ARTIST

Action Research To Innovate Science Teaching

The ARTIST Guidebook

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A Guidebook to Prepare and Conduct Workshops on Action Research in Science Teacher Education

Prepared by the ARTIST – Action Research to Innovate Science Teaching Project (Editors Franz Rauch, Marika Kapanadze, Nadja Frerichs and Ingo Eilks with contributions from the whole ARTIST consortium)

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This guide is part of the ARTIST – Action Research to Innovate Science Teaching project. The project was co-funded by the European Union under the program ERASMUS+ - Capacity Building in Higher Education (CBHE) from 2016-2019 under grant agreement number 573533-EPP-1-2016-1-DE-EPPKA2-CBHE-JP.

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The ARTIST Guidebook

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1. About this guide

The *Action Research to Innovate Science Teaching* (ARTIST) *Project* aims at improving teacher education practices. Its objective is to provide practicing and prospective science teachers with the knowledge and skills to implement action research for the innovation of science education. ARTIST identified and developed resources to implement action research in science teacher education courses. This guidebook contains materials and information used and disseminated in workshops during the ARTIST project, focusing on the implementation of ARTIST courses in the partner institutions. It also provides insights into the development of the ARTIST project.

The materials in the ARTIST Guidebook provide teacher educators and continuing professional development providers with tools for their teacher education courses. The guidebook provides workshop ideas, workshop materials, and resources that can form the bases of science teacher education practices with a focus on action research. It provides exemplary cases that might inspire teachers in their potential action research interests. The collection is free to be used in the provision of non-commercial professional development for science teachers (pre- and in-service) at all levels.

Within the ARTIST consortium, books, articles, chapters, and internet resources were identified that are suitable to build a broad information base for the implementation of action research and classroom-based innovation in science teacher education. A corresponding list of recommended resources is given within this book.

ARTIST centres were founded in Germany, Austria, Ireland, Turkey, Georgia, Israel and the Philippines. The teams in the ARTIST centres are available to support science teachers and teacher educators on their way to implement action research in science teacher education. The final chapter of this guide introduces the ARTIST centres and provides contact information.

Through the ARTIST Guidebook, the ARTIST homepage, and the founding of the *Action Research and Innovation in Science Education* (ARISE) journal, the ARTIST project hopes to support science teacher education in general as well as in the different science disciplines at all levels of education, from primary science to higher education.

The consortium wishes all science educators, teachers and students good luck and fruitful experiences in applying action research for the promotion of modern, innovative and effective science learning.

Ingo Eilks, Marika Kapanadze and the ARTIST consortium

ARTIST
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2. The ARTIST project

Ingo Eilks, Nadja Frerichs and Marika Kapanadze

This chapter describes the ARTIST project in which this guide was developed. ARTIST is an ERASMUS+ Capacity Building in Higher Education (CBHE) action and aims to introduce science education researchers as well as teachers to the philosophy of action research. Action research targets the research-based transformation of science education practices.

The idea of ARTIST

The focus of the *Action Research to Innovate Science Teaching* (ARTIST) *Project* is to innovate science education through classroom-based and teacher-driven action research. Action research aims to transform authentic practices through the action research cycle of innovation, research, reflection, and further improvement of the innovation approach. Beyond the interest of concrete change and innovation, action research aims to generate knowledge and best practice strategies, serving as patterns for innovations in the field of interest, but also in contributing to the continuous professional development of the active practitioners. ARTIST considers action research to be one of the most promising strategies for innovating science education and creating evidence-based classroom practices in domain-specific educational studies.

Transforming science education by action research

Action research in science education seeks to improve science classroom practices through cycles of planning and operating action, observation/research, reflection, and revision (Laudonia *et al.*, 2017). Action research has been identified as one of the most promising strategies for research-oriented science teacher education and continuing professional development as well as for classroom innovation. The potential of action research has been suggested both by educational policy (e.g. European Commission, 2013; 2015) and domain-specific science education research (Eilks, 2014; Mamlok-Naaman & Eilks, 2012). Action research strategies provide an alternative route (or even a different paradigm) of educational research. It also provides evidence-based practice improvement in science education including a different view on the research to practice relationship (Bodner *et al.*, 1999; Mamlok-Naaman *et al.*, 2018).

There is a large variety of action research strategies and research foci provided in the science education literature (Laudonia *et al.*, 2017). The approach suggested in the ARTIST project is an accompanied, participatory, but also teacher-centred interpretation of action research. Innovations are suggested to be thought out, implemented, researched, and reflected by the practitioners under the direction of science educators from higher education institutions (HEIs) leading towards further steps of development and innovation.

ARTIST is a curriculum reform project in higher education. The curricular focus behind ARTIST is introducing science education researchers and prospective or practicing science teachers towards the philosophy and methods of action research, in order to form a basis for research-based transformation in science education. ARTIST provides the framework for the development of appropriate training materials, courses and activities. ARTIST will be the platform for the exchange and sustainable implementation of action research in science education within the participating HEIs.

In order to give action research activities within ARTIST a joint and valuable focus, ARTIST aims to raise motivation and achievement in science education. It also aims to enhance interest and improve the opportunities of the young generation in careers and further education in science and engineering fields. To connect the idea of action research for innovating science education with the aim of improving the career opportunities of the young generation in science and engineering, a unique feature of ARTIST is the development of networks of universities with schools and industry/SMEs (Small and Medium Sized Enterprises). Each HEI within ARTIST builds up a regional network around it, consisting of the HEI, secondary schools and representatives of industry/SMEs.

Figure 1. The ARTIST website

The ARTIST partners

The ARTIST project is an ERASMUS+ Capacity Building in Higher Education (CBHE) action (www.erasmus-artist.eu). The action is cross-regional, encompassing partners from Europe and Asia. The ARTIST consortium was formed based on the successful project *Student Active Learning in Science (SALiS)* funded by the European Union under the TEMPUS framework from 2010-2012 (Kapanadze & Eilks, 2014).

Partners in ARTIST are:

- University of Bremen, Bremen, Germany
- Ilia State University, Tbilisi, Georgia
- University of Limerick, Limerick, Ireland
- Alpe-Adria- University, Klagenfurt, Austria
- Gazi University, Ankara, Turkey
- Batumi Shota Rustaveli State University, Batumi, Georgia
- Acadenic Arab College of Education, Haifa, Israel
- Oranim College of Education, Oranim, Israel
- De la Salle University, Manila, Philippines
- Ateneo de Manila University, Manila, Philippines

The project is funded by the European Commission for the years from 2016-2019.

ARTIST courses, centres, and networks

Course structures and teaching materials about how to do action research in educational settings with a special focus on science education are developed. Guidance is given about how to establish and maintain partnership networks of HEIs, schools and industry. The course structures and teaching materials were developed based on a needs analysis, good practice reports, collaboration between the partner institutions, and adapting the ARTIST principles to the local needs of the partner institutions.

Training materials, teaching guides, slide shows and handouts were prepared for the ARTIST workshops and course. An action research guide specifically focusing on science education is developed, which will help secondary and tertiary science teachers to learn about action research. Materials cover the basics of conducting action research for informing practice and the introducing innovations in teaching science. ARTIST courses are provided and implemented. As action research is suggested as one of the most promising strategies in science teacher professional development (Mamlok-Naaman *et al.*, 2018), student teachers and participants in continuous professional development participate in all ARTIST beneficiary institutions.

Networks of the partner universities, schools and enterprises are maintained around each of the ARTIST HEIs to ensure sufficient background and impact of the project. Institutions develop existing infrastructure by procuring and installing specific equipment and materials needed to promote teacher education for career orientation related to the industries in the partnership network. Equipment includes special media or items for demonstrating, studying and investigating, e.g. biochemical, genetic or technological processes. Equipment is purchased and installed in all ARTIST universities in the so-called partner countries, namely Georgia, Israel, and the Philippines. ARTIST centres are established as supporters and facilitators for schools and teachers doing action research in science education.

The means of the communication from the ARTIST project are diversified in order to achieve the maximum outreach. ARTIST educational workshops are held in 2018 in the Philippines, Georgia and Israel. All workshops include a day for the interested public, namely teachers, teacher educators, and educational policy stakeholders. A final conference will be held in summer 2019 in Batumi, Georgia.

ARISE – The journal of action research and innovation in science education

To promote long-term sustainability and for the stimulation of the interest into action research, a new international, electronic peer-reviewed journal has been established. The journal is called *Action Research and Innovation in Science Education* (ARISE). It provides a unique place for teachers and researchers to publish action research and small-scale innovation studies in all fields of science education. In order to feed the first volume of the ARISE journal, action research and innovation case studies were conducted by all partners focusing on aspects of inquiry-based science education, teaching and learning of science, and career orientation in science education.

ARISE is a peer-reviewed international journal. ARISE publishes academic and practitioner research in the field of science education. Papers shall be about action research, practitioner research, or classroom-based research and innovation studies. Papers may comprise theoretical discussions, research studies, or reports on evidence-based curriculum innovation. Contributions may focus on all the science teaching domains, from early childhood science through the secondary and university level, to informal science and environmental education. Manuscripts on science teacher education in connection to action research, classroom-based research and innovation or research-based learning in teacher education are welcome, as well as papers on the methodology of action research for classroom innovation in science education.

The ARISE journal, launched by the ARTIST project, will become a central focus for visibility and impact of the ARTIST project. After the ARTIST project, the ARISE journal will be maintained by the *International Society for Educational Research (iSER)*. All partners designated from the consortium agreed to serve as editors and editorial board members beyond the funding period to make ARISE a success in the long run. The editorial board also incorporates further experts from the field of science education across all regions of the world.

Outlook

Action research is a unique way of transforming educational practices based on evidence and at the same time, contributes to teachers' continuing professional growth. Action research is suggested by educational policy (European Commission, 2013; 2015) but is still under-represented in the literature of science education (Laudonia *et al.*, 2017). The ARTIST project intends to strengthen action research in science education for the sake of better science teaching and more effective science learning. The ARTIST project intends to support sustainable transformations in teacher education in the participating HEIs and countries. First implementations already show changes in teacher education practices. These will be improved further and will be continued in the ARTIST centres and networks established with the help of the project.

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3. Action research to innovate science teaching

Ingo Eilks, Franz Rauch, Nadja Frerichs and Marika Kapanadze

This chapter describes the main principles, goals and ethical aspects, as well as limitations of action research in the context of the ARTIST project. In particular, the differences between traditional formal research and action research are outlined. A model of the action research cycle is described.

The potential of action research to innovate science teaching

Science, engineering and technology are in the heart of every modern society and related education is suggested to be needed for its development (Bradley, 2003). Both the growth of prosperity as well as coping with local, regional and global challenges (e.g. supplying clean water or mitigating climate change) are indispensably connected to science and technology (Matlin *et al.*, 2015.) and related education for sustainable development (Burmeister *et al.,* 2012). Society needs its citizens to be educated and scientifically literate in order to make informed decisions about corresponding developments within society (Hofstein *et al.*, 2011). One solution towards improving how we cope with these challenges, is investing in more relevant science education from the primary to the tertiary sectors (Stuckey *et al.*, 2013).

The keys for developing science education are evidence-based curriculum development and investment in teacher education (pre- and in-service). Teachers are essential for any effective practice in education (Hattie, 2008) and their views and experiences play an important role in any development or implementation of reform in general (van Driel *et al.*, 2001) or concerning relevant science education in particular (Hugerat *et al.*, 2015). This is the point where action research comes into play. Action research has great potential to contribute to positive developments in science education teaching practices and corresponding teacher education (Mamlok-Naaman *et al.*, 2018). Action research provides potential to directly change classroom practices and at the same time, enriches science teachers' professional knowledge base (Eilks, 2014) leading to teachers' professional growth (Mamlok-Naaman & Eilks, 2012).

Action research seeks to establish a culture of research - based innovations in science education based in participatory and pragmatic research paradigms (Creswell, 2003) and with connections to critical theory (Kemmis, 2007). Action research is a set of strategies for cyclically researching and innovating authentic practices (in this case in science education) by the practitioners (in our case science teachers) (Altrichter *et al.*, 2008). A large variety of action research strategies and initiatives exist already in science education (Laudonia *et al.*, 2017). Implementation of action research needs, however, continuing support through the development and provision of courses, course materials, guides and support. Action research will allow further science teachers to become active and reflective innovators of their classroom practices.

Generally, all action research aims to enable teachers to reduce deficits in their teaching and develop more motivating and effective educational practices (Eilks & Ralle, 2002). This work is guided by evidence gained in small-scale research activities operated by the teachers in their authentic teaching and learning environments (Altrichter *et al.*, 2008). Cooperative and collaborative practices of action research also intend to bring practitioners together with each other and also with other stakeholders relevant to science education (Mamlok-Naaman & Eilks, 2012). Collaboration provides support for the individual teacher and allows the newly recognised solution strategies to be of help to the wider regional, national and international audiences (Eilks & Ralle, 2002).

Science education works in an international landscape covering a wide area of different cultural and socio- economic conditions. This means that action research has to appear differently under various cultural, educational and societal conditions. Since the experiences of applying action research will vary according to the different educational settings, it is likely that action research will produce more authentic innovations than traditional research methods. In doing so, action research allows also for learning from each other by respecting and reflecting different foci, activities and methodological decisions in different socio-cultural environments. Action research can provide cultural insights relevant to science education and make science teacher education an intercultural experience. In the case of the ARTIST project networking takes place between researchers and practitioners from Western Europe with Turkey, Georgia, the Philippines and Israel. The intercultural aspect is particularly relevant within Israel, with the involvement of both Jewish and Arab sectors, as they are two very different cultural environments within the one nation. Furthermore, networks might help to support classrooms that face increasing diversity as a result of growing migration in many countries of the world.

