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Enactment of a geoscience curriculum by using innovative curriculum materials - an exploratory case study

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Summary

Trying to implement interdisciplinary geo-science curriculum materials in geography and science education we asked how they fit into teachers' existing practices, their needs for support and strategies to plan instruction. The focus of our case study has been the identification of the goals teachers pursue with the materials, of strategies for customizing and using them in the classroom and of the features of the local context that help to enact an interdisciplinary geoscience curriculum. The study made use of three independent data sources: the results of a workshop questionnaire, the written outcomes of enactment scenarios and the transcripts of telephone interviews. In section 1 the theoretical background is presented that includes ideas on lesson planning, the customization of curriculum materials and the relationship between implementation and local enactment. Section 2 describes the case study approach and section 3 the outcomes, starting with the goals teachers plan to pursue with the curriculum materials and the enactment strategies that indicate how they use the materials (3.1). Section 3.2 presents details on supportive and hindering conditions for local enactment and 3.3 selected data about the practical realization of the scenarios in the classroom.
We found that the term "quarry" is a metaphor that allows describing the strategy of most practitioners to deal with innovative curriculum materials. Moreover, our study has shown the central role of modular curriculum materials for the implementation of geoscience education combined with opportunities to learn through well structured in-service workshops. Based on these outcomes, summary chapter 4 presents suggestions for a successful local enactment of geoscience curriculum materials.

1. Theoretical background and research questions

Even though geoscience topics are discussed a lot in the media, they do not have a firm place in the German school curriculum (HLAWATSCH & HANSEN 2004). Both geography and science education tend to neglect physical geography. The project "Research dialogue: System Earth" (HLAWATSCH et al 2003) was a collaborative effort of Earth scientists, educational researchers, geography and science teachers for an Earth science curriculum (called "System Earth") based on a variety of teaching materials. It was influenced by the scientific literacy framework of the PISA study that includes knowledge of the Earth's sub-systems,

changes in Earth systems and other geoscience topics (NAEP 2004). The geosciences and thus System Earth have challenged geography and science education as a truly interdisciplinary field of learning by presenting a broad range of subject matter knowledge and a focus on interdisciplinary competencies and system thinking skills. They include contents and methods that are new for most German teachers. Based on this situation, the curriculum materials became a central tool to implement a geoscience curriculum in general education.

We use the term "implementation" to describe the process by which a new curriculum is put into action (Fullan & Pomfret 1977, Snyder, Bolin & Zumwalt 1992). "Enactment", on the other hand, denotes the realization of a curriculum in the classroom by close interaction among teachers, students and subject matter. In many implementation studies a "fidelity perspective" is taken that suggests understanding a new curriculum as a prescriptive guideline to put the material into practice (Fullan & Pomfret 1977; Bolin, Snyder & Zumwalt 1992). From an "enactment perspective", on the other hand, teachers have a more active role. They become instructional designers and coordinators of diverse resources rather than mere executors of the prescribed curricular reform (e.g., Brown 2002; Barab & Luehmann 2003). The enactment perspective draws its importance from the observation that teachers "… necessarily select from and adapt materials to suit their own students" (Ball & Cohen 1996, p. 6). They shape the intended curriculum to become the enacted curriculum. This perspective directs the attention to the teachers' knowledge about the students' prior experience, the local availability of resources and the educational context.

Even though professional development workshops, discourse communities and the administrative context of a school play an important role in educational change (see Brown 2002, p.12), Ball & Cohen (1996 p. 6) have directed our focus to the availability of instructional materials: "Unlike frameworks, objectives, assessments, and other mechanisms that seek to guide curriculum, instructional materials are concrete and daily. They are the stuff of lessons and units, of what teachers and students do." Following Ball & Cohen's (1996) arguments, the development group was asking how teachers and teacher educators make use of the materials in their respective fields of practice. Ben-Peretz (1990) contends that teachers usually interpret new curriculum materials in terms of their potential for classroom use. They have to tune the new approach to existing resources or the individual needs of their students. Other authors describe various forms of local customization and adaptation during curriculum enactment (e.g. Brown 2002).

The use of new curriculum materials puts teachers back into the position of a learner who has to change proved practices or to acquire new ones. Lesson planning

that is based on the new materials can foster change as it involves the coordination of pedagogy, content knowledge and various material or non-material resources. While pre-service teachers usually plan by making a linear list of activities and assignments, experienced teachers tend to employ a more open strategy. They prefer ad-hoc decisions in the classroom that allow them to react flexibly on the students' needs while working with new curriculum materials (JOHN 2006). We assume, however, that these teachers employ explicit planning strategies if they try to put a new approach into practice.

BROWN (2002) distinguishes "offload", "adaptation", and "improvisation" as teachers' strategies to interpret and use new curriculum materials. He regards them as "markers" on a scale that extends from total fidelity to the developer's intention to total disregard. Offload is preferred by teachers who rely on existing material to prepare their lessons. They may be unfamiliar or feel uncomfortable with the new approach, have little time to develop a personal perspective, or want to provide an example of what happens if the new approach is enacted as prescribed. Curricular improvisation is selected by teachers who use the new materials as a starting point to follow their own path of instruction. Very often these teachers believe that good educators tailor their own materials rather than using existing ones. Adaptation and customization seem to be the most frequently used strategies. Teachers who follow them anticipate the culture of their school and try to balance the innovative materials with routines or practices that have been meaningful for them in the past.

