SWiSE – RESEARCH AND DEVELOPMENT IN PRACTICE

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ABSTRACT

SWiSE intends to qualitatively further develop science and technology education in 61 Swiss obligatory schools (i.e. kindergarten to 9th grade). The most basic aim is to increase students' interest and joy in science. SWiSE aims to offer children and young people an age-appropriate access to science and technology, reflect and further develop science and technology education, exchange the experience with other schools and build networks, explore and implement new paths in competency-based education and develop teaching and learning materials. SWiSE approaches this in a combination of school development and teacher professionalization in relation to improved teaching and student commitment (Maheshwari, Sharma, & Chatterjee, 2011). Usually there are two SWiSE teachers per school and one aim is to foster first between-SWiSE-teacher collaboration, then within-school co-operation and last between-school co-operation. Some SWiSE teachers receive personal coaching from experts in the field of science didactics (SWiSE coaches). The project is evaluated in a three-year quasi-experimental panel study with two control groups. Besides project-related interests, the SWiSE evaluation also allows to ask empirical educational research questions. In a broad selection of further education – e.g. learning modules, innovation days/ conferences, practice and network meetings – teachers and schools are supposed to learn from and with each other.

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OVERVIEW

SWiSE - Swiss Science Education has been a joint initiative of eleven Swiss-German educational institutions since 2009: The Schools of Teacher Education PH Bern, PH FHNW, PH St. Gallen, PH Thurgau, PH Central Switzerland and PH Zurich, the Institute Unterstrass of the PH Zurich, the Swiss Science Center Technorama, and the two training bodies PZ.BS Basel-Stadt and Baselland FEBL. SWiSE aims to develop interest in science and technology of 4- to 16-year-old students. Teachers are supported to reflect on the scientific and technical education and develop a competency-based education, to exchange the experience with other schools, and to develop networks.

SWiSE represents a unique collaboration between the different regions. In Switzerland, educational policy is regulated by canton and thus, the diversity of the educational systems is tremendous and challenging. SWiSE brings together experts from different educational institutions, research centers, ministries, and school practice. They share their knowledge and expertise vice versa in order to effectively innitiate innovative practice implementation.

SWiSE supports school teachers to realize their individual continuing development in focusing on science and technology. The 61 SWiSE- schools (20 kindergarten / primary, 38 secondary, and 3 comprehensive schools) are distributed over six autonomous regions. In three school years (2012 to 2015), two so-called SWiSE-teachers per school engage in science and technology education and receive a compensation, financed from cantonal funds and contributions from foundations. Initially, teachers decide about their continuing development regarding their own teaching and the school's possibilities in science and technology education. Along with their school administration, they analyze needs and define individual goals in the areas of inquiry based learning, competence orientation, and education for sustainable development. During the project, SWiSE teachers visit training modules and participate in practice meetings and other SWiSE events, as for example the annual conference.

SWiSE schools and teachers are accompanied and supported by coaches, i.e. science didactic specialists in school development and education policy, who also cooperate regionally in order to coach according to regional/ cantonal educational standards. Schools and teachers also network with training institutions, other schools, and teachers from all areas of German-speaking Switzerland. Together they face the challenges of everyday teaching and the education policy changes in the Swiss educational system (see www.edk.ch/dyn/11659.php). They start to implement the new Swiss German-speaking curriculum (Lehrplan 21) and evaluate the initial experience with competence orientated teaching and assessment.

USE-INSPIRED EMPIRICAL EDUCATIONAL RESEARCH

SWiSE was inspired by the idea of similar projects in Germany (e.g. SINUS, project to improve science and mathematics teaching) and Austria (e.g. IMST, Innovations in Mathematics and Science Education). These projects established model schools with at least two teachers per school involved in the project, regional and national continuing education offers, network meetings, and a scientific evaluation. Yet, in Switzerland interdisciplinary science education at school is far more common than in the neighboring countries Germany and Austria. Therefore SWiSE addresses the needs of interdisciplinary educated in-service science teachers. From this practical perspective SWiSE wants to initiate innovation in schools via a direct mediation of research and practice in the personification of SWiSE coaches. Coaches are former teachers now working in empirical educational research. These natural science teaching professionals ensure the link to educational trends and research. On a higher level representatives of the cantonal education departments (ministries) bring in the current educational standards and policies. These, in turn, will receive valuable insight and feedback from school practice.

