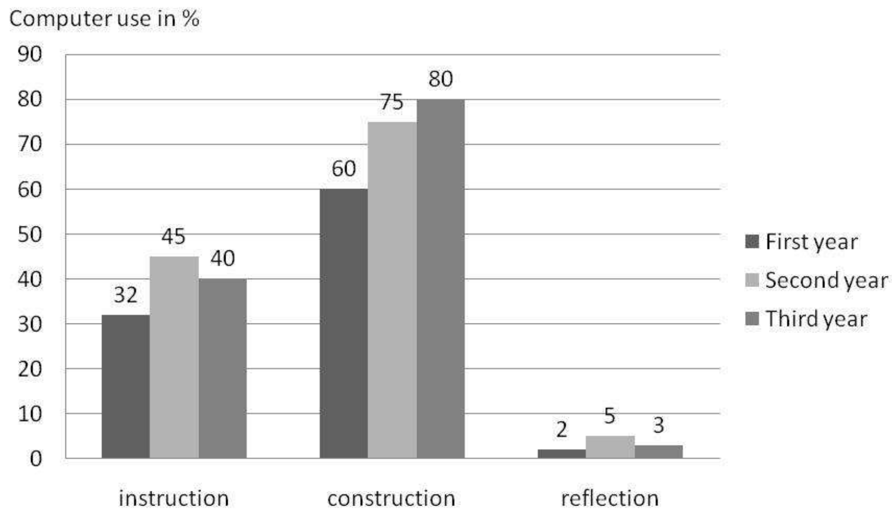

Figure 8. Working processes (instruction, construction and reflection) and computer use in bik learning communities. Results from the interview study with teachers, researchers and set coordinators (first year: n = 53; second year: n = 48; third year: n = 41). The graph shows the percentage of reported computer use for each working process over three years, as well as how often the use of the computer was mentioned in %.
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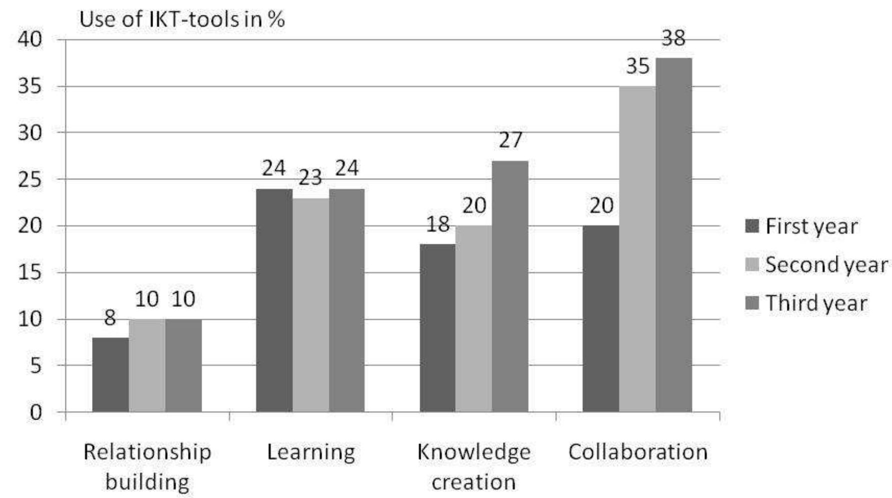

Figure 9. Social features and computer use in bik learning communities. Results of the interview study with teachers, researchers and coordinators (first year: n = 53; second year: n = 48; third year: n = 41). The graph provides information, given in %, on how often a social feature was mentioned.
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Table 1: Competence areas and examples of standards.

Subject knowledge	▪ Understanding biological phenomena, concepts, principles, facts and their connection to basic concepts (system, structure and function, development and evolution). ▪ Conveyance of basic biological facts and concepts, as well as ability to impart complex knowledge, rather than to relate details of the subject matter. ▪ Lays the foundation for cumulative learning by connecting biological concepts to concepts in other science-subjects and to render them applicable through both horizontal and vertical networking.
Epistemological skills and knowledge acquisition	▪ Use of experiments and other inquiry methods such as criteria-based monitoring and comparison, as well as models. ▪ To foster an understanding of the influence of scientific thought on the working methods applied in biology.
Subject-related communication	▪ To collect and exchange subject related information and to reflect upon norms and values. ▪ Previous knowledge, the notions held by pupils, the learners' level of expertise are all of crucial importance to subject-related communication.
Decision making, valuing and moral judgement	▪ To recognize and value biological facts on the basis of models of ethical reflections and to discern descriptive and normative aspects. ▪ To systematically relate subject knowledge to relevant norms and values with the intention of arriving at a substantiated conclusion.