Considering the importance of adaptation and customization, BROWN (2002) suggests understanding teachers' strategies as a "design process", a process of perception, interpretation and coordination of material and non-material resources. This process creates variation in the classroom rather than fidelity and it can be described as a mutual adaptation in which both the reform and the local educational setting change in order to accommodate curricular change (BROWN 2002, p. 5). Variation in the enactment process is regarded as necessary as the fidelity approach often produces resistance. It can be perceived as a form of "remote control" that does not sufficiently consider teachers' routines and experiences, local syllabi, resources and competencies. Local customization of curriculum material, on the other hand, can produce outcomes that contradict the developer's ideas with respect to subject matter knowledge, educational objectives or teaching methods. However, BROWN (2002) and BARAB & LUEHMANN (2003) argue that customization is necessary to make a curricular innovation sustainable. The dissemination of the curriculum materials of the project System Earth follows this argument by encouraging German teachers to integrate the approach into geography or science teaching and into the culture of German schools.

Looking at the curriculum materials of System Earth as a resource for enacting a geo-science curriculum, we wished to know how they fit into teachers' existing practices, their needs and strategies to plan instruction. Our questions concerning these issues were:

- How do the participants of in-service workshops perceive the role of the workshop experience, the curriculum materials and the local context for classroom enactment? What are features of System Earth that foster curriculum customization and local enactment? What makes enactment difficult? What is missing in the curriculum that might improve local enactment?
- How do the workshop participants use and adapt the scenarios that they developed during the in-service workshop? What kind of problems do they encounter during local enactment?
- How do practitioners envisage the enactment of System Earth? How do they plan to align this approach and its materials with proven routines and with the resources of their school? How do they customize the materials?

2. Research design and sampling

To answer these questions we conducted a case study of a series of in-service workshops. We asked the participants to write scenarios about their approach to local enactment and conducted interviews about the realization of the scenarios after the workshops. The workshops combined expert lectures on geoscience topics, an introduction to the new curriculum and its experimental materials and work groups on "implementation scenarios" in which the participants wrote plans for a local enactment of the new approach. The materials of the project are composed of work sheets, animations, hypertexts, images and experiments and developed with upper-secondary science and geography students in mind. It is structured in 11 modules to support flexible use in the classroom and in the diverse contexts of the German educational landscape and included instructions for teachers that help them employ the materials in the classroom. A version on CD-ROM was prepared that allows creation of individual student versions without teacher instructions. Important modules are: "System Earth - an introduction", "The rock cycle", "Earthquakes and waves", "Convection", "Matter cycles", "Plate tectonics and volcanism" and "Climate change". Relationships among the geoscience topics are emphasized in the materials to support an interdisciplinary approach to teaching and learning.

The workshops were hosted by the in-service institutes of the respective federal state that also selected the participants and provided a place for the meetings. The participants were primarily "multiplicators", e.g. enthusiastic teachers or teacher educators who planned to develop local courses on geoscientific issues or who wished to convey their

knowledge to others. Representatives from the school authorities also participated. The group work during the workshops provided time for planning, collaborate learning and reflection. The workshop participants discussed the problems of teaching a new field and wrote scenarios on the transfer of System Earth into their respective field of practice.
To answer the questions of the previous section we conducted a case study. YIN (1984, p. 23) defined a case study as an empirical inquiry that "investigates a contemporary phenomenon within its real-life context when the boundaries between phenomenon and context are not clearly evident and in which multiple sources of evidence are used". Case studies are appropriate when the researchers primarily ask "how" questions about a contemporary set of events over which they have little or no control and when it is impossible to separate the phenomenon's variables from their context.
Our case study was based on the dissemination of the curriculum materials during well-planned in-service workshops. The "case" was the series of seven workshops in six German federal states with each single workshop as a sub-unit. They were conducted in close collaboration with geoscience institutes, the teacher training institutes of the states and the project staff that had developed the teaching materials and conducted research activities. The teacher training institutes selected the workshops participants and hosted the meetings. One third of the participants piloted their scenarios after the workshop. The case study made use of different kinds of instruments for data collection during and after the in-service workshops that are described in the sections 3.1 (scenario worksheets), 3.2 (workshop questionnaire) and 3.3 (follow-up interviews) to facilitate the interpretation of the outcomes. They were used to document the experience of the workshop participants and the succeeding enactment of the scenarios in their respective field of work. Figure 1 shows how we connected the in-service workshops and the case study research.

The case study was based on a purposive sample (MERRIAM 1988, p. 48f.) of workshops and participants. The respective in-service institution and the development team selected the participants by focusing on "multiplicators", i.e. participants who planned to disseminate the workshop experience in a local setting. When not enough multiplicators were found active teachers were also allowed to participate in the workshops. The achieved sample[1] comprised 61 male and 47 female participants. All of the 108 participants had prior teaching experience. About 90% were engaged both on the upper and lower secondary school level and 22% additionally named teacher education as their field of work. With respect to subject area, 59 of the partici-