From a research perspective Ostermeier, Prenzel, & Duit (2010) for example showed that SINUS teachers significantly gain professional competencies and improve their classroom instruction.

In our approach we additionally incorporate the idea that attitudes play a vital role in training evaluation and rely on Kirkpatrick & Kirkpatrick (2006) that suggest successful evaluation should include four aspects: (1) participants' satisfaction and their intention to continue in the program; (2) participants' change in attitudes, improved knowledge, and/or increased skill as a result of the program. (p.22); (3) and (4) include behavioral change and the benefit of teaching as a result of attending a program.

On student level, as teachers are supported to implement inquiry-based learning, students may profit in their interest, active knowledge construction and science competence development (e.g. Höttecke, 2010).

We will address these aspects later again in the section on the evaluation of the project.

Need-orientation in SWiSE

On the one hand one could implement standards in science education that students develop con-ceptual and procedural knowledge (e.g. Bybee, 1997, 2002). Critics highlight the processes of student learning and their deep understanding of science (HarmoS, 2008; Shamos, 2002). On the other hand school improvement does not necessarily mean to implement standards or to adjust outcome measures in school research. School improvement can be seen as a teacher focussed professional development investment (Katzenmeyer & Moller, 1996).

Many have done research on teacher professionalization and Smith & Sela (2005) conclude that pre-service teacher education provides the framework for in-service professional development. Yet, in Switzerland, science teachers from kindergarten to lower-secondary level receive an integrated university education. Often initial teacher education also lacks practical experience in inquiry-based teaching methodology (Krämer, Nessler, & Schlüter, 2012). But how can one achieve in-service professional development based on an integrated science teacher education - including not only novice but also experienced teachers? With reference to andragogic ideas one also has to consider adults as need-driven developers: They usually prefer continuing education that helps solve current issues in their job. In the realm of constructivist teaching and the advantages of inquiry-based learning environments, one need is the feasibility to implement these methods and develop competencies accordingly. Thus, SWiSE offers its teachers a variety of need-based opportunities and ideas to get the development going. A major focus is to spread the idea of cooperation, sharing ideas within and between schools. Thus, SWiSE implemented regional meetings where SWiSE teachers from one region, but different schools get together and the host teachers present their idea on how to deal with a particular topic in class, and all participants develop on this collaboratively. The annual SWiSE conference comprises a national event. There, teachers from all regions present successful projects or offer workshops similar to those in the regional meetings. The evaluation results suggest that teachers rate this conference very useful, but, what is more, they perceive it as part of their continuing education in their developmental process. A second opportunity for need-driven development is the coaching, where teachers may draw upon an experts view or suggestions right on demand. As coaches combine methodological and content knowledge, we believe teachers can profit the most and according to their highly individual needs. Finally, from practical experience we found teachers in former projects feeling like the lone warrior in developing their lessons. This experience, to us, indicates that some higher-order identification with the project and its participants is neccessary latently. In our full three-year project we hope the label SWiSE may lead to a sustainable intention for self-regulated and cooperative development, as it has been coined by SWiSE.

The Networking Concept

In general, SWiSE itself comprises a macro-network that is supposed to foster micro-networks. As a meta-network we define the cooperation of 11 institutions; mainly universities of education, but also public institutions and the Swiss Science Center Technorama, an out-of-school hands-on learning location. Each institution sends repreeantatives to the various SWiSE-boards which hold particular authorities. They are cascaded top-down from strategic to practical, but informed bottom-up in order to ensure the practibability of decicions. The top advisory board high rank representatives decide on strategic and pecuniary issues.