Among the major deficits described in many reports in science education, especially in the physical sciences, are poor student motivation, a misplaced perception of the relevance of science teaching (Stuckey *et al.*, 2013), and a shortage of young people embarking in careers in science and engineering (Osborne & Dillon, 2008). Action research can help to reduce these problems. Innovations by action research can address student motivation, their perception of relevance of science learning, career orientation, and preparation for science careers. By directly applying innovations based on evidence, action research has direct potential to reduce deficits reported from practice. (Stuckey *et al.*, 2013).

To make most use of action research, networks consisting of HEIs for science education, schools and businesses are suggested. Within these networks action research and innovation case studies have the potential to give students an authentic perception of science by showing them the relevance of science in industry applications as well as in everyday life processes and products. This connection with industry and SMEs is suggested to help in reducing the gap in students' perception of the relevance of science education (Hofstein & Kesner, 2006). This is most successful when science education refers to the three dimensions of relevant science education, namely individual, societal and vocational relevance (Hofstein & Kesner, 2015).

The implementation of action research case studies into science education can help science teachers to become reflective practitioners (Leitch & Day, 2000). The teachers can gain skills for ongoing innovation of their teaching based on evidence and reflection through action research. Action research case studies that integrate science education with society and the economy sector can contribute towards raising the level of scientific literacy in the young generation. This may promote the idea of a self-determined life and the ability to democratically participate in society, today and in the future, following the EU policy of promoting science education for responsible citizenship (EU Commission, 2015b).

Action research in science education and needed implementation

Action Research aims for the cyclical innovation of authentic practices through the action research cycle of planning, action, evaluation, and reflection, leading to further improvement of the innovation approach (Altrichter *et al.*, 2008). Beyond the interest of concrete change and innovation, action research – in all its different interpretations - aims for the generation of knowledge and best practice strategies, serving as a pattern for innovations in the field of interest, but also in contributing to the continuous professional development of the acting practitioners (Laudonia *et al.*, 2017). Action research is suggested to be one of the most promising strategies for innovating science education and creating evidence ‐ based classroom practices in domain ‐ specific educational studies (Marks & Eilks, 2010).

More generally, action research has not only to meet the requirements of any other social research methodology, but also must be of practical use for the people concerned. It must include high ethical standards and comply with values like democratic participation, sharing of knowledge and emancipation from ignorance and dependency. Based upon the work of Heron and Reason (2008) and others, four principles of action research could provide guidelines for action researchers (Stern *et al.*, 2014):

(1) Good Action Research pursues worthwhile practical purposes

- by trying to find solutions for authentic problems and empowering the people concerned to acquire relevant knowledge and to share it with others;
- by leading to actions that are embedded in a humanistic value system.

(2) Good Action Research is collaborative / participatory

- by involving the people concerned into the research process;
- by agreeing upon ethical rules for the collaboration.

(3) Good Action Research is responsive and developmental

- by engaging in a continuous series of research-and-development cycles;
- by taking the different perspectives of various stakeholders into consideration in search of satisfactory problem solutions.

(4) Good Action Research connects theory and practice

- by balancing action and reflection; (reflection can inspire or evaluate actions or uncover the motives behind them; action can prove or disprove theoretical assumptions);
- by generating theoretical knowledge, delivering problem solutions and promoting practical improvements.

A core question in this work is: Should action research meet the same standards for validity and rigour as traditional scientific research? Or is it a distinctive way of approach to inquiry and which should therefore be judged by its own standards? This chapters is written in the belief that an answer to this question is crucial for the recognition of action research in the academic arena.

As a first step, we offer the following quality features (Altrichter *et al.*, 2008; Altrichter, 1990):

Action research is a mode of reflective professional action

Action research, in this sense,

- builds on everyday competencies by which practitioners observe, interpret, make sense of and develop their practice,
- attempts to give assistance to develop, differentiate, and systematise these professional competencies, and
- aims to establish and develop a professional discussion between people working in and concerned with education in order to improve and validate educational practice and the knowledge underlying it.

Professional practice is "research in the practice context" and it resembles a "reflective conversation" with the situation

Classrooms are not places to apply laboratory findings, rather they are laboratories themselves. There is no structural difference between reflective professional activities and research activities. Thus, we may argue vice versa: Action research is a mode of reflective professional action. Action Research starts from and is explicitly based on everyday reflection and tries to give stimulation and practical assistance for its elaboration.

Action Research is characterised by confronting data from different perspectives

Practically, action researchers tackle this problem by the following strategies:

- Collect also other views than your own. Interviewing the students obviously makes the 'practical theory' more comprehensive and improves the chance that some reasonable action strategy might be derived from it. The views of all relevant parties directly concerned with the situation under research must be represented in the practical theory.

- Action researchers confront different perspectives on the same situation and use 'discrepancies" as a starting point for the analysis, e.g. the discrepancy between the students' and the teacher's perception.
- Action research's emphasis on the confrontation of different perspectives is expressed in the procedure of triangulation. In triangulation, data from different sources are confronted, e.g. the teacher's view of a situation, the students' views (as collected through interviews, for example) and a third person's perception (e.g. a classroom observation by an observer who has been invited by the teacher).

Action research incorporates reflection and development of educational values

Action research holds that a teaching strategy is an attempt to realise an educational idea in a concrete interactional form. As educational ideas always incorporate educational values, it does not make sense to separate instrumental questions from intentional ones.

Action research is characterised by holistic inclusive reflection

Reflective practitioners do not evaluate their practical experiments by asking: "Did we achieve the ends we set ourselves?" Rather they ask: "Do we like what we got?" The reflection also involves the context and conditions of the practice researched.

Action research implies research and development of teacher´s self-concept and competencies

Practically, action research's usual practice aims to counter feelings of being deskilled by peer collaboration and consultation by 'critical friends'. Action research projects or courses try to establish a supportive climate through group support and facilitation.

Action research is characterised by inserting findings into a critical professional

Action research encourages practitioners to formulate their experiences and practical knowledge in order to share them (e.g. with fellow professionals, parents, administrators and an interested public) and publish teacher studies.

Anyhow, all action research seeks to improve classroom practice by cycles of planning and operating innovative action, research-based observations, reflection, and revising the operated teaching strategy (Figure 1) (Laudonia *et al.*, 2017). One of the most promising approaches for wider dissemination of action research and its findings is an accompanied, participatory/collaborative and at the same time teacher ‑ centred interpretation of action research. Following corresponding strategies, innovations are thought out, implemented, researched, and reflected by the practitioners (or groups of practitioners) under the direction and guidance of science education researchers from academic science education, leading towards the next step of innovation (Mamlok-Naaman & Eilks, 2012). A corresponding curricular focus in teacher education is needed to introduce science education researchers and prospective and practicing secondary school teachers to the philosophy and methods of action research, which are substantially different from traditional, positivistic/post-positivistic education research (Table 1). Teacher education curricula are needed in order to form a basis for research-based innovation in science education via the teachers and their students. This book tries to provide a framework for the development of appropriate training courses and activities.

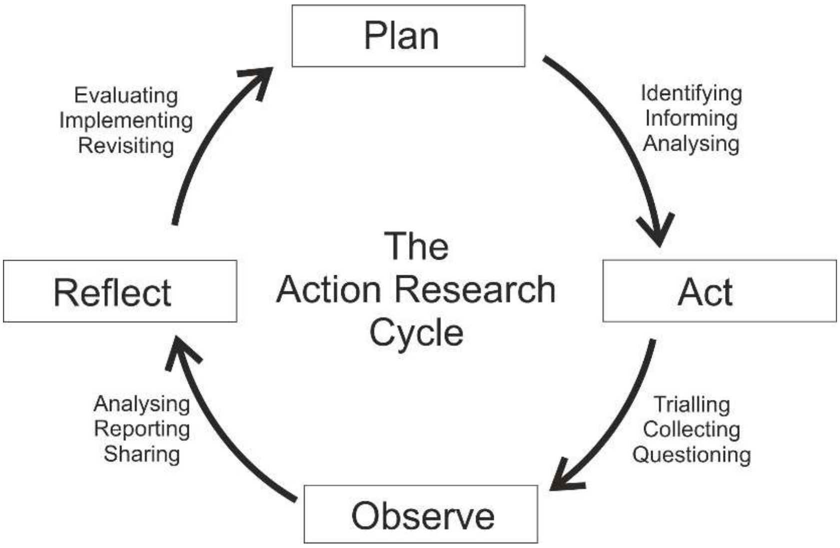

Figure 1. A typical model for the action research cycle

Table 1. Differences between traditional formal research and action research (www.seameo-innotech.org)

Topic	Traditional research	Action research
Training needed by researcher	Extensive	On own or with consultation
Goals of research	Knowledge that is generalizable	Knowledge to apply to the local situation
Method of identifying the problem to be studied	Review of previous research	Problems of goals currently faced
Procedure of literature review	Extensively using primary sources	More cursory, using secondary sources
Sampling approach	Random or representative sampling	Students or clients with whom they work
Research design	Rigorous control, long time frame	Looser procedures, change during study; quick time frame; control through triangulation
Measurement procedures	Evaluate and pretest measures	Convenient measures or standardized tests
Data analysis	Statistical tests, qualitative techniques	Focus on practical, not statistical significance, present raw data
Application of results	Emphasis on theoretical significance	Emphasis on practical significance

Participation of student teachers in classroom-based research studies conducted by in-service teachers are suggested to become part of pre-service science teacher education (at undergraduate or graduate level). This is suggested as one way towards developing research-oriented learning in teacher education. Participation of in-service teachers in action research should be made part of their continuous professional development (Mamlok-Naaman *et al.*, 2013). This needs to be implemented to form a continuously growing community of practitioner researchers in science education. Higher education institutions and national institutes of education might serve as coordinators and facilitators for ongoing classroom-based action research within their local and national environments.

Additionally, cooperation between teachers, schools, universities, industries and businesses will further help to develop and implement relevant content and student-active methods for teaching science. This will be achieved by considering the competencies mapped out together with industry and business representatives. Action research can be used for evidence-based and sustained development and implementation of the curricular activities and related pedagogies, towards fulfilling the needs identified in society, industry and businesses.

Foci of corresponding studies might encompass:

- Developing and implementing context-based and societally-driven science curricula, by including industry, society and business related contexts and socio-scientific issues in science education
- Supporting science learning by connecting formal and informal learning, i.e. through school-industry partnerships
- Promoting inquiry-based science learning and innovative practical work in science, as essential elements for future academic and any other professional careers in science and technology related fields
- Implementing student-centred teaching methods in science for the development of soft skills important for raising further education and employment opportunities
- Creating and researching alternative methods of assessment of learning processes considered relevant for future employment.

Continuing professional development based on a self-learning experience of science teachers, while reflecting on their own practices on the basis of small-scale classroom-based research and innovation studies will help to improve science teaching practices. It will contribute to the innovation of science teaching at large by dissemination of quality studies from science classrooms.

Action research, science education and the problem of dissemination

Action research has limitations in disseminating its effects and findings (Mamlok-Naaman & Eilks, 2012). Action research activities and findings are often not well documented and reported, especially when it comes to traditional academic channels of knowledge dissemination (Laudonia *et al.*, 2017). Teachers are often not trained for academic writing, nor is this in their focus. Collaborative networks with higher education institutions might help to overcome this gap (Eilks, 2014). Nevertheless, new channels for knowledge dissemination of action research are needed.

Teacher action research might be better reported in smaller documentations than in traditional educational research papers. An international platform is, however, missing, aside a few English language national science teacher journals. A new platform and format needs to be established to allow teacher to learn from each other's action research experience. The ARISE journal aims to provide a corresponding platform. In time, we will know whether or not this new format succeed in documenting knowledge from action research and disseminating it to an international audience.

Educational action research and aspects of ethics

Educational action research is educational research and thus has to respect certain ethical standards. These standards encompass, among others, the requirement to be always clear and transparent to students, respect teachers' and students' rights and interests, and to avoid harm to any individual. Consent is needed from all persons involved, and in case of children consent of their parents. Data has to be handled with sufficient care. Results have to be documented throughout, but anonymized and confidential.

There are, however differences between action research and traditional positivistic/post-positivistic research (Creswell, 2003). Participatory/critical research traditions do not want to omit but intend to purposefully change authentic practice (Treagust *et al.,* 2014). Critical research and action research intend to change societal practice so as to improve the situation and chances of the persons involved (Kemmis, 2007). This means action research cannot do research just for the sake and interest of the researcher. It has to respect the interests of all persons involved, generally the students and teachers. This has consequences for the available research designs. Control group studies are very prominent in positivistic/post-positivistic research. A critical researcher would not teach a control group with a traditional approach just for research's sake if the alternative setting promises better effects based on theoretical and experiential assumptions.

Action research is participatory and critical research (Kemmis, 2007). It aims to impower and emancipate (Mamlok-Naaman & Eilks, 2012). It will never aim to show that a certain practice is misleading or less successful. Action research seeks to identify improved practices and to understand the mechanisms of practice improvement. In the same way that a good teacher will always try to do the best he/she knows to support his/her students learning, any action researcher will try to identify, implement and understand the best possible practice he/she can imagine. If any changes are not successful, an action research teacher will adapt his/her teaching strategy to an improved or altered strategy until the originally identified problem is eased.