1 These numbers are outcomes of the "workshop questionnaire" (see below).

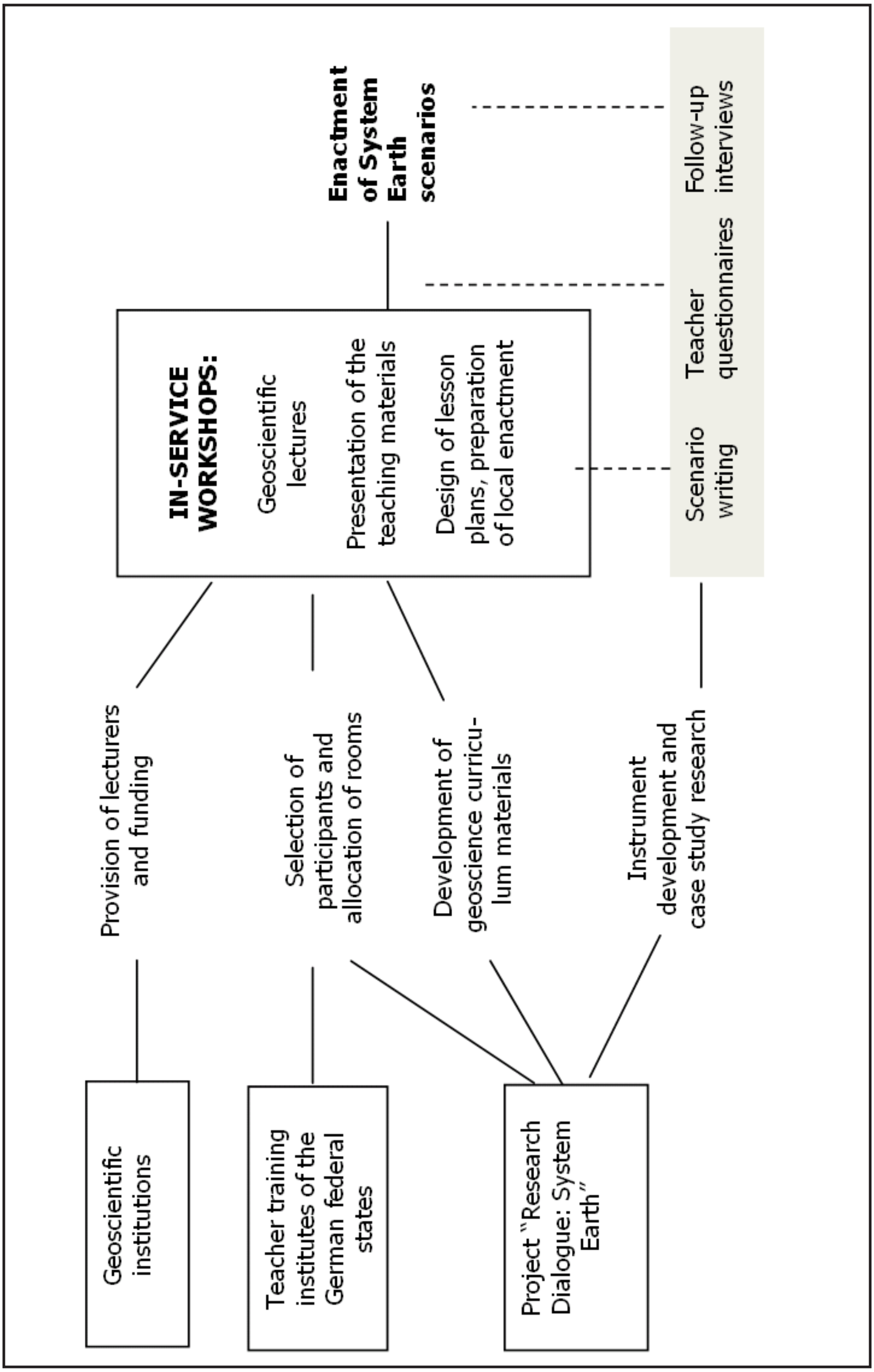

Figure 1: Implementation of project System Earth via in-service workshops and case study research

pants had a background in geography teaching, followed by biology, chemistry, mathematics, physics and a variety of other subjects. About one fifth of the participants had combined geography with at least one of the sciences. 16 of the 108 participants said that they had known the materials and concepts of the project System Earth before the in-service workshop.
The status as teacher educators was one of the features that qualified the participant as "multiplicator", the primary addressees of the workshops. About 20% of the participants spent most of their time in teacher in-service education, while 48% were occasionally involved in various kinds of teacher education activities. The number of teacher students or in-service teachers they reached varied between 2 to 400 per year. The other participants had engaged themselves for geoscience instruction as headmasters or policy makers.

3. Results and significance of findings

The results of the study are presented in three sections. In 3.1 we discuss the workshop participants' implementation scenarios with respect to the goals they want to pursue with the materials and the strategies they plan to integrate it into their teaching practice. In 3.2 we analyze the contribution of the in-service workshops, the curriculum materials and the local educational context to enactment. In 3.3 we analyze telephone interviews with 52 of the participants that were conducted after the workshops to find out how many of them had been able to realize the enactment scenarios and why some of them failed. Each subsection is introduced with some paragraphs on the respective approach to data collection.

3.1 Enactment of System Earth by using innovative curriculum materials

3.1.1 Data collection

BROWN (2002) suggests understanding teachers as curriculum designers rather than mere executors of a curricular reform. Based on this understanding we will ask how the workshop participants align the approach of System Earth with their own resources and local context, assuming various forms of adaptation or customization. Data about the customization process were mainly collected by "implementation scenarios" that the participants wrote during the workshops.
A scenario is a story about a future event that allows planning and assessing alternative actions. In our study, the actions were represented by the participants' plans to use the materials that were introduced during the workshops. The participants started by documenting their choice for a module, building block or theme of System Earth that they wished to teach during the forthcoming months. Then they developed a learning sequence based on the concept and the new materials. Most of the participants selected

the "stone cycle", the "carbon cycle" and various special issues connected to these modules.