Below the advisory board one can find two major strands of committees, the conceptual strand and the school-oriented strand. The conceptual strand includes the SWiSE conference planning group and the coordination group, which is formed by academics in practical teacher education. They advise supervisors that teach continuing education seminars. The school-oriented strand includes the evaluation group that discusses and supervises the scientific evaluation of the project and the operative group that organizes and supervises regional sub-groups, e.g. in Basel, Bern or central Switzerland. Each regional group advises its SWiSE coaches which themselves are in close correspondence with SWiSE schools and teachers.
Micro-networks in our sense is the networking activity of schools and teachers. In each school SWiSE teachers are supposed to initiate collaboration and innovation. They may then share their ideas regionally in self-organized regional meetings or even nationally in presentation at the SWiSE conference. Results of the quantitative evaluation show that SWiSE teachers significantly improve in their in-school collaboration and report that this has a disburdening effect. SWiSE teachers also evaluate coaching as extraordinariliy useful and they meet their coach 2 half days on average per school year. Regional meetings seem to be extremely productive as well. Supra-regional meetings are rather or absolutely useful. Visits to other SWiSE schools are evaluated as profitable as well. From this practical view one could assume that cooperation in the meta-network works well within each group or board. (Note: Details on these statements can be found in the evaluation section below.)

SYNERGIES OF RESEARCH AND PRACTICE

In advance SWiSE had been initiated in a close research-practice interaction. For example the Technorama (see *The Networking Concept*) offered free entrance to SWiSE teachers and their classes. Also cantonal education departments supported the project. Finally, pleasant news was that one school's participation has been funded by a local enterprise, because the project's financial limitations were reached. In these joint initiative forces the national, cantonal, and public relevance seem to be evident.
Upon the initiation of SWiSE we the find three different types of persons that interact with each other to establish a strong link between research and school praxis. There are the researchers, people educated in educational psychology and empirical educational research. They work together with professionals in teaching (e.g. former teachers/ practitioners) at university level, more academically educated practitioners. In this collaboration the result brought about fruitful and participant-oriented discussions and decisions on a conceptual level. Additionally, they share and implement their ideas into the micro-network (see 3.), where they offer a certificate of advanced studies, anchor regional meetings or hold seminars for teachers.

As a result scientific and practical knowledge cannot be disentangled anymore and in this triangulation. SWiSE thus forms a collaborative notion of development that diffuses top down bottom up through all instances and finally reaches the third type of person, the practitioner, the teacher. This diffusion is achieved by means of SWiSE coaches who are the above mentioned professionals. In this helical cascade there is continuous mutual development at each level in the project with a very close link to actual praxis at schools and in classes.
A supplementary person and central mediator is the operative project manager, who serves as a ubiquitious contact person. She usually attends every meeting on both macro and micro level, brings in current project issues or news and gathers demands whenever some are expressed. Therefore she leverages the potential of the top down bottom up transfer processes and contributes to the shared knowledge development of research and practice.

PRODUCTS AND OUTPUTS IN SWISE

SWiSE offers a continuous website (www.swise.ch) where anybody interested can find information about SWiSE aims as well as upcoming events and prospective further education modules. Furthermore SWiSE teachers are offered a web platform called educanet. There the teachers may share ideas and/ or documents they developed online.
By participating the project, schools include the aims of SWiSE in their school profiles and define precise development steps. Accordingly ,they reformulate the school's guiding principles and establish an appropriate school culture. During the three years of the project, they develop different teaching materials and school projects, coached by the experts of didactics. A selection of teaching materials developed during the project will be published in a book.
From a practical point of view, SWiSE teachers can initiate and invite to regional or interregional meetings where they present their own school project or idea of inquiry-oriented teaching. Participants gain insights into teaching methods, team collaboration, school organisation and infrastructure of that specific school. Addictionally, they exchange experiences and teaching materials. These meetings are open for teachers and school management participating the project but also external schools.
The products of the teaching and school development achieved during the three years of the project, such as teaching materials and school projects, are presented on different public conferences, meetings, exhibitions and in further education modules. SWiSE also offers a certificate of advanced studies (CAS) and includes there the experiences of the SWiSE schools and teachers. The schools of Teacher Education, partners of SWiSE, integrate the findings of the SWiSE schools in other research and school development programms.

Besides these teacher-centered products we also share the idea of SWiSE in a variety of publications, both practical magazines as well as scientific journals. Within four years we placed about twenty articles in regional and national school magazines, presented the project in a short video, had two peer-reviewed book chapters and held about 30 presentations in Switzerland, Germany, Latvia, Cyprus, and the USA. Two doctoral students also write their PhD theses on specific aspects in the project. As SWiSE is mainly financed by three foundations (Stiftung Mercator Schweiz, Avina Stiftung, Ernst Göhner Stiftung) another output are newsletter articles and notes in their own publications.