Science education action research and the future

Politically, action research is an area in high demand, encouraged by the European Commission (2013; 2015a) and UNESCO (2015). Globally, there is political motivation for the improvement of science education. However, support for action research is still limited. In many countries, resources and funding for schools are limited. Higher education institutions, who support and coordinate action research in schools, report difficulties in securing funds for this specific kind of research when compared to traditional, formal and positivistic/post-positivistic research.

The ARTIST project shows that funding is becoming available to support action research. The European Union has started to fund action research, in our case in science education. The ARTIST case may become a crucial example for future project applications. Evidence of improved practices through the process of action research in the ARTIST project will serve as justification for other similar projects. We must continue to collate and showcase the benefits of action research. Investing in action research is one of the most promising ways to transform and innovate science education. It provides teachers with better tools to grow and professionalize and enriches academic research practices in science education.

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4. Activities and materials to be used in science teacher education action research workshops

Ingo Eilks and Franz Raunch with contributions from Doris Arztmann, Rachel Mamlok-Naaman and Stefan Zehetmeier

Identifying action research questions

Action research questions emerge from own experiences and needs. Action research questions are of a different kind than traditional research questions. Think about the following questions and identify any need from your practice that can be challenged this way:

- I would like to improve ________________________________

  ____
- I am perplexed by ____________________________________

  ____
- I am really curious about _________________________________

  ____
- Something I really think would make a difference is __________

  ____
- Something I really would like to change is __________________

  ____
- What happens to student learning in my classroom when I ___

  ____
- How can I implement ___________________________________

  ____
- How can I improve _____________________________________

  ____

From Pine, G. (2009). *Teacher action research*. Thousand Oaks: Sage.

Developing action research activities in a group

1. Form groups of four participants.

2. Develop and write down individually one research question, and indicate the population to which it is addressed (10 minutes):

   ____

   ____

3. Each participant should present his/her research question to his group (5 minutes).

4. The group members should discuss and choose one research question out of the four (15 minutes):

   ____

   ____

5. The group members should discuss the way in which they would like to conduct their research in class, namely, what kind of research tools will they use (15 minutes):

   ____

   ____

   ____

   ____

6. Each group member should write a reflection on the activity (5 minutes):

   ____

   ____

   ____

   ____

   ____

   ____

7. Each group member should share the reflection with his/her group colleagues.

What will be the benefit?

If my action research will be successful, the benefit will be …

for me

____
____
____
____
____
____

____
____
____
____
____
____

for my students

for my colleagues

____
____
____
____
____
____

____
____
____
____
____
____

for ______________

Documenting a concept of an action research study

1. What is your developmental interest? What would you like to make better? What are your goals?

   ____

   ____

2. What is the research question? Formulate a research questions. (The research question has to serve the developmental interest.)

   ____

   ____

3. What do you already know about the research question? How do you know it? What evidence to you have? What hypotheses do you have?

   ____

   ____

4. What further information do you need to answer your research question?

   ____

   ____

5. How could you get information? What research methods are best to get valid information?

   ____

   ____

6. How could you plan your action research process? What resources do you have (Know-ledge, time, money ….? Make a plan. What you want to do, how would you do it and when.

   ____

   ____

Reflections on ethics in educational action research

Preparation phase:	Done	Improve
Develop awareness of ethical issues by reading documents about ethics of action research and any relevant legal restrictions.		
Reflect the aims of your research: What do you hope to achieve? What should be the gains for you, the students, and the school? What implications may arise from your action research?		
Communicate the aims of your research to relevant groups of participants and potential audiences (headmaster/principal, colleagues, parents, students).		
Prepare short written research outlines for the various audiences (headmaster/principal, colleagues, parents, students). State the aims of the research, the possible outcomes, and potential implications.		
Be open, talk about the plans for your research with colleagues. Check whether they are interested to join you in your research.		
Gain formal permission from the headmaster/principal and any other relevant authorities.		

Implementation phase:

Become aware of your professional obligations as a teacher to your students.		
Become sensitized to gender / ethnic / socio-economic issues.		
Communicate the aims of the action research to the students.		
Offer confidentiality as far as possible, offer the right to withdraw from data collection as far as possible.		
Become aware of the possible implications of one to one interviewing situations with students and regulations around using electronic recording equipment (audio and video).		
Plan mechanisms to reflect continuously on your research as it grows and consider all potential consequences of whatever action you decide to take.		
Become sensitized to reconsider intended changes as the research develops.		

Evaluation phase:

Become reflective on your own perspective and subjectivity. Prepare reflections of your perspective with colleagues or supervisors.		
Use communicative validation with the students to validate data interpretation.		
Plan to maintain a dialogue with all participants. Become sensitized to handle carefully any conflict between their perspectives and your perspective.		
Become sensitized to accept changes as result of findings and feedback.		

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Formal research vs. action research

Topic	Formal research	Actio research
Who is doing the research?		
What interest does the research have?		
From which base is the research question set up?		
What is the role of literature in the research?		
How is the research sample selected?		
What characterizes the research design (linear vs. cyclical)?		
What type/depth of data collection procedures are dominant?		
What type of data analysis procedures are dominant?		
What aspects make the research of high quality?		
Which research paradigm is behind the research?		

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Data sources for my action research

Reflect on sources of data for your research with respect to their feasibility both to the research interest and the research process (++ very high, + high, o medium, - low, -- not at all)

	Potentially useful	Demand in collection	Demand in analysis	Comment / N.A.
Standardized questionnaire				
Open questionnaire				
Written narrative				
Semi-structured, structured interview				
Open, narrative interview				
Observation				
Audio, video recording				
Performance test				
Analysis of student artefacts				
Mind-mapping, concept mapping				
Other: ___________________________				

Developing a questionnaire

Reflect on the following questions individually or in a small group before formulating a questionnaire:

- What do you want to get information about?
- Why would you like to get this information? What would you like to do with the information?
- Why would you like to get this information with a questionnaire?
- What are your experiences and knowledge with the creation and analysis of questionnaires?

Formulate questions by taking the aspects below into account. Design the draft of a questionnaire.

Types of questions

Basically, we distinguish *open questions* (cannot be answered by yes or no) and *closed questions* (the answer are formulated already and the respondent mark with a cross). In both cases, you should take into account the following aspect when constructing the questions:

- Is the question really necessary? In how far could you use the answer for solving your problem or answering your research question?
- One question must contain only one topic. Otherwise, you cannot interpret the answers clearly.
- Do the respondents know enough about the question? Are they able to give substantial answers?
- Questions on subjective information (opinions, attitudes) might be complemented by questions on concrete actions and facts.
- Personal and controversial questions might not be answered honestly (socially desirable answers or wrong answers to protect the respondent).
- The questions in a questionnaire should not be one-sided (only negative or only positive aspects).
- Is the question formulated in a clear language? Are the respondents able to understand it?
- Is the formulation suggestive? Does the question put answers into the mouth of respondents?
- Does the question foster emotional resistance among respondents?
- Is it better to ask the question directly or indirectly? An example for a directly asked question: “What did you like in group work?” An example for an indirectly asked question: “Stefan and Franz talk about the group work. Franz says, that he did not participate in group work because the others did the work anyhow. What is your opinion?”

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Reflecting on questions for a questionnaire

Is it better to ask an open or closed question? Could questions could also combine both forms?

Example:

Please chose one or more answers:
O I liked to work alone
O I liked to work with another student
O I liked to work in a group

Please note why you choose this/these answer(s)?

____

____

____

____

In case of a closed question: how many answers should be possible? Only two (yes or no) or more (three to six …)

Examples:

Please tick the answer:

The teacher was interested in my work?
O Correct
O Wrong

Or with three possibilities:

O Always
O Sometimes
O Never

Is it clear for the respondents what is expected from them, what they have to do?

What is the best sequence of questions in the questionnaire? Usually it is better to ask about facts at the beginning and about meanings, attitudes, and emotions later.

Train yourself for interviews

Train yourself by three interviews. Form groups of three people. Each one in the group of three takes over one of the following three roles:

1. **Interviewer:** asks questions
2. **Interviewee:** answers questions
3. **Observer:** listens and give feedback about the interview as a critical friend, and serves as a time keeper

First round (approx. 40 minutes):

1. Choose the theme of the interview
2. Choose roles
3. The interviewer notes down some questions he/she wants to ask (ca. 5 minutes)
4. Interview: approx. 10 minutes
5. Feedback from observer
6. Discussion in the group: what did we learn?

The interview could be recorded or you make notes.

Change roles for the second and third round.

Task of the roles

Interviewer

Listen:

- Do not interrupt interviewee.
- Accept pauses (These are necessary to order thoughts).
- Attention (neutral but showing that you are interested in understanding).

Questions:

- Do not formulate questions in a suggestive way.
- Inquire in order to understand what the interviewee means.

Interviewee

Answer as honestly as possible

Observer

Listen carefully and make notes about the process of the interview. Give feedback about your observations after the interview. Be careful with criticism. Tell mainly what you have observed. Pay attention to the time.

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Some hints for interviewers

Listening instead of talking. *Most important is that you have a neutral attitude and show the interviewee that you are interested in what he/she is telling you.*

You should not talk for more than 10 % of the conversation.

Note down some guiding questions before the interview

These questions help you not to lose focus. You should, however, be open to new perspectives within the theme of the interview. The interview should have the character of a conversation.

Be neutral in your reactions.

Do not judge what the interviewee says.

Ask clear questions. Avoid suggestive questions.

Do not put words in the mouth of the interviewee.

Accept pauses

The interview might be interrupted when you do not accept silence.

Do not urge the interviewee to answer questions.

The interviewee decides what he/she wants to say.

Be careful asking for feelings too directly and at the beginning of the interview.

The flow of the interview might be interrupted.

Do not give up questioning

Do not accept a change of roles during an interview.

If necessary, for better comprehension in the later analysis:

- Repeat statements of the interviewee in order to understand fully.
- Ask for examples and more concrete information.
- Ask for reasons and purposes.
- Ask for clarifications of contradictions.

Time and space

Schedule enough time for the interview (approx. 20 minutes depending on the topic). Find a place where you will not be interrupted by others, e.g. choose a room which you can reserve for the interview.

After the interview

Check if the interview is tape-recorded. Start with the transcript and analysis of the interview as soon as possible.

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Participatory classroom observation

Purpose: Direct observation offers authentic information and builds upon everyday experience. Mutual learning of the observer and observed can take place.

Steps of participatory observation

- A teacher invites a person (other teacher or researcher) to observe a class. A teacher should not be forced to be observed in an Action Research process.
- Both persons meet before the observation and negotiate a time and the focus of the observation and the feedback meeting afterwards.
- In general, one can distinguish between *open observation* and *focused observation* (e.g. focused on a student, a group of students, or the teacher; focused on a certain phase or activity of the lesson).
- Students should be informed that an observer is in the class and why the observation takes place.
- The observation should last no longer than an hour as it needs intensive concentration. Use an observation sheet:

Location: Time: Observed person: Observer:	
Observations (What do I see and hear?)	**Interpretations/reflections** (What are my thoughts, interpretations, and suggestions?)

- If there is time, interpretations/reflections can be added during the observation. Shortly after the observation the observer reads the write-up and adds reflections etc.
- A feedback meeting with the observed person helps for mutual learning. *Keep in mind: The observer is not the evaluator of the observed.*
- Steps of feedback:

1. The observer informs the observed person about what he/she saw and heard (the left column of the observation sheet)
2. The observed person reacts and mentions reflections and interpretations.
3. The observer offers his/her interpretations und reflections (right column of the observation sheet)
4. Further steps and consequences are discussed.

Analytical Discourse

Steps

1. Basic information on the issue by the person who wants to analyze a situation (10 – 15 minutes)
2. Participants ask questions to gain a comprehensive and consistent impression of the situation (approx. 20 minutes).

   Rules:

   Only questions,

   No critical comments,

   No suggestions

   Mainly three types of questions are suitable:
   * *concretion of remarks* (i.e. to give an example or provide more details)
   * *underlying theories* (i.e. to give reasons for any action described)
   * *expansion of the system* (i.e. to give more information about people or events who may be related to the problem but have not so far been mentioned)

3. All participants may give comments, share reflections etc. (no question rule anymore) (approx. 5 to 10 minutes)

Facilitation

Someone in the group (or an outsider) should moderate the analytical discourse. He or she is also allowed to ask questions.

SWOT-Analysis

The SWOT-Analysis is a simple method to gain information/assessment/estimation from individuals and groups who are involved in an initiative, project, organization etc.

The SWOT-Analysis has four elements

- Strengths
- Weaknesses
- Opportunities
- Threats/risks

Those who participate at a SWOT-Analysis have to be involved in the project or know enough about it.

Steps:

- Choose a project, initiative ….
- Write answers in the four boxes

Strengths	**Weaknesses**
Opportunities	**Threats/Risks**

- Compare and discuss answers in a group (in case of more than one participant)
- Based on the data/analysis draw consequences for the project

Sociometry

Purpose of the method:

Identify differences and similarities in a group by means of self-positioning and group-reflection. The method is used for data collection.

Time required 30 to 60 minutes, depending on group size and number of questions

What is sociometry?