To collect the scenarios in a standardized way we developed a template-like worksheet. It allowed documenting the design for a teaching-learning sequence in a systematic manner. During the first workshops, we handed the worksheet to each participant individually. Later, 3-6 teachers with different subject backgrounds were asked to collaboratively write a scenario. These groups were composed of participants with different subject affiliation who were focusing on learners of similar grade level. While designing the scenario the participants were asked to reflect the …

- specific theme or module of System Earth that they wished to teach,
- meaning of the theme for themselves and for their students,
- teacher and student activities that support learning,
- context factors that foster or hinder classroom enactment, and the
- envisaged time frame for teaching the selected theme.

The scenarios developed by the groups turned out to be more salient with respect to detail and elaboration than those that had been designed individually. 28 scenarios were selected for analysis.

Almost all of the group members had a background in pre-service or in-service teacher education. However, only 13 of the 28 scenario groups designed a scenario for this field. Many of the members were simultaneously teaching in schools. This may have stimulated them to start by designing a scenario for their own class and afterwards planning an in-service course. Only two of the scenarios focused on curriculum development. In the next sections we discuss the workshop participants' implementation scenarios with respect to the goals they can reach with the materials and the strategies they use to integrate them into their teaching practice.

3.1.2 Outcomes with respect to goals and relevance of the materials for teachers and students

The curriculum materials for System Earth were developed to implement an interdisciplinary geoscience curriculum in science and geography education. Considering the differences among the educational systems in the German federal states and the variety of the teachers' needs, we knew that the materials would be used in many different ways. Wishing to learn more about this variety we asked the workshop participants to reflect the meaning of the materials for themselves as educators and for the students before they started their scenario.

The inspection of these data yielded seven types of goals that the participants planned to pursue with their respective module or theme (Table 1). Most of them planned to foster teaching or learning methods, followed by subject matter knowledge. The focus on methods is in tune with the intentions of the developers. However, "system thinking" was not

Table 1: Goals that the participants planned to pursue with the curriculum materials

Category	**Count**	**Example**
Supporting teaching and learning methods	27	- experimental work; learning by experimentation; learning to conduct experiments; understanding similarities by simple experiments; experiments related to subject matter - measuring methods and analysis of diagrams - use of the Internet; use of the instructional CD-ROM - opportunities to work with materials; students can encounter real objects; real application of waves; significance for everyday life - presentation of autonomous work; documentation of results - introducing "stones" by building on students' preconceptions - jigsaw; self-organized learning; fostering student collaboration; discovery learning
Teaching subject matter knowledge	21	- elaboration of theoretical backgrounds; role of gas hydrates in the carbon cycle; introduction to evolution; elaboration of the lithosphere; global warming; development of stones, understanding the stone cycle
Raising environmental and social awareness	12	- careful handling of combustibles and the environment; developing a feeling for nature; critical reflection of global warming - considering the human impact; sensitization based on system thinking; considering oneself as part of System Earth; rethinking the impact on local conditions; recognition of the role of men in the carbon cycle
Improving the curriculum	10	- a starting point for interdisciplinary work; relation among subjects; interdisciplinary teaching - adaptation to in-service events - replacement of the official syllabus on waves - emphasis on science aspects in geography
Developing practical competencies	9	- competencies; methodological competencies; training of methods; competencies for team work - practical abilities; developing practical abilities; developing experimental abilities
Cognitive development & system thin-king	5	- system thinking; understanding the Earth as a system; the carbon cycle as a system - support of cognitive abilities
Raising motives or interest	5	- motivation; motivating students; motivation by practical activities - motivating teachers for System Earth; motivating them to illustrate physical subject matter

mentioned very often even though it was a central feature of System Earth. The participants primarily referred to this goal when they wished to raise the students' social and environmental awareness.

Table 1 indicates that System Earth's curriculum materials is primarily used to foster new teaching and learning methods in close connection with geoscientific subject matter. Many teachers also seem to be motivated by opportunities to raise the environmental and social awareness that is part of a sustainable development of System Earth.

3.1.3 Enactment strategies

The groups that wrote their scenarios about the enactment of System Earth for a student classroom differed from those who planned to use the curriculum for in-service or pre-service teacher education. In spite of these differences, there was a considerable overlap between the scenarios of these two groups as many teacher educators planned to start piloting the approach in their own classroom and later to disseminate their experiences in teacher education courses. The analysis of the written scenarios yielded three enactment strategies of the workshop participants that resembled the strategies found by Brown (2002) (see section 1.).

- Short term exploration and long-term dissemination of the materials

Teacher educators often started designing a scenario for their own class rather than for an in-service course. For example, a group of three participants from Hamburg suggested using System Earth as an introduction to the theme "evolution". In the context of this theme the members wished to foster students' independent and practical work. They critically discussed the constraints of the obligatory syllabus and of the available time, finally proposing to use a selection of the available curriculum materials. As a long-term perspective they suggested introducing System Earth into a school program for grades 10-13 that integrates geography and the natural sciences, and to also develop school based in-service courses.

Another scenario group from Hamburg followed a similar strategy. First, its members planned an analysis of the obligatory syllabus for physics education of upper secondary students to find a space for teaching System Earth. After this step they wished to select parts of the curriculum materials for use in physics classes. At the same time they planned to integrate chemistry, biology and geography education and to employ the curriculum materials in their own classes or eventually in those of their colleagues. After an evaluation of this experience they wished to edit the materials and to conduct teacher education courses.

An interdisciplinary group of teachers from Mecklenburg Pommerian, also pursued a two-step strategy. First, they wished to design an

exemplary lesson, integrating perspectives from geography, physics, biology and chemistry. Based on this model, teachers with different subject backgrounds were expected to align their plans for the following lessons. After the planning period they would teach four lesson periods, have students present their results in front of all subject teachers and discuss the respective issues. On a second level, the group planned to transfer their model to social subjects by elaborating topics like sustainability, choice of location of industry, etc.