SUSTAINABILITY OF SWISE

Sustainability in a narrow professional sense: SWiSE wants teachers to establish innovation and cooperation and the explicit goal is sustainability itself after the project's end. Due to the current success and financial parsimony SWiSE will be continued on a self-financing basis beyond the official end in summer 2015. Then all cooperations and networks will be continued upon teachers'/ school's interest. As we find most of our project teachers identifying with the label "SWiSE" we assume sustainable development after the end of the organised project.
Sustainability in a narrow practical sense: Every SWiSE school has initiated individual projects and still produce a variety of sustainalble outcomes, e.g. teachers built up a new science classroom, elaborated on experiments for students, introduced new ways of teaching or produced a broad spectrum of new or revised teaching materials. As teachers chose their projects autonomously and they were integrated and linked with already existing structures and processes we assume that teachers and school management use their products in a more sustainable manner than in projects that predetermine the outcome.
Sustainability in an interactive sense: In the horizontal interaction between SWiSE offers for example teachers may implement knowledge from the CAS into their own school and transfer their knowledge to other MINT (mathematis, informatics, natural sciences, and technics) projects running simulaneously or in the future. In a vertical interaction between researchers or coaches respectively and teachers, personal identification may foster future collaboration in MINT projects.
Sustainability in a broader sense: SWiSE could model future school development projects in Switzerland regionally in cantonal education departments or nationally in the Swiss Conference of Cantonal Ministers of Education (EDK). These projects may want to mimic the strong praxis-research interaction in order to implement innovation in other subjects. Especially the individualized coaching could be interesting in further projects as well as the in depth scientific evaluation.

Sustainability in a visionary sense: If one sees professionalised teachers as a product of SWiSE, we reckon that they invest the professionalism in their teaching and fruitfully reach their students at their interest and motivation in science learning and exploration. Therefore we hope for a social sustainability in Switzerland as a location for knowledge and research.

EVALUATION

According to Ostermeier, Prenzel, & Duit's (2010) results in SINUS teachers can gain professional competencies and well improve their classroom instruction in developmental projects.
In SWiSE we also evaluate with reference to Kirkpatrick & Kirkpatrick (2006). They belief participants' attitudes toward the project form an incremental part of a project evaluation. Four aspects should therefore be taken into account: (1) satisfaction and intention to continue in the program; (2) change in attitudes, improved knowledge, and/or increased skill as a result of the program. (p.22); (3) and (4) address behavioral change and the benefit of teaching as a result of attending a program.
Höttecke (2010) also points out that, as a result of teacher change, students may be more interested or motivated in learning.
According to the aforementioned, in the evaluation we ask a) whether there can be a "SWiSE effect" down to students, b) how SWiSE teachers develop in comparison to their colleagues, and c) how SWiSE teachers assess the utility of the coaching.

Methods

General evaluation design, method and measurement procedure
SWiSE is evaluated in a double controlled multi-level panel design (table 1). In the experimental group, 118 teachers receive SWiSE offers as is explained below. Control group one, i.e. colleague teachers (n=24) in SWiSE schools, is used to follow indirect SWiSE effects on colleagues. Control group two (n=20), off SWiSE's reach, follow their usual practice. The evaluation started in November 2012 and will end in summer 2015. Teacher assessments follow a beginning of school year (pre) – end of school year (post1) – end of school year (post2) – end of school year (post3) rhythm (see table 1). Here we report results from the pre-post1-post2 assessment.

Table 1

SWiSE evaluation design

Level	Group	November 2012		May 2013		May 2014		May 2015	
		Pre		Post 1		Post 2		Post 3	N
School	IG + AG & CG	Δ		Δ		Δ		Δ	60 + 15
Teachers	IG	□	x	□	x	□	x	□	118
	AG + CG	□	η	□	η	□	η	□	24 + 20
Students	IG	◯	d	◯	d	◯	d	◯	2300
	AG + CG	◯	δ	◯	δ	◯	δ	◯	480 + 360

IG: Intervention group, **AG**: Affected group, **CG**: Controlgroup
x: SWiSE intervention on teacher level, **η**: indirect effect of intervention
d: effect of teacher level on student level, **δ**: indirect effect of affected teacher level on student level

Teacher sample and variables

Chi-square tests do not show any significant group dependencies between SWiSE teachers and control teachers as regards their gender (Fisher's Exact; p=.592), the grade they teach (kindergarten/ grammar school; primary school, lower-secondary school; $X^2(2)=.331$; p=.848), and the teaching experience ($X^2(35)=31.623$; p=.632; range=[1;39] years; AM=15.73 years; SD=10.19 years).