Sociometry is a method in empirical social research founded by Jakob Moreno in the 1930s. It is useful for the open analysis of relationships between members of a group in a so-called sociomatrix. Based on a question, group members position themselves in the room along their own answers. The visible individual positions that ensue highlights similarities as well as differences within the group directly, in a way that is visible and tangible. It provides information about the composition of group-members and enables a reflection of one's own position.

How does it work?

Sociometry starts with informing the participants that the researcher/facilitator will ask several questions. The researchers/facilitators stress that participants should answer these as they feel today (answers may look differently tomorrow).

Then the facilitator asks their first question. This may be something like: "What is the age distribution in this group? Please form a line according to your age, the oldest person stands on the left side of the room, the youngest at the end of the row to the right." The task of the group members now is to communicate with each other and form a row according to their age. Further questions can be adapted according to research context. Some questions may be answered with a yes/no line-up. For some questions, we recommend clouds of interest/affiliation (e.g. what are my preferred teaching formats in science education?)

After each question posed by the facilitator, time should be taken for its resolution and possible discussion in the group. The group members are invited to explain why they are standing where they stand. Some questions might touch social taboos of the specific group (according to context these might be income, religious affiliations etc.) Here it is advisable to discuss the meaning of the question in the group. After some questions from the facilitator, I recommend giving the group members the space to formulate their own questions to the group and have them set up. At the end of sociometry exercise there should be a general reflection of the method and its outcomes with all participants.

What is sociometry good for? What can the method do?

The method reveals instantaneous differences and similarities in a group based on self-positioning and provides an opportunity to reflect on it together.

Investigating practices and practice architectures

Elements of practices	**Practice architectures**
Project	*Practice landscape*
What do participants (including myself) say they are doing, or intend to do, or have done?	How do different participants (and other involved or affected) interact with different people or objects?
Sayings (Communication)	*Cultural-discursive arrangements*
What do different participants say in the practice as they do it (what language is used, especially specialized language)?	Where does this language or specialist discourse come from?
What ideas are most important to different participants?	
Doings (activities)	*Material-economic arrangements*
What are participants doing?	What physical spaces are being occupied?
Are there sequences or connections between activities?	Are particular kinds of set-ups or objects involved?
Are ends or outcomes being achieved?	What material and financial resources are involved?
Relatings	*Social-political arrangements*
How do participants (and others involved or affected) relate to one another?	What social and administrative systems of roles, responsibilities, functions, obligations, and reporting relationships enable and constrain relationships in the project?
Are there systems of positions, roles or functions? Are relationships of power involved?	Do people collaborate of compete? Is there resistance, conflict or contestation?
Who is included and excluded from what?	
Are there relationships of solidarity and belonging (shared purposes)?	
Dispositions (habitus)	*Practice traditions*
Understandings: How do participants understand what is happening?	What do our observations tell us about practice traditions in the sense of "the way we do things around here"?
Skills: What skills and capacities are participants using?	Is there evidence of professional practice traditions – like following an inquiry approach in science teaching – and do these enable or constrain what participants hope to achieve?
Values: What are participants' values, commitments and norms relevant to the practice?	

Based on Kemmis, S., Mc Taggart, R. & Nixon, R. (2014). *The action research planner*. Singapore: Springer, p. 81f.

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An exemplary timetable of an action research

Cycle	Week/Activity	Monitoring	Duration	Comments
1	1 Clarifying general idea 2 3 Recon-naissance 4	Class 4T: keep diary for all lessons. Tape-record in one lesson per week, and collect examples of written work and assignment cards for these lessons	One lesson per week (with exception of keeping diary)	Team meeting
	5 General plan 6	Diary (4T)		Write an analytic memo and begin to formulate plan
	7 Half term break			Write first draft of general plan
	8 General plan	Diary (4 T)		Discuss general plan at team meeting
	9 Develop action 10 Steps 1			Write time table for monitoring in weeks 11-14
	11 12 Implement action steps 1 13 14	Diary (4T) (+ techniques selected at weeks 9-10)	Two lessons per week One lesson per week	Study evidence collected Write analytic memo to share at team meeting
	15 16 17	Write case study (3.000 words maximum + case record for team meeting in week 1 next term		
2	18 ….			

Based on Elliot, J., (1991). *Action research for educational change*. Milton Keynes: Open University Press, p. 85ff.

Who can help me?

1. Are there individuals or organizations in my district or community who are already working to research and innovate science teaching in my domain? If so, what are they doing? Is it working? What can I do to help them?

   ____

   ____

   ____

2. Are there teachers in my school who are passionate about seeing an increase in the quality of science education? If so, what steps have they taken to make this reality?

   ____

   ____

   ____

3. Is the principal of my school supportive of science education? What do I expect him/her to do to support my initiative?

   ____

   ____

   ____

4. Are there any external partners (industry, small and medium size enterprises, public sector, non-formal education providers) that support science education?

   ____

   ____

   ____

5. Are there any school-based groups that do fundraising work for education in my school or district? Are there parents with relevant science and technology related professions that also want to increase science education in my school/district?

   ____

   ____

   ____

Make a list of any such individuals, organizations or businesses on the backside of this sheet!

My action research network

Reflect on who should be involved and who can help in your action research. Consider students, colleagues, advisors (e.g. from the academia or institutes of education), or external partners (e.g. from non-formal learning providers, societal groups, or business). Describe the purpose and potential contribution to the action research.

Students

Purpose, contribution:

Names:

Colleagues

Purpose, contribution:

Names:

ME

Advisors

Purpose, contribution:

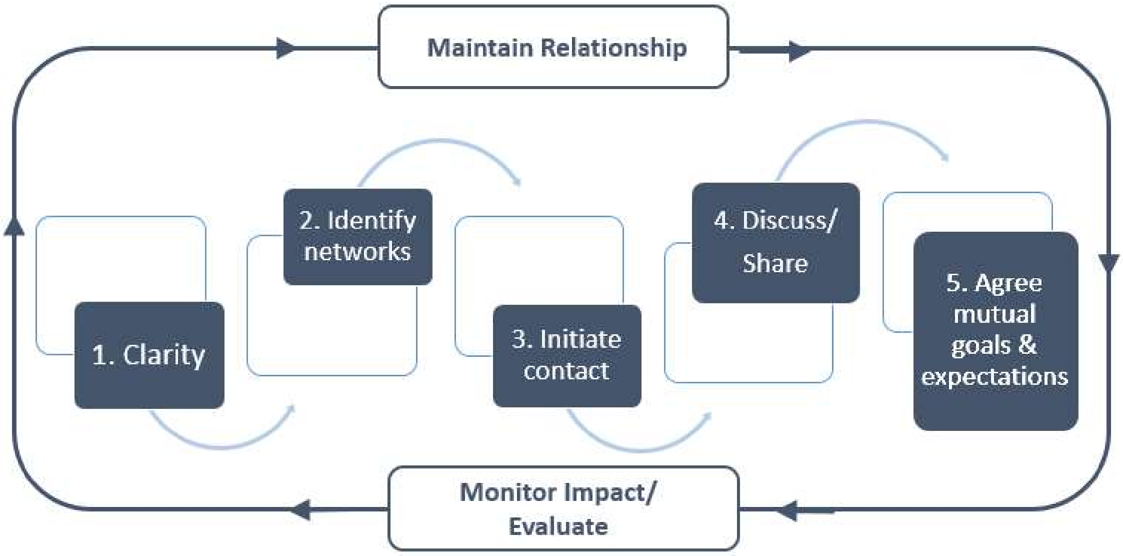
Names:

External partners

Purpose, contribution:

Names:

Networking: Step by step



Step 1: Clarity

- ❑ Able to articulate benefits to company (inspire future workforce, boost staff morale and improve staff communication skills, corporate social responsibility…)
- ❑ Clear about what are we asking for? Time, expertise, access to staff…
- ❑ Have identified potential concerns (lack of time…)

Step 2: Identify Networks

- ❑ What are the main STEM related industries in your locality?
- ❑ What partnerships are already in place or not?
- ❑ What information is available on STEM related careers?
- ❑ What proportion of pupils move into STEM related careers?

Step 3: Initiate Contact

- ❑ Find out who is the person to contact
- ❑ Do I know someone who could make an introduction
- ❑ Cold call

Step 4: Discuss/Share

- ❑ Describe/Explain the ARTIST project
- ❑ Listen to challenges or concerns
- ❑ Have a flexible approach

Step 5: Agree mutual goals and expectations

- ❑ When will the partnership start
- ❑ When will it end? Duration?
- ❑ How much time commitment is expected weekly/monthly?

Maintaining and strengthening partnerships

- ❑ Acknowledge effort / joint successes
- ❑ Schedule follow-up meetings. Check-in with partners regularly
- ❑ Keep alert for changes (e.g. company expansion/down-sizing/restructuring) that may affect plans
- ❑ Remind networks of mutual goals to stay on track

Monitor/Evaluate Impact

- ❑ Decide what the intended outcome/impact of ARTIST network should be
- ❑ What are the key performance indicators?
- ❑ What tools will we use to measure impact?

Who might be interested in my action and research?

The results of my research might be interesting …

for ____________________	Interest: Because:
for ____________________	Interest: Because:
for ____________________	Interest: Because:
for ____________________	Interest: Because:
for ____________________	Interest: Because:
for ____________________	Interest: Because:

Ways to disseminate my action research

	Appropriate	Interested	Done
Meetings with colleagues from my school			
Handouts/materials for colleagues from my school			
Local or regional teacher networks			
Regional or national teacher conference			
School website			
National science teacher journal			
Online collection of teaching strategies and materials			
Printed collection of teaching strategies and materials			
International science teacher journal or research journal			

Reflecting on media for my publication

Publication types in science education

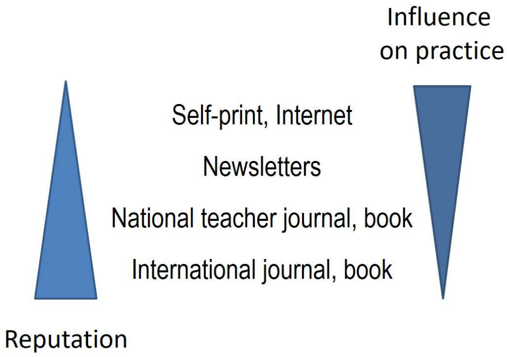
- Articles in international journals
- Articles in national teacher journals
- Chapter in books (national or international)
- Monograph
- Collection of teaching materials
- Self-prints
- Internet

What do I have to offer?

- Empirical research findings
- Report on the development of an innovation
- Report on teacher learning processes/professional development
- Description of an innovation or changed teaching strategy
- Teaching materials/media

Do I want to influence practice or raise my own reputation?

- Research journal vs. practice publication
- Availability (access, spread, acknowledgment, …)
- Reputation
- Formal quality criteria (peer-review, international publisher, etc.)
- Time to publication



5. Selected figures to be used in science education action research workshops

Ingo Eilks and Franz Rauch

Overview

A model to reflect potential fields for action research to innovate science education

Area: Readiness / preparedness for teaching
- Pedagogical, scientific and socio-cultural competence
- Familiarity with the curriculum and awareness of relationship of the lesson to the curriculum
- Awareness of learning processes and teaching methodologies

Area: Planning and preparation
- Whole-school planning and provision of resources
- Whole-school planning for the subject
- The teacher's long-term planning
- The teacher's short-term planning

Area: Management of classroom learning
- General learning environment
- Lesson content and learning context
- Pedagogy and methodology
- Use of practical work, models, vizualization and language
- Monitoring and assessment of student progress

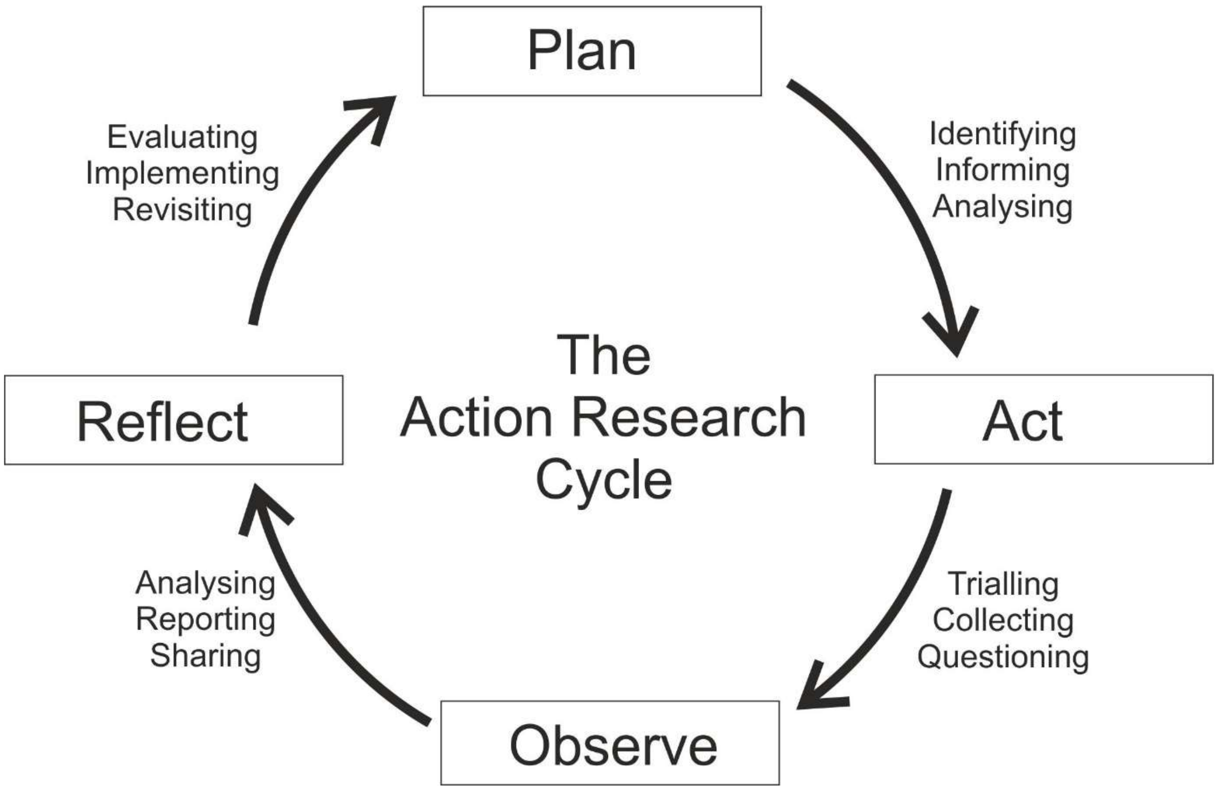
Area: Student learning and achievement
- Student engagement in learning
- Student ability to assess own progress and to reflect on learning
- Student learning progress and skills devlopment

Adopted from European Network of Policy-Makers for the Evaluation of Educational Systems (w.y.). Evaluation of Foreign Languages at Upper Secondary Level (EFLUSL) - EFLUSL quality indicators.