• Use of System Earth as a quarry

A second strategy that emerged from the analysis of the scenarios was using the curriculum materials as a quarry. This strategy is tempting as it leaves open many possibilities. However, it can come down to an arbitrary selection of materials for a lesson or a teaching sequence. To avoid arbitrariness, most of the participants were applying criteria like compatibility with the obligatory syllabi of the federal state, availability of local resources, collaboration among teachers, individual teachings style or prior knowledge of System Earth. It should be noted that the quarry strategy played a central role for all participants.

A workshop participant from Hamburg described his individual scenario as a "selective coming to terms with distinctive segments of the material" to indicate that he was looking for the "bricks" of System Earth that he would like to select for his class. A teacher group from Brandenburg planned a scenario for students from two school types, a Gymnasium and a comprehensive school. In both cases they were focusing on the carbon cycle with a perspective on gas hydrates. The group members argued that they were able to follow the suggestions of the curriculum materials in most respects. However, they would prefer to shorten the materials and to tune them with the obligatory syllabus and time constraints. On the background of these constraints they took the respective module and critically went through every building block. They suggested replacing the module's introduction to the "carbon cycle" with their own one, the discussion of a spectacular geoscience event. The consecutive building block of the module was accepted and allotted a one-hour lesson. Furthermore, the group planned to present this block in a simplified manner after considering that many of their students have problems interpreting diagrams and reading complex texts. Changes in another building block were suggested to consider the current discussion about global warming and allowed two lesson hours. Two building blocks were totally excluded from their selection.

A group of geography, mathematics, physics and biology educators planned a unit on climate change by freely mixing their own material with parts of System Earth. They envisaged introducing students to the topic "climate change" by pre-

senting parts of a spectacular movie (Crash 2030) and then wished to continue with the first building block of the module. For the third lesson hour they wished to use concept maps on the spheres.

- Curricular improvisation: System Earth as a stimulus for an individual course concept

Indicators for the improvisation strategy in the scenarios were a lack of explicit references to System Earth or scenarios that built upon self-developed experiments. For instance, a scenario from Baden Württemberg suggested the module "carbon cycle" as a starting point, and organized instruction around experiments that had been developed by two active teachers in that group.
Why did some of the participants choose improvisation? We assume that they might have not had enough opportunities during the workshop to clearly recognize the ideas and possibilities of the new curriculum materials. They would need more time to work through the texts or the CD-ROM and to pilot the suggested experiments. An alternative explanation would be that these participants' ideas of "good teaching" demands developing individual material rather than employing existing ones. More research would be needed to clearly identify the motives of those who use System Earth as a stimulus for their individual ideas.

3.2 Supportive and hindering conditions for putting System Earth into practice

3.2.1 The approach to data collection

In the scenario worksheets (see 3.1), the participants were asked to reflect expected problems of a local enactment and likewise supportive conditions. Some of the supportive conditions were the availability of material or non-material resources needed for teaching System Earth, e.g., an appropriate obligatory syllabus, a stone collection in school or small class sizes. Hindering conditions were, for instance, an inappropriate local syllabus, too little time or the lack of a classroom for geo-science instruction.
In this section we want to explore supportive and hindering conditions for local enactment in more depth by using a "Workshop Questionnaire" that combined demographic data of the participants with their ratings of prior knowledge about System Earth, various features of the in-service workshops, the materials and the local educational context. Fullan (2001) argues that five characteristics of a curricular innovation determine its success: relevance, complexity, quality, practicality and clarity. Rogers (1995) points to the relative advantage of an innovation over the approach it supersedes, the compatibility with existing routines and the needs of the adopters. These variables also indicate a possible impact of the characteristics of

System Earth on classroom enactment.
The participants filled out the questionnaire at the end of each workshop. The instrument was iteratively improved over the seven workshops, making use of the experiences of the prior workshop for the questionnaire that was employed in the consecutive one. As a result, we can only compare the rating data of 30 to 50 of the 108 participants, depending on the respective items, while the demographic data and background variables are available for all participants.
A central part of the questionnaire was composed of a collection of rating items about the participants' professional learning during the workshop. The workshop participants rated statements about their understanding of the goals, the modular structure of the materials of the project System Earth above average. The statement "The goals of the materials became evident" received the highest rating, followed by "I better understand the materials' modular structure". The latter is a central feature of project System Earth that can help to foster local enactment. Apart from the participants' learning experience we wished to know if the workshop had stimulated the use of the curriculum materials.

3.2.2 Contribution of the in-service workshops
The participants were presented six items to assess the significance of the workshop experience for classroom enactment. The ratings are