Attitude toward the implementation of inquiry-learning (4 items) was constructed with reference to van Hooft, Born, Taris, van der Flier, & Blonk (2005). For example: "I only have a vague idea how to do inquiry-learning in my classes. [orig.: Ich habe bisher nur eine vage Idee, wie ich forschend-entdeckendes Lernen in meinen Unterricht einbringen kann.]".

SWiSE aims (8 items) we constructed on the basis of the initial ideas of the project, for example: "Collaboration with other science teachers or external experts. [Zusammenarbeit mit anderen Fachlehrpersonen oder externen Fachleuten.]".

All items could be rated on a 4-point Likert scale (strongly disagree=1 to strongly agree=4).

Student sample and variables

Students from grade 3 to 9 (primary and lower-secondary school) was given an online link to the questionnaire from their teacher in class and did the questionnaire together with their teacher. In item generation and adaption we decided to construe content unspecific items. That means that there is noch reference to a subject like biology or physics.

The items rather ask for science subjects in general. Yet, the students were instructed to rate the items with reference to the subject they were taught by the teacher we also evaluate.
Intrinsic learning motivation was assessed with 7 adapted items suggested by Koch (in press 2015), e.g. "I am totally engaged in science lessons. [Im Naturkundeunterricht bin ich ganz bei der Sache.]".
The relevance of science learning was assessed with 4 adapted items taken and adapted from Buff, Dinkelmann, Steiner, & Reusser (2012), e.g. "Science means a lot to me. [Naturkundeunterricht bedeutet mir viel.]"
Self-regulation was assessed with 4 items, e.g. "I learn best in science lessons, when my teacher let's me do on my own. [Am besten lerne ich im Naturkundeunterricht, wenn die Lehrerin oder der Lehrer mich allein machen lässt.]" (see Rakoczy, Buff, & Lipowsky, 2005).
All items could be rated on a 4-point Likert scale (strongly disagree=1 to strongly agree=4).
51% of the students were male and the average age of the whole sample was 12.94 years (SD=1.74). Altogether we assessed 2959 students, 76% of them were taught by a SWiSE teacher and 79% were native speakers Standard German/ Swiss German.
Chi-square tests do not show any significant group dependencies between SWiSE students and control students as regards their gender (Fisher's Exact; p=1.00), the language they speak (Standard German/ Swiss German/ other language: $X^2(2)=4.755$; p=.093).

Results

Can there be a SWiSE effect?
In the initial evaluation before the program we wanted to know how relevant SWiSE-aims considering student motivation are. Therefore we asked teachers, both control and SWiSE teachers, on the implementation of the teaching-relevant SWiSE aims (α=.73), and we also assessed their students' intrinsic motivation (α=.87). Because our data have hierarchical structure, i.e. students are nested in classes, we used multilevel analysis to find out about the impact of following SWiSE aims on student motivation. On student level we also controlled for the attitude towards the relevance of science learning (α=.89), self-regulation (α=.75), grade (primary=reference vs. lower-secondary), and sex (girls=reference).
In sum, results show that considering SWiSE-aims in class has a significant positive impact on student motivation, independent from students' sex. Teaching more according to SWiSE aims may increase students' intrinsic motivation by .09 points.

Longitudinal analysis

After two years of SWiSE (i.e. pre-post1-post2 evaluations) we hardly had attrition, neither in the SWiSE group, nor in the two control groups. Yet, longitudinal analyses revealed, that only about 50% of the teachers' questionnaires could go into a repeated measures ANOVA (SWiSE: N=70, Control1 in SWiSE school: N=9, Control2 outside SWiSE: N=11). Therefore we use a more liberal 10%, $p<.10$, level of significance.

We found a significant time effect where the intention to do inquiry-learning in class increases from pre to post1 and from post1 to post2. There is also a significant group effect ($p=.05$) in exchange. Dunnett T3 post-hoc analyses revealed that SWiSE teachers were significantly above the level of the external control group ($p=.07$).