Classroom research, teacher research, and action research in science education

	Classroom research	Teacher research	Action research
Takes place in an authentic science teaching practice where students and teachers come together for learning science	X	X	X
Is operated either by a teacher or under strong involvement of the corresponding science teacher		X	X
Intends to change something. Applies a clear and cyclical strategy of change, data collection, evaluation and reflection			X

A model of the action research cycle



A comparison of formal (traditional) research with action research

Topic	*Formal research*	*Action research*
Training needed by researcher	Extensive	On own or with consultation
Goals of research	Knowledge that is generalizable	Knowledge applicable to the local situation
Method of identifying the problem to be studied	Review of previous research	Problems or goals currently faced
Procedure of literature review	Extensive using primary sources	More cursory, using secondary sources
Sampling approach	Random or representative sampling	Students or clients with whom they work
Research design	Rigorous control, long time frame	Looser procedures, change during study; quick time frame; control through triangulation
Measurement procedures	Evaluate and pretest measures	Convenient measures or standardized tests
Data analysis	Statistical tests, qualitative techniques	Focus on practical, not statistical significance, present raw data
Application of results	Emphasis on theoretical significance	Emphasis on practical significance

From Classroom action research. www.seameo-innotech.org/iknow/wp-content/uploads/2014/03/COMPETE-21.-Classroom-action-research.pdf.

Research paradigms in educational research and their characteristics

(post-)Positivism

- *Deterministic*
- *Reductionistic*
- *Empirical observation and measurement*

Aim: Theory verification

Constructivism

- *Understanding by interpretation*
- *Multiple meanings*
- *Social and historical (re)-construction*

Aim: Theory generation

Pragmatism

- *Consequences of action*
- *Problem-centred*
- *Pluralistic*
- *Real-world oriented*

Aim: Change

Criticality (Advocacy/Participatory)

- *Political*
- *Empowerment*
- *Issue-oriented*
- *Collaborative*

Aim: Emancipation

Inspired by J. W. Creswell (2003). *Research design*. Thousand Oaks: Sage.

Modes of action research inspired by S. Grundy and illustrated by quotes from J. Masters

Technical action research	Practical (or collaborative/ participatory/interactive) action research	Emancipatory (or teacher-centered) action research
"The underlying goal of the researcher in this approach is to test a particular intervention based on a pre-specified theoretical framework, the nature of the collaboration between the researcher and the practitioner is technical and facilitatory. The researcher identifies the problem and a specific intervention, then the practitioner is involved and they agree to facilitate with the implementation of the intervention."	*"In this type of action research project the researcher and practitioner come together to identify potential problems, their causes and potential interventions. The problem is defined after dialogue with the researcher and the practitioner and a mutual understanding is reached."*	*"Emancipatory action research promotes emancipatory praxis in the participating practitioner, that is, it promotes a critical consciousness which exhibits itself in a political as well as practical action to change. […] This mode of emancipatory action research does not begin with the theory and ends with practice, but is informed by theory and often it is confrontation with the theory that provides the initiative to undertake the practice. […] The dynamic relationship between theory and practice in emancipatory action research entails the expansion of both theory and practice during the project."*

- Grundy, S. (1982). Three modes of action research. *Curriculum Perspectives*, 2(3), 23–34.
- Masters, J. (1995). The history of action research. In I. Hughes (Ed.), Action research electronic reader. Sidney: The University of Sidney. Retrieved from www.docstoc.com/docs/2187576/THEHISTORY-OF-ACTION-RESEARCH.

From Mamlok-Naaman, R., & Eilks, I. (2012). Action research to promote chemistry teachers' professional development – Cases and experiences from Israel and Germany. International Journal of Mathematics and Science Education, 10 (3), 581-610.

Modes of action research and its reflection in terms of interest and power

"Technical action research serves the interests of exercising greater control over human behaviour to produce the desired outcomes;

practical action research serves the interests of practical wisdom in discerning the right course of action in particular circumstances;

critical [emancipatory] action research serves the interests of emancipating people from oppression."

Elliott, J. (2005). Becoming critical: the failure to connect. Educational Action Research, 13, 359-374.

"The differences in the relationship between the participants and the source and scope of the guiding 'idea' can be traced to the question of power.

In technical action research it is the 'idea' which is the source of power for action and since the 'idea' often resides with the facilitator, it is the facilitator who controls power in the project.

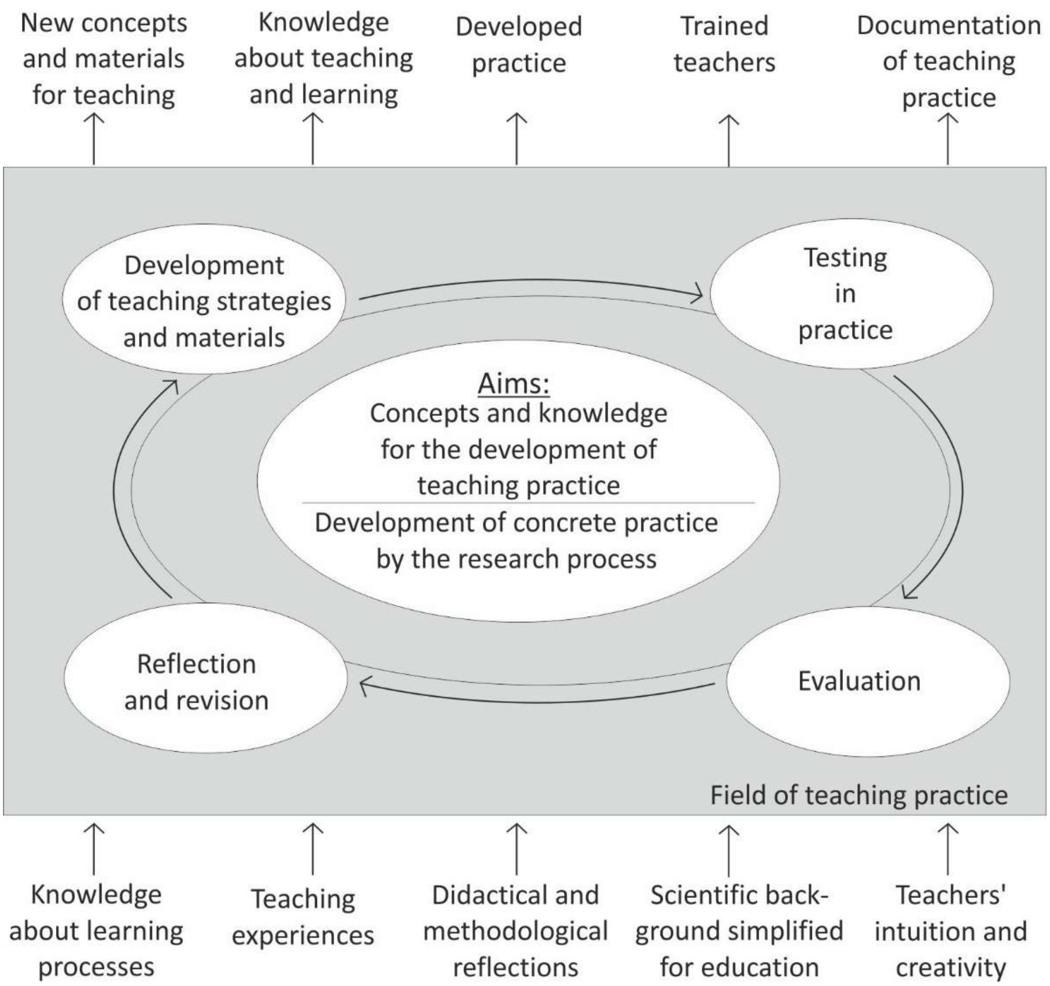
In practical action research the power is shared between groups of equal participants, but the emphasis is upon individual power of action.

Power in emancipatory action research resides wholly within the group, not with the facilitator and not with individuals within the group.

It is often the change in power relationships within a group that causes a shift from one mode to another."

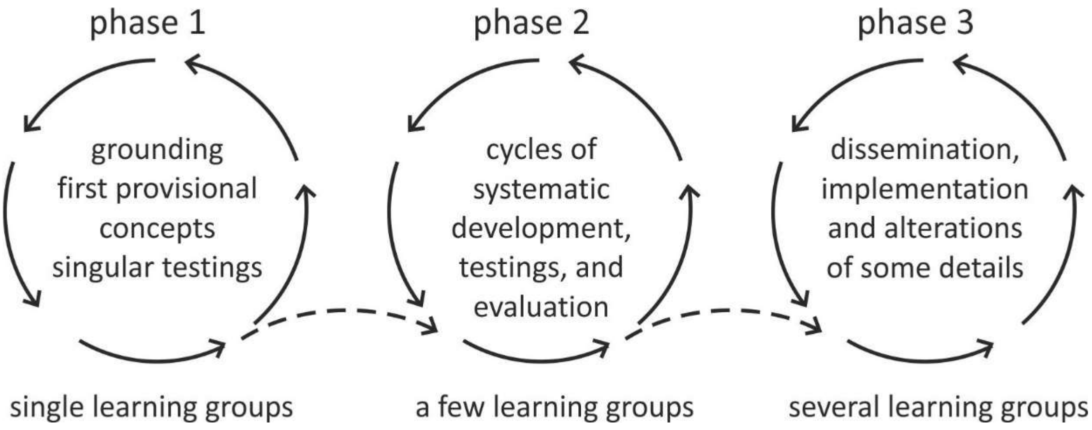
Grundy, S. (1982). Three modes of action research. *Curriculum Perspectives*, 2(3), 23–34.

A model of participatory action research in science education



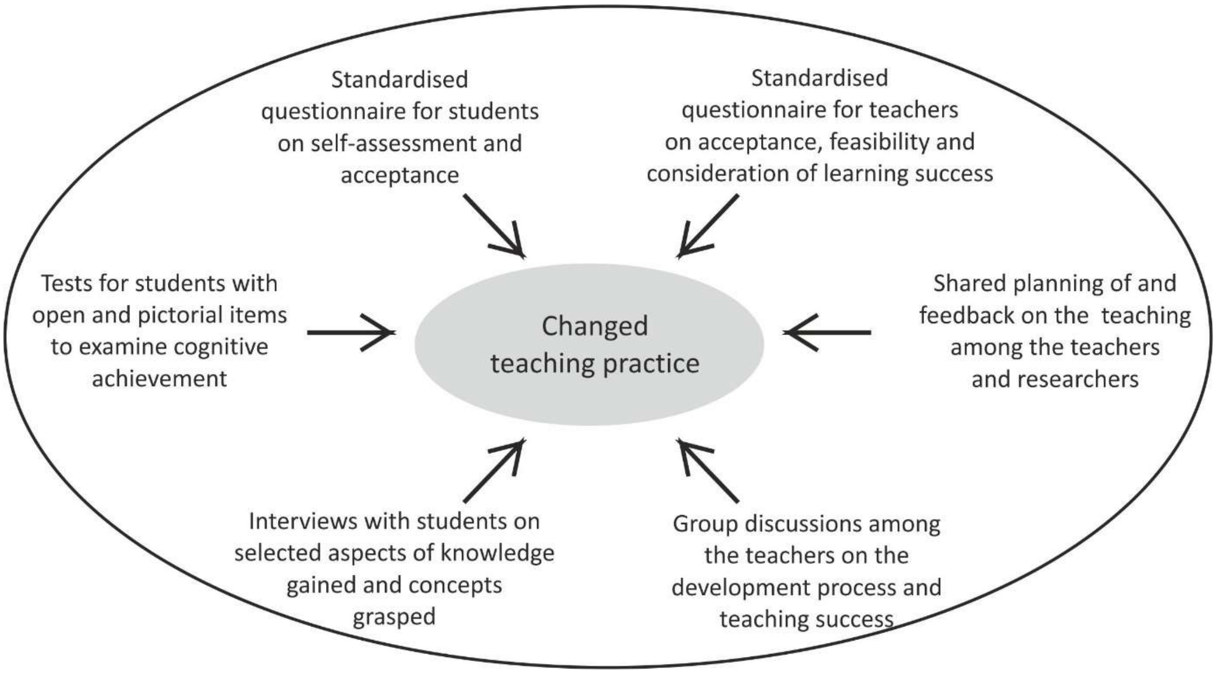
From Eilks, I., & Ralle, B. (2002). Participatory Action Research in chemical education. In B. Ralle & I. Eilks (Eds.). *Research in Chemical Education - What does this mean?* (pp. 87-98). Aachen: Shaker.