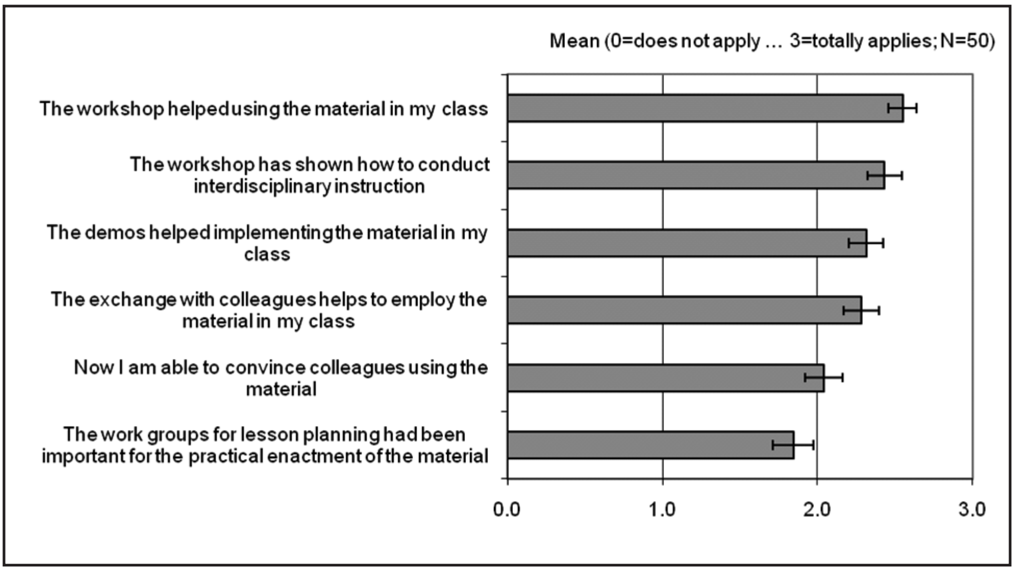

Figure 2: Which of the following statements describes the just finished in-service workshop?

sorted by mean value (Figure 2):
All of the items were rated above average. The general statement "The workshop helped using the materials in my class" was rated most highly. This result and the above average ratings for the other items indicate that the workshops had contributed to teacher readiness to put the new curriculum into practice and thus supported the important role of in-service education for the implementation of System Earth.

3.2.3 Curriculum materials
In the workshop questionnaire we asked "Which of the following features of System Earth support local enactment in your field of work?" The features of the materials were presented by 15 items. Figure 3 shows the results sorted by mean values (again, the bars present the standard errors of the mean):
Ten of the features received a rating of two and above with "Availability on CD-ROM" on the top and "Didactical hints", "Assessment" and "Opportunities for the … curriculum" at the lower end. The item "Availability on the Internet" was also not rated very positive. We assume that the teachers can easily handle material on a CD-ROM while downloading texts and images from the Internet

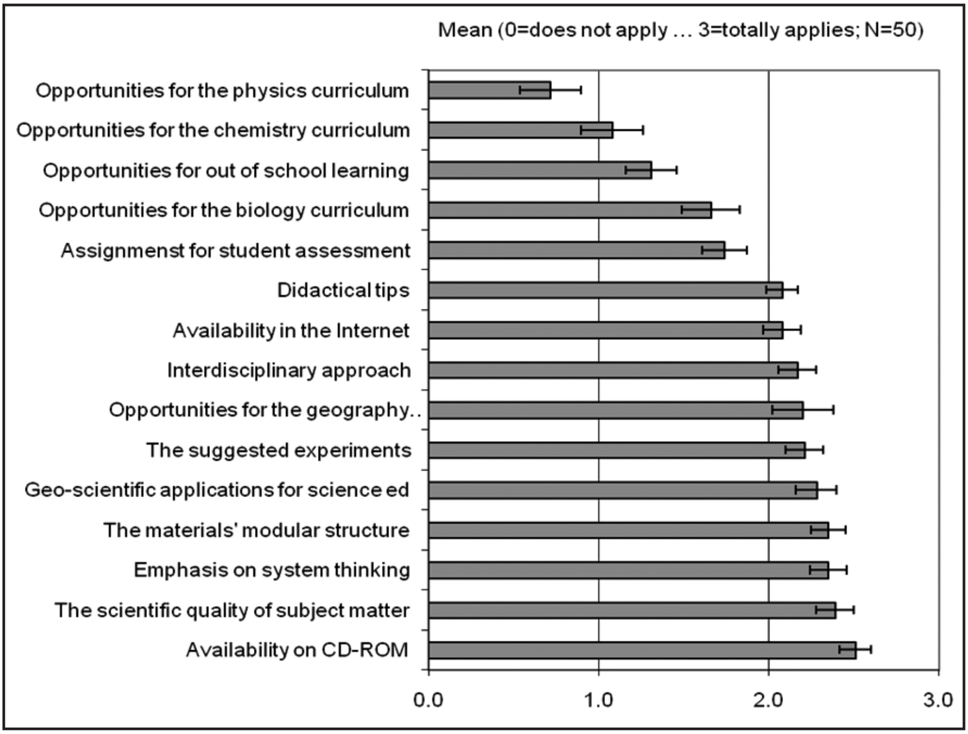

Figure 3: Features of System Earth that support to local enactment

can become time-consuming with a slow service provider. The positive rating of the materials' modular structure indicates that the participants appreciate a material that can easily be customized to their needs (see also section 3.1.). Considering the standard errors of the mean that are indicated by error bars in Figure 3, participants with a background in teacher education rated this item significantly better (mean value=2.61) than those without (mean value=2.04).
Another outcome of Figure 4 is that most respondents rated the curriculum materials as more useful for the geography curriculum than for the science curriculum. However, they rate the item "Geoscientific application for science education" higher than both the "Opportunities for the geography curriculum" and "Opportunities for the science curriculum". This result indicates that the in-service workshop had helped to clarify the opportunities of geoscientific topics for geography and science education. However, many participants assume restraining effects of the obligatory science curricula for the innovative approach.
Apart from comparing the mean values of the 15 features for the whole sample, we also compared subgroups. The ratings of the "interdisciplinary approach" by science teachers were more positive than those of the geography teachers (mean value of 2.21 vs. 1.81). The difference between participants without prior knowledge of System Earth and those with prior knowledge was even larger (mean value= 2.56 vs. 1.53). The above average ratings for the interdisciplinary approach indicate that the in-service workshops helped develop an idea of the interdisciplinary nature of System Earth for participants with a science background and experience in teacher education.