Utility of coaching and meetings

We evaluated the utility of the coaching process after the first (post1) and after the second year (post2) in the project. Results show that 56 SWiSE teachers were being coached for two half days in the median each year. 59% considered the coaching extraordinarily useful after the first year and 63% after the second year. Correlations show that neither satisfaction with coaching, nor the amount of coaching requested are dependent from teaching experience.

SWiSE teachers significantly improve in their in-school collaboration compared to non-SWiSE teachers. 79% report that their in-school collaboration has a disburdening effect. 59% of the SWiSE teachers that receive coaching consider this as extraordinariliy useful and they meet their coach 2 half days on average per school year. 36% evaluate regional meetings as extremely productive. 10% (12 out of 114) also participated in supra-regional meetings and of these 75% think these meetings are rather or absolutely useful. Only a couple of SWiSE teachers also visit other SWiSE schools, but when they do, 9 out of 10 declare they profit from the visit.

SUMMING UP AND EXPECTATIONS

With reference to the utility and success of SWiSE and its scientific evaluation we believe that the project can be seen as a model for prospective developmental projects in Switzerland. SWiSE aims at lifelong learning combined with in-service teacher professional development with a special focus on networking and collaboration within and between schools. By reference to just some examples the idea of SWiSE makes practical and scientific sense (Alfieri, Brooks, Aldrich, & Tenenbaum, 2011; Berkemeyer, Manitius, Müthing, & Bos, 2009; Dean & Kuhn, 2007; Hofman & Dijkstra, 2010; Meirink, Meijer, Verloop, & Bergen, 2009; Samarapungavan, Mantzicopoulos, & Patrick, 2008). SWiSE tries to bring "together practitioners, researchers and policy makers in order to support Practice-

Based research and its contribution to practice and theory." (www.eapril.org/about_eapril/ What_is_EAPRIL). This is achieved as the project leaders established general aims on six levels in education: Children, teachers, schools, universities, educational system, and research which to a large degree correspont to the levels of reseach and development suggested by Burkhardt & Schoenfeld (2003): Learning, individual teacher, representative teacher, and system change (p. 11).

First, children and young adolescents should get the chance to develop and keep their interest in scientific phenomena and questions and also increase their disciplinary and meta-disciplinary competences. All this is also seen in the context of personality development and preparation for career choice.

Second, teachers develop, test and reflect on innovative lesson planning and teaching material. They exchange and cooperate among each other at school and establish regional networks. Teachers may also profit from job enrichment as they themselves initiate and participate in developmental processes at their school. Furthermore, working with a professional coach seems to be a good opportunity for teachers for specialist counseling on the individual level. Therefore, coaching can represent a good model for permanent, successful and sustainable professional development.

Third, organizational school development focuses on school cooperation as well as regional partnerships with enterprises and institutions. Schools may also link current development programs to SWiSE.

Fourth, universities, the Swiss Conference of Cantonal Ministers of Education (EDK), other institutions for school development etc. collaborate with each other and gain/ share their experience in this large-scale developmental project.

Fifth, on the level of the educational system, SWiSE, as mentioned above, may function as a role model for future projects, because it is the first of this kind in Switzerland. SWiSE wants to build a basis for future Swiss teaching. Within the next years there will be national curricular as well as structural changes in the school system (HarmoS and Lehrplan 21) which all highlight competence-oriented learning and teaching. Additionally, SWiSE wants to enhance the status of a scientific and technological education that is highly relevant for the future research position of Switzerland itself.

Public conferences/ innovation days and educational seminars, initiated by SWiSE, are meanwhile well established and appear to be important platforms for discussions about science education and inquiry-based learning.

Sixth, the project is evaluated continuously and systematically based on established ideas of school and teacher prerequisites (e.g. Shulman, 1987), well grounded theories of program evaluation (e.g. Huber, 2011; Kirkpatrick & Kirkpatrick, 2006), profound knowledge in educational and andragogical psychology (e.g. Baumert & Kunter, 2006; Knowles, 1979), and recent developments in competence assessment (e.g. Brovelli, Bölsterli, Rehm, & Wilhelm, 2013).

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