A potential model for upscaling action research based innovations



From Eilks, I., & Ralle, B. (2002). Participatory Action Research in chemical education. In B. Ralle & I. Eilks (Eds.). *Research in Chemical Education - What does this mean?* (pp. 87-98). Aachen: Shaker.

Potential views of evaluation in classroom-based action research for innovations in the curriculum and pedagogy



From Eilks, I., & Ralle, B. (2002). Participatory Action Research in chemical education. In B. Ralle & I. Eilks (Eds.), *Research in Chemical Education - What does this mean?* (pp. 87-98). Aachen: Shaker.

Potential roles of teacher researchers and external researchers in action research

Teacher researcher	External researcher
• Initiation of action research motivated by experience • Analysis of the literature in comparison to classroom experience • Structuring new strategies and concepts • Application of new strategies and concepts • Data collection • Evaluation of data • Joint reflection and negotiating of further change	• Initiation of action research motivated by prior research • Co-ordination and support of the teacher research • Providing relevant literature and information access • Providing access to already existing strategies and concepts • Support in keeping ethical measures and maintaining standards for handling research data • Methodological training and support in evaluation of data • Joint reflection and negotiating of further change • Support in dissemination and publication of the action research findings

Inspired by Eilks, I., & Ralle, B. (2002). Participatory Action Research in chemical education. In B. Ralle & I. Eilks (Eds.), *Research in Chemical Education - What does this mean?* (pp. 87-98). Aachen: Shaker.

6. Exemplary action research sketches from ARTIST and beyond

Compilation by Ingo Eilks

Cases to be used for inspiration in seminars when looking for a research question:

Spaces for self-directed learning and decision-making by students in a project on forests

Done by

Franz Rauch, Klagenfurt, Austria

Field of practice

Lower secondary biology education, grade 9

Research interest

General aim:
How can students be better prepared to live in a complex and contradictory world? How can students be prepared to take the initiative and shape their local environment?

Specific research question: How do students react when given space for more self-directed learning and decision-making?

Action

- Project on forests for two month
- Excursion in a school nearby with a ranger organized by the teacher
- Students work in three thematic groups chosen by the students: (1) plants in the forest; (2) Dying of forests (air pollution); (3) Rainforest in South America
- Students inquire about the topics in groups: searching and analyzing materials; interviewing experts
- Students write reports, present them and reflect on the results and processes

Data used

- Research diary by the teacher
- Observation of students made by the teacher
- Interviews of students after the project by the teacher
- Observation of students made by another teacher (critical friend)
- Analysis of students' reports

Gained knowledge

The teacher successfully offered the students space for decision-making and self-directed learning. The students took this opportunity and were able to make decisions even better than the teacher expected.

Offering space for decision-making does not mean to leave students alone. The students struggled sometimes to deal with the complexity of the topic and the materials.

References

Rauch, F. (2000). Schools – A place for ecological learning. *Environmental Education Research*, 6 (3), 245-258.

A self-study of the use of interactive historical vignettes enhanced with concept cartoons in teaching the nature of science

Done by

Manolya Yücel Dağ & Mehmet Fatih Taşar, Ankara, Turkey

Field of practice

Middle school 5th grade students

Research interest

I designed this research study involving classroom implementations of interactive historical vignettes (IHV) enhanced with concept cartoons to develop 5th grade students' understandings of the nature of science.

Action

I conducted a research to reveal how I implemented culturally relevant IHVs in my classroom through by adapting a self-study method.

View into the data or action

	Action
Before classroom implementations	Writing life stories
	Preparing journals and implementing the questionnaires (pre-test)
Classroom implementation process	IHV 1: Bin Bilimli Ahmet Çelebi IHV 2: Kuşçu Ali'nin Ay Sevdası IHV 3: Ömer Hayyam Gökyüzünü İzliyor IHV 4: Koca İnsan Kocasinan IHV 5: Ak Dede Akşemseddin
After classroom implementations	Implementing the questionnaires (post-test)
	Analyzing my collected data through the narrative analysis technique

Data used

- IHV documents
- Video recordings
- Questionnaires
- Journals
- E-mail together with life stories
- Peer reviews
- Photographs

Gained knowledge

The findings revealed the importance of the presence of the teacher as a researcher during classroom implementations of IHVs while teaching the nature of science. I observed that I was reflecting my experiences, values, and beliefs in my classroom practices and they effected my communication with my students. Through this self-study, I found an opportunity to get to know myself better as a teacher. I was urged to change some of my characteristics as a result of this experience of self-discovery. This self-study, which has shed light on my personal life, can be seen as a step towards other teachers' self-discovery.

References

Yücel Dağ, M. (2015). *A self-study of the use of interactive historical vignettes enhanced with concept cartoons in teaching of the nature of science* (Doctoral thesis). Gazi University, Ankara Turkey.

Applying a POE teaching strategy sequence in teaching floating and sinking with regard to students' alternative conceptions

Done by

Jumana Hasan and Aya Sabah, Rene village, Israel, and Fadeel Joubran, Haifa, Israel

Field of practice

Physics teaching in middle school

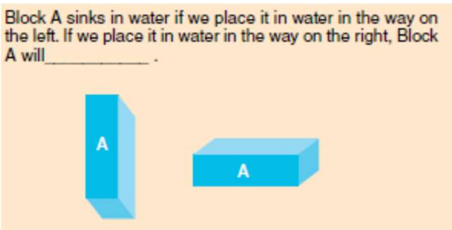
Research interest

Recovering alternative conceptions of 8th grade students in "Floating and Sinking". Understanding the influence of applying POE strategy in teaching Sinking and Floating" on student alternative conceptions.

Action

An active learning sequences based on POE strategy was developed and implemented in teaching "Floating and sinking" in the 8th grade.

View into the data or action



Applying ten questions test aimed at discovering alternative conceptions in "Sinking and Floating" – Pre-test

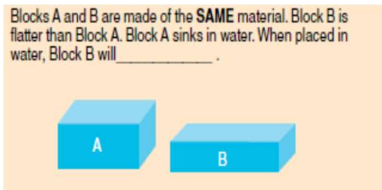
Name:-----------

Subject:----------

Predict before POE demonstration:------

Filling POE worksheet (5-7 cycles with stage no. 3)

Teaching "Sinking and Floating" with POE strategy. (5-7 cycles with stage no. 4)



Applying ten questions test aimed at discovering alternative conceptions around "Sinking and Floating" – Post-test

Data used

- Feedback questionnaires
- Feedback POE sheets
- Interviews

Gained knowledge

Reducing alternative conceptions. Students have a better understanding regarding natural phenomena. The POE strategy contributes to make the learning-teaching more active.

Implementing phosphate recovery in formal and non-formal chemistry learning

Done by

Christian Zowada, Antje Siol & Ingo Eilks, Bremen, Germany

Field of practice

Secondary and vocational formal and non-formal chemistry learning in grade 10

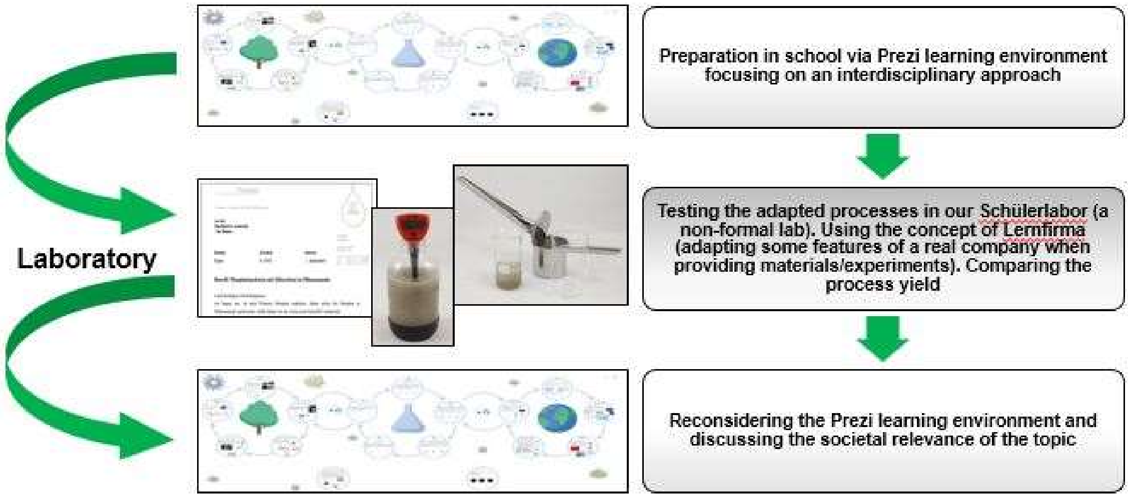
Research interest

Implementing phosphate recovery as an example of applied environmental technology into secondary and vocational education. Understanding how non-formal learning in this case can be supported by digital media learning

Action

A non-formal learning environment was developed and implemented dealing with modern technologies for phosphate recycling. The implementation was framed by a digital learning environment based on PREZI technology.

View into the data or action



Data used

- Classroom observation
- Feedback questionnaires

Gained knowledge

A non-formal learning environment was developed based on PREZI technology can be highly supportive in preparing a class visit to a non-formal learning place. It helps to frame experimental learning with necessary content and contextualization.

References

Gulacar, O., Zowada, C., & Eilks, I. (2018). Bridging chemistry learning back to life and society. In I. Eilks, S. Markic & B. Ralle (Eds.), *Building bridges across disciplines for transformative education and sustainability* (pp. 49-60). Aachen: Shaker.

Improving student's understanding and perception of cell structure and function using laboratory activities, computer video and paste models

Done by

Riam Abu Mokh, Haifa-Israel

Field of practice

Secondary school science, grade 8

Research interest

Encourage teachers to make a difference. Research aims to improve the student's perception of the cell structure by:

- Checking out the current situation
- Applying different teaching modes
- Checking out the situation after applying the new method for teaching

Action

Developed alternative teaching modes based on laboratory activities, computer videos, paste models and competitions. The competitions between students were created around different activities like developing bezels and game cards.

View into the data or action

Pre-Test based on frontal teaching

Innovation and various means to reflect the scientific facts based on lab activities, paste models and video simulations

New teaching method rather than Frontal learning

Data used

- Questionnaire includes several questions regarding different concepts about the cell. It was distributed twice, first, after teaching by conventional frontal method, and second, after applying the alternative method.
- Observation

Gained knowledge

There was a need to change the teaching mode from frontal teaching to more "reactive" teaching. This "reactive" teaching mode engages the students and give them the opportunity to plan, discover and draw conclusions more palpably.

Inquiry based learning in physics

Done by

Marika Garsevanishvili, Sofio Kharchilava, Tamta Makhatadze & Marika Kapanadze, Tbilisi, Georgia

Field of practice

Secondary school students

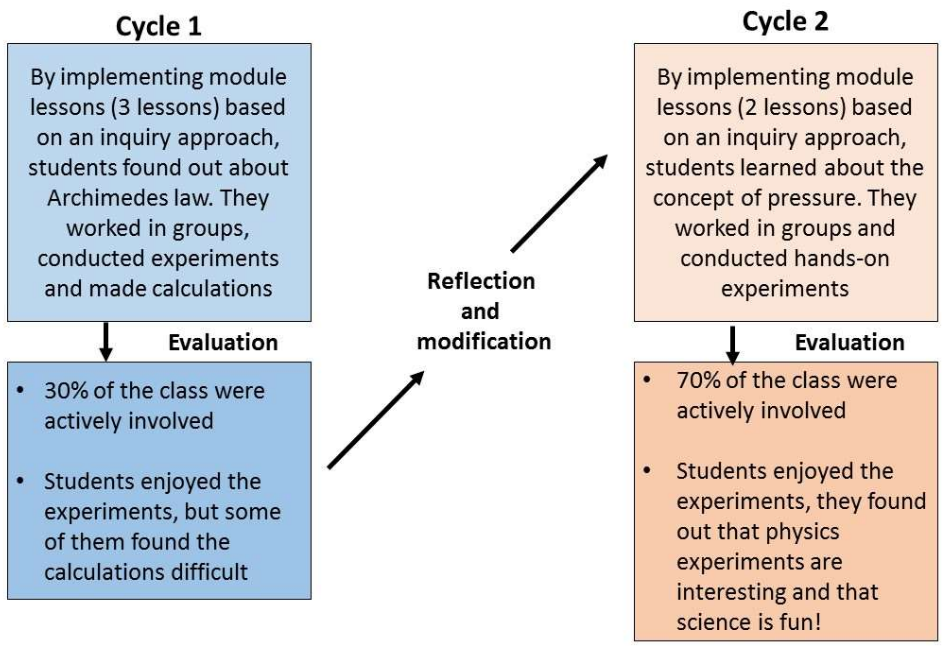
Research interest

Implementing Inquiry-Based Learning (IBL) in physics and identifying the changes in students' motivation. Understanding the influence of hands-on experiments in changing the attitudes of students towards Physics.