Table 2: An exemplary bik task and its analysis.

A strange discovery

It's winter. An excavator is digging ditches into a snow covered southern slope. Two girls are watching curiously as they suddenly discover something greenish glimmering, about two feet beneath the surface. It turns out to be a frog, which is feeling cold and is lying motionless on the ground. One of the girls thinks it's dead and wants to throw it back into the ditch. The other girl, however, wonders, 'if the frog is dead, why has it not started decomposing?'. Thoughtfully, they observe the animal and bend its stiff body. One of the girls puts the frog into her pocket, for further examination at home. After a few minutes she notices that the frog is moving in her pocket. "It came to life!" she exclaims and takes it out of the pocket. But the frog moves so swiftly that it jumps right out of her hand trying to escape into the snow. There, however, it doesn't get too far. Its movements become slower and slower until finally it is again as stiff as in the beginning.

__Questions:__

a. **Explain** the frog's behaviour in the pocket and in the snow to the two girls. The following terms could be of help: body temperature, ambient temperature and activity. Please note down your ideas in the form of a short dialogue.

b. **Establish** together with your neighbour why the frog was buried.

c. In small groups (4 people max.) **explain** the stiff condition of the frog to the two girls and give reasons why the frog comes to life again. Create a **dialogue.**

d. With a partner **write** in whole sentences what is going on in the body of a frog in winter. Take terms such as food, cold and hunger in consideration.

e. **Name** a few animals with similar behaviour in winter. What is this state called?

Analysis of the bik task

Context: How animals survive in winter; hibernation of frogs.

Basic concept: Structure and function, system

Competencies: The students should

- **describe** and **explain** interactions between organisms and inanimate matter.
- **describe** and **explain** the adaptation of selected organisms to the environment.
- **communicate** facts about hibernation, **argue** in small groups and create a dialogue.
- **evaluate** the information of the introductory text with regard to the biological question and process it by means of various techniques and methods as is appropriate for the audience and the situation.
- **present** biological systems, e.g. organisms, scientifically correct and appropriate for the audience and the situation.
- **explain** biological phenomena and relate them to the personal conceptions.

Affective dimension: extreme situation between life and death.

Table 3. Overview about the bik learning communities (school sets).

Set	Focus of research	Teachers and school partners *	University partner	Federal state
1	Fostering subject knowledge by using basic concepts.	19 teachers from 3 HS, 2 ICS and 2 MS.	Duisburg Essen	Nordrhein-Westfalen
2	Cumulatively increase of subject knowledge.	20 teachers of 6 HS, 1ICS and 1 MS.	Duisburg Essen	Rheinland-Pfalz
3	Building blocks to foster experimentation competences.	11 teachers from 2 ICS, 1 MS, 2 HS.	Giessen	Bayern
4	Building blocks to foster experimentation competences.	15 teachers of 4 HS and 1 MS.	Giessen	Hessen
5	Verifying the competence model of subject-related communication.	9 teachers of HS	Kiel	Berlin
6	Testing a competence model for knowledge communication.	12 teachers of 5 HS, 2 MS and 1 ICS.	Kiel	Schleswig-Holstein
7	Testing a competence model of ethical judgment.	21 teachers of 6 HS and 4 MS	Oldenburg	Hamburg 1
8	Testing a competence model of ethical judgment.	5 HS and 2 MS	Oldenburg	Niedersachsen North-West
9	Verifying a competence model of judgment in environmental issues	13 teachers of 8 HS	Göttingen	Niedersachsen South-East
10	Verifying a competence model for judgment of environmental issues	11 teachers of 11 MS.	Göttingen	Thüringen
11	Cumulatively increase of subject knowledge.	17 teachers of 5 HS and 4 MS	Münster	Hamburg 2**

* HS = High School, MS = Middle School, ICS = Integrated Comprehensive School.

**School set Hamburg did not take part in the interview survey.

Table 4. Student scaled assessment of classroom activities.

Number of items (n), Cronbach's Alpha (α) and examplary items.

Scale	n	α	Exemplary item *In our biology lessons....*
Fostering subject knowledge	8	0.72	We learn how animals, plants and humans may have evolved.
Fostering inquiry acquisition	10	0.77	We learn to predict, observe and explain experiments.
Fostering subject related communication	3	0.91	We learn to argue and discuss scientifically.
Fostering valuing and decision making	4	0.77	We learn to discuss bioethical issues such as cloning of living beings.
Context-oriented teaching	3	0.82	We learn about themes that I can apply in daily life.
Inquiry-oriented teaching	4	0.72	My teacher assigns tasks that I have to cope self-consistent.
Individual performance feedback	3	0.84	My teacher gives me feedback about how to better my school performance.
Teacher centred education	4	0.94	Our teacher instructs us in detail how to solve a task.