3.2.4 The role of the local context and resources

Having analyzed the impact of in-service and features of the materials on local enactment we also wished to know how the participants rated the local context by asking "Which of the following features support the enactment of System Earth in your field of work?" The term "context" is understood here in a broad sense. It includes material and non-material resources that the participants can work with in their local settings. Many of the resources are not under direct control of the teachers. The questionnaire allowed negative, neutral and supportive responses. Wishing to present the different qualities of the participants' responses, a stacked bar graph of the three item categories was calculated for each of the 13 items. To facilitate the interpretation the items were sorted by the frequency of the "supportive" category (Figure 4).
For the upper three items ("Internet access", "Places for out of school learning", "Public discourse") the supportive ratings dominate, followed by two items with high neutral and supportive ratings combined

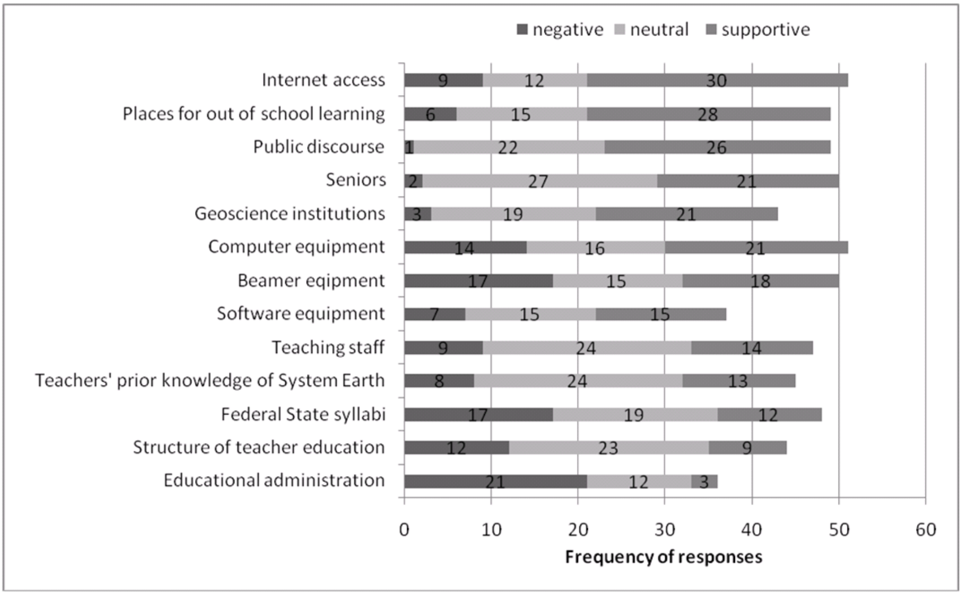

Figure 4: Supportive, neutral and negative effects of context variables on the local enactment of System Earth (stacked bar graph; items are sorted by "supportive")

with very low negative ratings ("Seniors", "Geoscience institutions"). For seven items the negative, neutral and supportive are rather similar ("Computer equipment", "Beamer equipment", "Software equipment", "Teaching staff", "Teachers' prior knowledge of System Earth", "Syllabi of the federal states", "Structure of teacher education"). Only for the item "Educational administration" are the supportive ratings extremely low and the negative very high.

The supportive ratings for "Public discourse", "Places for out of school learning" and "Internet access" indicate that German teachers consider these resources as available and helpful to enact System Earth. Moreover, teachers appreciate that the materials offer a variety of opportunities to make learning meaningful for students. Internet access is a technical resource that most participants rated as "supportive". We assume that many German teachers have learned to access geoscience knowledge and additional educational resources on the Internet and to engage their students in Internet searches. It should not be overlooked that the item "seniors" also received a high proportion of supportive counts. This result is not amazing since most participants were sent to the workshops by their seniors.

Other technical resources like "Beamer equipment" and "Computer equipment" seem to divide the participants: there are almost as many counts for "negative" as

for "supportive" with an equal proportion of "neutral". A closer look shows a gender difference: men rate the contribution of these resources to local enactment as more supportive than women (however, due to the small sample these differences are not statistically significant). For the items "software equipment", "teaching staff" and "teachers' prior knowledge" Figure 4 shows a high proportion of raw counts for "neutral". The impact of these resources on local enactment seems to depend on other variables that had not been collected in our exploratory case study.

While the impact of "Beamer equipment", "Computer equipment", "Syllabi of the Federal State and "Structure of teacher education" received many negative ratings, they only dominate for the item "Educational administration" that also received only 3 supportive ratings, a result that indicates that the workshop participants expected the least support from educational administrators.

3.3 The telephone interviews: an outlook on practical realization

In the scenario worksheets and workshop questionnaires we had asked about the role of various factors for the local enactment of System Earth. The answers reflect the ideas and expectations that arose during the in-service workshops. Wishing to know what happened with the scenarios in the school or the teacher seminar and why the plans often could not be carried out, we conducted telephone interviews with 57 of the 108 workshop participants 12-24 months after the workshops. The interviewees came from four federal states and represented a variety of educational settings. We asked them whether they had been able to enact the workshop scenarios in their context, how they had structured their lessons, how the students had responded, what kind of other resources they had used and finally, why some of them had not been able to enact the scenarios. The results presented here are based on a qualitative analysis of the participants' verbal responses.