Action

Set of different hands-on experiments were developed. Lesson modules based on an inquiry approach were planned and implemented at secondary level.

View into the data or action



Data used

- Focus group discussions
- Classroom observation
- Motivation questionnaire

Gained knowledge

Students enjoyed lessons with hands-on experiments. They stressed their interest in inquiry. Areas of change needed in the teaching approach were identified. Lesson modules should be planned using an inquiry approach and hands-on experiments.

ARTiST
Action Research To Innovate Science Teaching

Interactive lecture demonstration and inquiry-based instruction in addressing students' misconceptions in electric circuits

Done by

Mark Anthony Casimiro, Cornelia C. Sotto and Ivan B. Culaba, Manila, Philippines

Field of practice

Secondary school

Research interest

Which is more effective in addressing the misconceptions in electric circuits of junior high school students: the interactive lecture demonstrations (ILD) or the inquiry-based instruction (IBI)?

Action

Two classes composed of randomly selected grade 9 students were taught about electric circuits. In one class the IBI approach was used while in the other class the ILD approach was used.

View into the data or action

Determining misconceptions in electric circuits from previous studies → Designing of different learning activities ↓ Administering the pre-test → Executing the different approaches (ILD and IBI) ↓ Conducting interviews (before, during and after the intervention) → Administering the post-test ↓ Analyzing and comparing the results of the pre- and post-test of the two groups as well as the responses in the interviews → Suggestions and recommendations for further studies

Data used

Pre-test and post test results, mean percentage gain, interview of students and teachers, focus group discussions...

Gained knowledge

- Both the ILD and IBI approaches resulted in a positive conceptual change in the students' understanding of electric circuits, although the IBI group had a higher average post-test score
- With the ILD approach, classroom and time management is easier to handle and does not require multiple set-ups but students have no hands-on experience. It is more adoptable to small classrooms with many students.
- In the IBI approach, students have hands-on experience and enhanced collaborative work but it is difficult to manage time and supervision in large classes in small classrooms.
- In theory, IBI and ILD are both effective methods of teaching but in practice the local classroom environment and availability of equipment have to be taken into consideration.

The influence of teaching methods on the understanding of ninth grade students of basic concepts in chemistry

Done by

Hekmat Abo Saleh and Naim Najami, Haifa, Israel

Field of practice

Secondary science education, basic concepts in chemistry for 9th grade

Research interest

Improving the teaching process of basic concepts in chemistry

View into the action

Students practicing the methods from the research

Action

Checking the existing situation - interviews with students

Definition of difficulties - by analyzing the interviews

Learning through games, collaborative learning, laboratory experimentation

A class post-test after completing the subject, re-interviewing

Conclusions - After analyzing the interviews

Data used

- Interviews with students
- Feedback questionnaires

Gained knowledge

New insights regarding teaching to improve and promote the classroom instruction

Reflective study has its own value and is indeed beneficial to the teachers' work

Incorporating industry links in to a career orientation program for secondary school pupils

Done by

Aimee Stapleton, Martin McHugh, Laurie Ryan, Peter Childs & Sarah Hayes, Limerick, Ireland

Field of practice

Career orientation for secondary school students, aged 15-16 years

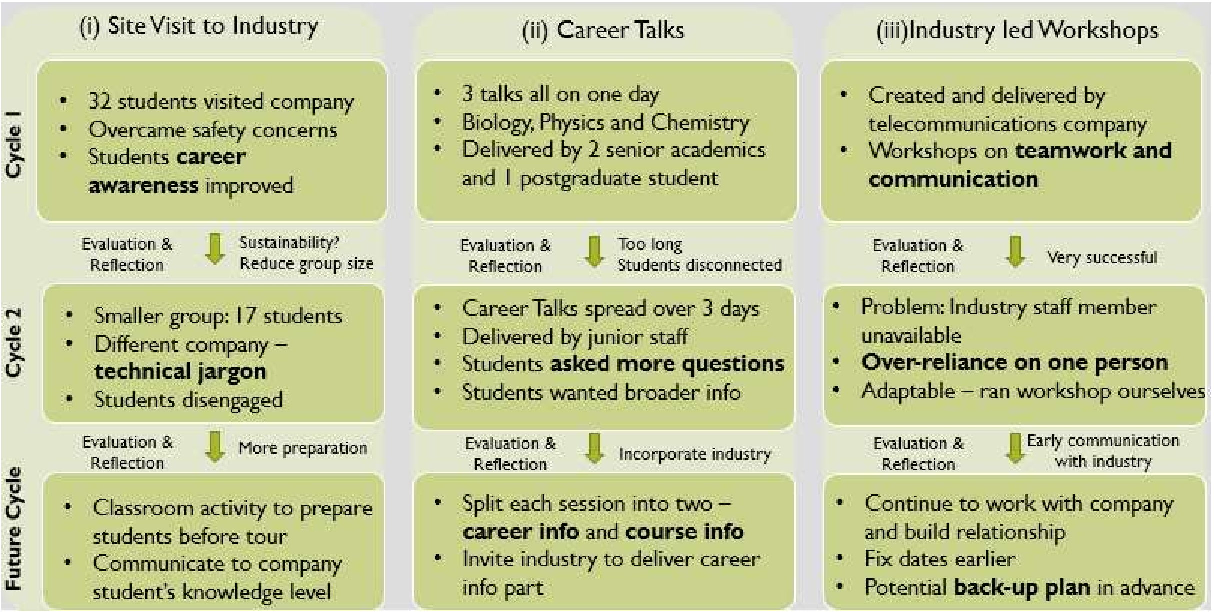
Research interest

Promoting and raising the awareness of careers and third-level courses in science among students. Running a dedicated weeklong programme with as many links to industry as possible.

Action

Development of a career-orientation week that involves (i) a site tour to industry, (ii) career talks and (iii) an industry-led workshop. Adjusting each element consecutively during two action research cycles.

View into the data or action



Data used

- Feedback questionnaires
- Draw a Scientist Test: Before and after the program, students were asked to draw and label a picture of a scientist at work

Gained knowledge

Networking with industry is very similar to networking with academic/education professionals. Although industry not familiar with the term "action research", they are very familiar with the concept of cyclical improvements in their own practice.

Increasing students' motivation in studying the module of "Reproductive Systems" applying the problem-based learning (PBL) towards life sciences

Done by

Rusudan Khukhunaishvili, Marina Koridze & Zhana Chitanava, Batumi, Georgia

Field of practice

Secondary school biology students

Research interest

Applying PBL methods to the learning of biology modules. Increasing students' motivation towards the study of Life Sciences. Using science commercialization opportunities to promote the learning process and establish the culture among students of gaining knowledge, as well as promoting healthy lifestyles.

Action

Formulation of the problem; finding ways of resolving the problem; lab work; practice skills that students will need in future.

Views into data or action

Cycle 1	Reflection – Cycle 2	Reflection – Cycle 3
The lesson process on the reproductive system; Discussion on the topic: Infertility - the result, the problem or the verdict. Discuss the problem statement and list its significant parts. Selection of target groups of students considering the focused observation and gender equality.	The photo session "we are the future parents"; Visit to the artificial insemination clinic; Role-playing games; Interview with specialists; Observation: counting and sorting genital cells, sperm injection and cryo-conservation.	Lesson module; Practical activity - microscopic observation on ready-made drugs. Short presentations and discussion.
Evaluation	**Evaluation**	**Evaluation**
60% of the class is less involved in the process, avoiding their opinion on the issue; Less understanding of infertility mechanisms and problems.	High interest in finding new information, ethical issues of artificial insemination. Developing communication skills	90% of students were actively involved in the process; feel that do not know enough to solve the problem but that is the challenge;

Data used

Focus group discussions
Motivation questionnaire
Classroom observation
Feedback questionnaires

Gained knowledge

Develop critical thinking and problem solving, collaboration skills, information retrieval and evaluation skills. Students acquired new knowledge and were interested in other challenges in life sciences.

Gamified science instruction in a reformatory classroom setting

Done by

Analyn Tolentino & Lydia Roleda, Manila, The Philippines

Field of practice

Secondary science education

Research interest

Exploring the effects of gamifying science instruction in terms of student achievement and student motivation; examining the students' and teachers' lived experiences on gamified science instruction

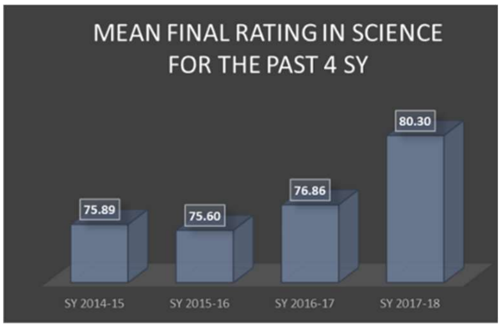
Action

The elements of gamification such as points, badges, leaderboards, storyline, rules and levels, were incorporated into science instruction.

View into the data or action

Paired Sample Test Between Pre- and Post-Gamification Responses to Science Motivation Questionnaire (SMQII)

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Pre_Gamification Post_Gamification	.60187	.70795	.05941	-10.131	141	.000



Gamified science instruction

Data used

Responses to Motivation questionnaire
Assessment scores
Interview responses
Journal entries

Gained knowledge

Gamifying instruction is an effective approach towards increasing student achievement and motivation in science. Students had both positive and negative experiences on the gamified science instruction but the former outweighed the latter. Preparing for and implementing a gamified science instruction can be a demanding task for a teacher but its positive effect on student's attitude towards learning science are remarkable.

References

Tolentino, A. N., & Roleda, L. S. (2017). Learning physics the gamified way. Paper presented at the DLSU Research Congress 2017. xsite.dlsu.edu.ph/conferences/dlsu-research-congress-proceedings/2017/LLI/LLI-I-019.pdf.

The constructivist approach as a process for changing the misconceptions about the elements, compounds and mixtures at the microscopic and macroscopic level among eighth graders

Done by

Ahmad Basheer, Sakhnin, Israel, Ayshi Sindiani and Mahmood Sindiani, Nazareth, Israel

Field of practice

Chemistry teaching in Junior "A" High School

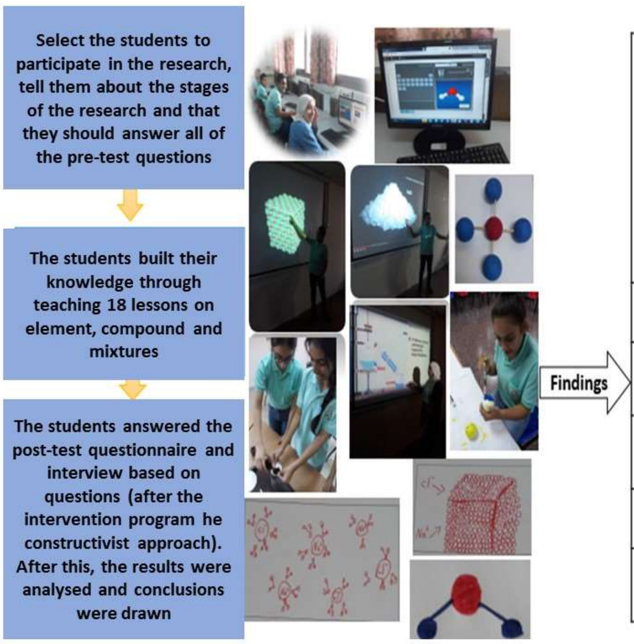
Research interest

Revealing alternative conceptions among 8th grade students of "elements, compounds and mixtures at the microscopic and macroscopic level"; understanding the influence of applying the constructivist approach strategy in teaching "elements, compounds and mixtures" on student alternative conceptions.

Action

An active learning sequences based on a constructivist approach (developing and implementing a self-directed learning scenario) was developed and implemented in teaching "elements, compounds and mixtures" in the 8th grade.

Views into data or action



Alternative conceptions	Percentage of students in eighth grade (%) before the intervention N = 29	Percentage of students in eighth grade (%) after the intervention N = 29
Only the element is pure matter	73.27	14.65
The properties of the compound are similar to those of its constituent elements	74.13	12.07
The properties of the material are similar to the properties of atoms built from them	75.86	22.99
All materials are made up of molecules	75.86	11.12
The physical properties of all materials in the mixture are similar	73.56	11.49

Data used

- Pre and Post-tests
- Interviews
- Classroom observation

Gained knowledge

- Reducing alternative conceptions.
- Students have a better understanding regarding the microscopic and macroscopic level.
- Constructivist approach contributes to more active learning and teaching.

Implementing open learning environments in a mathematics classroom

Done by

Eve (pseudonym), Austria; provided by Stefan Zehetmeier, Klagenfurt, Austria

Field of practice

Lower secondary mathematics education

Research interest

Eve had the goal of promoting open-learning settings by implementing new teaching approaches in her mathematics classes. She aimed to enhance pupils' self-directed and inquiry-based learning opportunities.

Eve's research question: "Are my pupils able to acquire mathematical knowledge by using self-directed learning settings?"

Action

Eve introduced open-learning environments and using working plans in her classes.

Thus, pupils could choose their individual working pace, task sequences and social forms. Moreover, pupils bore responsibility and control concerning their learning efforts.