Table 5. Profiles of teachers based on the results of the interview survey (n = 37).

Profile 1 teachers (12 females, 4 males)	They describe themselves as very innovative (enthusiastic), open for teaching experiments (whatever they may be) and willing to cooperate with colleagues at school and in out-of-school networks. Further, they are willing to reflect on practice experiences in group discussion. They are interested in their professional development at the classroom level and less interested in developmental processes of the school. Teachers classified as profile 1 are student-oriented, they discover references pertinent to the everyday life of the students, they motivate self-activity by setting complex tasks which promote problem solving. A typical statement: *I like to be a teacher, it is not only my job, it is my mission* (i1_LK25).
Profile 2 teachers (4 females, 8 males)	They describe themselves as open for innovations. They are interested in the development of their teaching, as well as in school development. Most of them have administrative functions in their schools (administrator, head of subject groups). They are subject and pedagogically oriented. The processes within their classrooms are dominated by instruction, they set a variety of tasks (for knowledge reproduction, as well as for problem solving). They are cooperative, but only take part in networks if, in their opinion, it would mean success. They like to reflect on the meta-level. A typical statement: *I am a teacher, but I am a biologist, too. I think the promotion of students' subject knowledge is as important as to show them boundaries which infer the limits to their actions (*i1_LK12).
Profile 3 teachers (3 females, 6 males)	They describe themselves as less innovative. They are performance-oriented and like to bring in specific scientific aspects. They are satisfied with their teaching and blame their students for unsatisfying learning results. At school and in the *bik* school-set, they are more or less the lonely actors, they are cooperative only to a certain degree, they are more interested in autonomy than in networking and cooperation, and they tend to reject reflection processes on teaching. A typical statement: *It is important to ready the students for their participation in the world. Therefore, they need factual knowledge which must be trained* (i1_LK17).

Table 6. Collaboration and networking: categories and subcategories (data from interview survey). The data report how often a certain subcategory is mentioned in %.

Category	Subcategory	i-1	i-3
Subject related work with other set teachers			
	Exchange of materials	60%	45%
	Subject related discussions	25%	60%
	Joint planning and reflection of tasks	45%	70%
Interdisciplinary work with other set teachers			
	Integration of the supplementary subject for task development	0%	15%
	Integration of interdisciplinary contexts	15%	30%
Collaboration across school types			
	Collaboration of own motivation	5%	30%
	Collaboration stimulated by the set researcher	10%	10%
Collaboration across schools			
	Joint school projects	0%	10%

Table 7. ICT skills: Categories and exemplary statements (data from interview survey).

Categories	Exemplary statement
No ICT skills	I cannot instruct my students on how to work with the computer.
Low ICT skills	I can instruct my students on how to use a word processing program and how to conduct research in the world wide web.
Average ICT skills	I can compile a website and use various software programs. I can convert files from Word to the PDF format.
Excellent ICT skills	I am aware of the pedagogical principles of ICT use and I am/could be a trainer in ICT.

Table 8. Construction of *bik* tasks and units. Results of the interview survey with the teachers. Comparison of the teachers' statements in start interviews (i-1), follow up interviews (i-2) and final interviews (i-3) in % of how often mentioned.

Categories	Subcategories	Total	i-1	i-2	i-3
Within the set-meetings		86%			
	Exchange of materials		17%	11%	12%
	Synchronization of task development		6%	8%	8%
	Co-construction		4%	8%	12%
Between the set-meetings		14%			
	Exchange of materials via e-mail		2%	2%	2%
	Using the *bik* website		0%	2%	6%

Table 9. Results of the interview survey with the teachers regarding their participation in reflective processes. Comparison of statements expressed by teachers in initial interviews (i-1), follow up interviews (i-2) and final interviews (i-3) in % of how often mentioned.

Categories	Subcategories	Total	i-1	i-2	i-3
Reflection occurs		58%			
	Reflection in action (individual)		6%	8%	17%
	Written self-reflection (individual)		2%	2%	4%
	Reflection on classroom experiences (group)		3%	2%	7%
	Reflection on theories (group)		3%	1%	3%
Reflection does not occur		42%			
	implicit knowledge of action		25%	9%	8%