20% of the interviewees told us that they had been able to realize the workshop scenarios in their local context. Two of those not able to teach the scenario at home answered that they did not find appropriate teachers, and 12 of them used curricular arguments like "the integrated subject "Nature and Technology" has not yet been established", "the syllabus restricts available time for geoscience instruction" or "the physical geography plays a subordinate role in the syllabus". The second most frequently used argument for not realizing the scenario was the lack of appropriate teachers and classes. Some participants explained that they had been ill for a longer period, that they had changed their school subjects or they blamed time constraints and the current situation of their students.

The telephone interviews mainly pro-

vided insights into the participants' problems when trying to enact their scenarios in their local context. With respect to the impact of the local contexts, the telephone interviews indicate a hierarchical dependence of resources: teachers need "core resources" like curricular support which enable them to enact a new curriculum and to combine it with subordinate resources like Internet access, texts or stone collections. The modular structure of System Earth doubtlessly helped to enact the workshop scenarios.

4. Summary and conclusions

The focus of our case study has been on the identification of the goals teachers pursue with System Earth in their class, of strategies for customizing and using the materials and of the features of the local context that helps to enact an interdisciplinary geoscience curriculum. The study made use of three independent data sources: the results of the workshop questionnaire, the enactment scenarios and the telephone interviews. Based on the verbal data of our study, the main outcomes have been categories and criteria that help to understand the enactment of System Earth - rather than statistically tested differences among groups of respondents. The in-service workshops for System Earth have provided the framework to explore the enactment process that included the concepts and materials of System Earth. The workshops comprised lectures on geoscience issues, an introduction into the curriculum materials that included the demonstration of experiments, and the work groups for the implementation scenarios. They were based on the collaboration among a research and development institute, the in-service centers of the federal states, and the Co-ordination Office Geo-technology in Potsdam/Germany. We also asked how practitioners integrate the materials into their routines and what kind of support they need.

As a general trend we found that the workshop participants accepted the curriculum materials as helpful for the enactment of System Earth. There is no doubt that the results would have been different without the learning opportunities of the in-service workshops. They have contributed to their knowledge of subject matter, to the design of lessons and to a deliberative use of the interdisciplinary and innovative materials. However, the case study also showed that practitioners need administrative support, e.g. by the adaptation of existing syllabi or science standards for geoscience issues. Moreover, our study has shown that geoscience instruction needs curricular resources and that teachers have to customize them for their local context.

On the background of these outcomes we recommend considering three aspects for an implementation of geoscience themes into science and geography education:

Goals: While instructional materials always include ideas about goals and orientations, teachers should

clarify and reflect very early not only what they can do with the materials in their classroom but also the specific goals they want to pursue. Our study has shown that System Earth materials support innovative teaching and learning methods as well as new subject matter knowledge.

Strategies to use innovative materials: Our study has supported the important role of local customization for the use of geoscience curriculum materials. To avoid that the quarry approach ends up with an arbitrary selection of ideas, themes or methods, it should be guided by rules for the customization and selection process and a modular structure of the materials. Some of these rules have already been incorporated in the CD-ROM that was finished after the case study, e.g. by links between content and methods.

The impact of the local context: The local context has been one of the most complex variables of our case study. It includes the variety of material and non-material resources the teacher has available and uses in school. Technology can be important but also the public discourse on geoscience topics that legitimates spending lesson time on System Earth. Teachers are usually part of this context and depending on their own preference or attitude these factors are either supportive or prohibitive with respect to curricular change. We suggest carefully reflecting the local context during in-service courses or other preparatory activities as a strategy to circumvent those which may cause problems and to make use of others that help to implement a geoscience curriculum.

Further research can show how these aspects interact and how further in-service activities should be planned to bring System Earth into the classrooms. This study has provided data about first trends and research questions to guide this process.

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THE Vth INTERNATIONAL GEOSCIENCE EDUCATION CONFERENCE (GEOSCIED V) IN BAYREUTH

This special edition of the German Journal "Geographie und Ihre Didaktik" contains selected contributions of the Vth International Geoscience Education Conference (GeoSciEd V). They cover important aspects of geoscience education research.

The conference took place from september 18 – 21, 2006 in Bayreuth on behalf of the Leibniz Institute for Science Education (IPN), Kiel, the Geo-Centrum at the German Deep Drilling site KTB, Windischeschenbach, and the University of Bayreuth. The conference program comprised the major dimensions of Earth science education. A great many contributions followed an interdisciplinary approach integrating geographical and geological aspects as well as biological, chemical and physical ones. This is in accord with the educational aims set by the German geoscience associations. It also corresponds with the educational approach of the IPN project "System Earth", which marks a milestone of the quality improvement of geoscience education in Germany.

The International Geoscience Education Organisation (IGEO) runs the international GeoSciEd-Conference approximately every four years, alternating with a representation at the International Geological Congress, which also takes place at four year intervals. The first conference was at Southampton in the UK in April 1993. This first conference sparked interest but it was not until 1997 that GeoSciEd was proposed as the name of the conference. IGEO was founded at that 1997 GeoSciEd II in Hawaii. GeoSciEd III in 2000 was held in Sydney, Australia and GeoSciEd IV was in Canada in 2003.

The aims of the International Geoscience Education Organisation (IGEO) are to promote geoscience education internationally at all levels, to work for enhancement of the quality of geoscience education internationally and to encourage developments raising public awareness of geoscience, particularly amongst younger people. It is affiliated with the International Union of Geosciences (IUGS).

The German conference came at an important time with the declaration of 2008 as the International Year of Planet Earth and the recognition of the significant role of geoscience education in creating a sustainable future for humans and their planet.

We are now looking forward to the VIth GeoSciEd 2010 in Southafrica.