Data used

Eve developed observation sheets to gather data regarding classroom activities. She kept a research diary in which to save personal experiences and thoughts. Furthermore, she prepared various tasks and conducted interviews with individual pupils to assess their mathematical learning progress. At the end of each semester, pupils were asked to complete a questionnaire concerning their learning and skill development, as well as their evaluation of the open-learning settings.

Gained knowledge

Eve's observations portrayed a picture of pupils with "eagerness, motivation, calmness, curiosity, and autonomy; however, also skepticism, uncertainty, and questions" (Eve's reflective paper, p. 20). Pupils gained positive achievements in the assessment tasks, which was "really surprising" for Eve: "All without exception were able to develop knowledge and skills in this self-directed and open-learning environment" (Eve' reflective paper, p. 21).

References

Zehetmeier, S. (2015). Sustaining and scaling up the impact of professional development programmes. *ZDM - The International Journal on Mathematics Education*, 47(1), 117–128.

Finding the right degree of student-centeredness in pedagogy when teaching chemical bonding in a Swiss vocational school

Done by

Ivano Laudonia, Chur, Switzerland, & Ingo Eilks, Bremen, Germany

Field of practice

Vocational school chemistry education

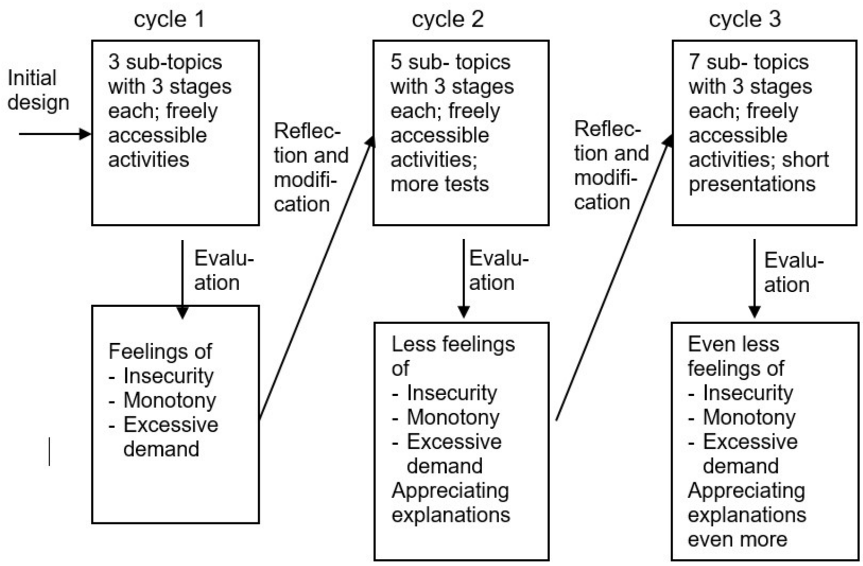
Research interest

Finding the right balance between teacher-centered and student-centered pedagogies when teaching chemical bonding in Swiss vocational education.

Action

Developing and implementing a self-directed learning scenario on chemical bonding. Consecutive adjusting the learning scenario and its related media in different action research cycles.

View into the data or action



Data used

- Feedback questionnaires
- Motivation questionnaire

Gained knowledge

Students in vocational education have a different view on student-centered pedagogies than reported from students in general education. Students ask for more guidance and teacher input before acknowledging and valuing student-centered learning scenarios.

References

Laudonia, I., & Eilks, I. (2018). Teacher-centred action research in a remote participatory environment - A reflection on a case of chemistry curriculum innovation in a Swiss vocational school. In J. Calder & J. Foletta (Eds.), *Participatory Action Research (PAR): Principles, approaches and applications* (pp. 215-231). Hauppage: Nova.

ARTiST
Action Research To Innovate Science Teaching

Innovating pre-service science teacher education in the field of ICT usage

Done by

Moritz Krause & Ingo Eilks, Bremen Germany

Field of practice

Chemistry pre-service teacher education

Research interest

Understanding the Information Communication Technology (ICT) related needs of chemistry student teachers for innovations of a teacher education seminar. Understanding the influence of the changes in the course on student teachers' ICT-related attitudes and self-efficacy.

Action

Continuing innovation of a chemistry teacher education course in ICT in science education by implementing new hardware and software, as well as newly developed media and teaching strategies.

View into the data or action

Mean values of the pre- and post-test (smaller values indicate more positive attitudes and correspondingly more positive self-efficacy beliefs):

Dimension		Mean
Attitudes towards using ICT in teaching in general	pre-test	2,6259
	post-test	2,2519
Self-efficacy beliefs about the use of ICT in general	pre-test	2,1769
	post-test	2,0000
Attitudes towards using ICT in chemistry teaching	pre-test	2,1926
	post-test	1,9852
Self-efficacy beliefs about the use of ICT in chemistry lessons	pre-test	2,6600
	post-test	1,9960

Data used

- Focus group discussions
- Feedback questionnaires
- Attitudes and self-efficacy questionnaires

Gained knowledge

Certain areas of change in the course content were identified. Constant innovation leads to more satisfaction among the participants. The course contributes to developments of ICT-related attitudes and self-efficacy.

References

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A metacognitive approach to the professional development of in-service science teachers

Done by

Osnat Eldar & Shirley Miedijensky, Tivon, Israel

Field of practice

Professional development of in-service high schools science and mathematics teachers

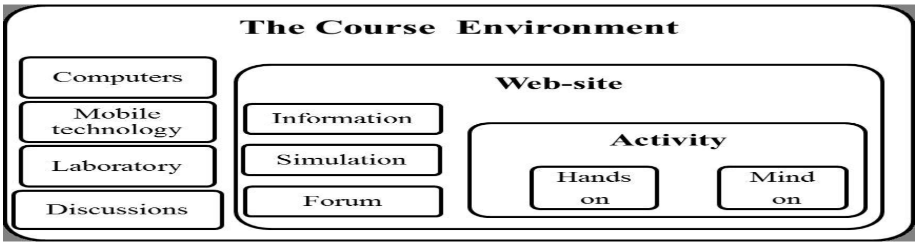
Research interest

Characterizing the design principles of two courses; exposing expressions of metacognition among the teachers and examining the changes they designed and applied in their teaching units and teaching processes; studying the interactions among the participants (researchers, teachers, children) in order to understand the teachers' metacognitive knowledge and skills.

Action

Designing and implementing science education courses based on a metacognitive approach. The teachers designed, made changes to their design, and experienced an iterative process of improving their activities.

View into the data or action



Data used

- Course design and activities
- Interviews with the teachers
- The teachers' teaching activities
- Teachers' reflections
- Researchers' reflections

Gained knowledge

Encouraging teachers to develop and design activities that challenge them within a supportive environment can promote their metacognitive knowledge.

References

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Professional development for teacher educators on education for sustainable development (ESD)

Done by

Franz Rauch, Klagenfurt, Austria, &
Regina Steiner, Linz, Austria

Field of practice

In-service science teacher education

Research interest

How might inquiry-based learning in Education for Sustainable Development (ESD) be developed and sustained within teacher education at universities? How can action research inform ESD?

Action

The University course *Innovation in Teacher Education – Education for Sustainable Development* (BINE) is a professional development course in higher education in Austria. The BINE course consists of three one-week seminars and regional mentoring meetings. Participants write case-based research studies in order to get a certificate. Equal emphasis is put on theoretical-methodical foundation and learning from one's own practical experiences/projects.

Data used

The course is evaluated by a formative and summative self-evaluation with internal (questionnaires, feedback by participants) and external (questionnaires interviews with participants at the beginning and the end of the course) components.

Gained knowledge

The BINE course offers an adequate instructional and learning strategy for the participants to construct the meaning of the complex issues of sustainable development and ESD by researching, reflecting and exchanging in the learning group focused on concrete examples. The action research process provides a basis for learning in order to further develop the participants' concepts of ESD as well.

References

Rauch, F., & Steiner, R. (2015). BINE: Professional development ESD course for higher education teachers, Austria. In D. Kapitulcinova et al. (Eds.), *Leading practice publication: professional development of university educators on education for sustainable development in European countries* (pp. 114-119). Prague: Charles University.

Action research as an impetus for building a course of collaborative learning, and promoting of a learning/investigating teachers' community

Done by

Rachel Cohen, Oranim, Israel

Field of practice

Science teaching in-service teacher education

Research interest

How can I improve my course instruction? How can I promote student action research and implementation of change processes in their schools on the subject of collaboration?

Action

Developing and implementing a collaboration course on science teaching. Consecutively adjusting the learning scenario in different action research cycles.

View into the data or action

The first circle: Exploring students' perceptions and teaching / action methods (before beginning the course)

The second circle: Building knowledge for teaching-learning and a cooperative professional community

The third circle: Action research - the "glue" that connects the components, motivates change, and develops professional community studying / investigating

Data used

- The researcher observed the learning processes
- Using collaborative maps (using the aquarium method)
- A two-stage quiz (personal and collaborative discussion)
- Content analysis of student action studies

Gained knowledge

Certain areas of change needed in course content were identified. Constant innovation leads to more satisfaction among the teachers participants. The course contributes to the development of positive attitudes relating to the idea of collaborative learning and promotes teachers' action-research.

Resources to prepare and to be used in action research workshops

7.1 Recommended books on action research

Altrichter, H., Feldman, A., Posch, P., & Somekh, B. (2008). *Teachers investigate their work: An introduction to action research across the professions* (2nd revised edition). London: Routledge.

Anderson, G. L., Herr, K. G., & Nihlen, A. S. (2007). *Studying your own school: An educator's guide to practitioner action research*. Thousand Oaks: Corwin.

Burnaford, G., Fischer, J. & Hobson, D. (Eds.). (2001). *Teachers doing research: The power of action through inquiry*. Mahwah: Lawrence Erlbaum.

Carr, W., & Kemmis, S. (1986). *Becoming critical: education, knowledge and action research*. London: Falmer.

Goodnough, K. (2011). *Taking action in science classrooms through collaborative action research*. Rotterdam: Sense.

Hollenbach, N., & Tillmann, K.-J. (Eds.). (2009). *Teacher research and school development*. Opladen: Barbara Budrich.

Kemmis, S., McTaggart, R., & Nixon, R. (2014). *The action research planner*. Dordrecht: Springer.

Mills, G. E. (2014). *Action research: A guide for the teacher researcher* (5th ed.). Boston: Pearson.

Noffke, S. E., & Somekh, B. (Eds.). (2009). *Educational action research*. Los Angeles: SAGE.

Rauch, F., Schuster, A., Stern, T., Pribila, M., & Townsend, A. (Eds.). (2014). *Promoting change through action research*. Rotterdam: Sense.

Stern, T., Rauch, F., Schuster, A., & Townsend, A. (Eds.). (2014). *Action research, innovation and change* (pp. 156-176). London: Routledge

7.2 Recommended articles and chapters on action research in (science) education

Bodner, G. M., MacIsaac, D., & White, S. R. (1999). Action research: overcoming the sports mentality approach to assessment/evaluation. *University Chemistry Education*, *3*(1), 31–36.

Capobianco, B., Horowitz, R., Canuel-Browne, D., Trimarchi, R. (2004). Action research for teachers. www.nsta.org/publications/news/story.aspx?id=49119.

Capobianco, B., & Feldman, A. (2010). Repositioning teacher action research in science teacher education. *Journal of Science Teacher Education, 8,* 909-915.

Dass, P., Hofstein, A., Mamlok, R., Dawkins, K., & Pennick, J. (2008). Action research as professional development of science teachers. In I. V. Erickson (Ed.), *Science education in the 21st century* (pp. 205–240). Hauppauge: Nova.

Dickson, G., & Green, K. L. (2001). The external researcher in participatory action research. *Educational Action Research*, *9*, 243–260.

Eilks, I. (2014). Action Research in science education: From a general justification to a specific model in practice. In T. Stern, F. Rauch, A. Schuster, & A. Townsend (Eds.), *Action research, innovation and change* (pp. 156-176). London: Routledge.

Eilks, I., & Ralle, B. (2002). Participatory action research in chemical education. In B. Ralle & I. Eilks (Eds.), *Research in Chemical Education - What does this mean?* (pp. 87-98). Aachen: Shaker.

Feldman, A. (1994). Erzberger's dilemma: validity in action research and science teachers' need to know. *Science Education*, *78*, 83-101.

Feldman, A. (1999). The role of conversation in collaborative action research. *Educational Action Research, 7*(1), 125–144.

Feldman, A. (2000). Action research in science education. *ERIC Digest*, www.ericdigests.org/2003-1/action.htm.

Feldman, A., & Minstrel, J. (2000). Action research as a research methodology for study of teaching and learning science. In A. E. Kelly & R. A. Lesh (Eds.), *Handbook of research design in mathematics and science education* (pp. 429-455). Mahwah: Lawrence Erlbaum.

Goodnough, K. (2004). Dealing with messiness and uncertainty in practitioner research,; the nature of participatory action research. *Canadian Journal of Education*, *31*, 431.458.

Hunter, W. J. (2007). Action research as a framework for science education research. In G. M. Bodner & M. K. Orgill (Eds.), *Theoretical frameworks for research in chemistry/science education* (pp. 152-171). New York: Prentice Hall.

Kemmis, S. (1993). Action research and social movement: a challenge for policy research. *Education Policy Analysis Archives*, 1, retrieved from epaa.asu.edu/epaa/abs1.html.

Kusch, J., Rebolledo, G., & Ryan, C. (2005). Practice in planning and planning in practice: re-assessing and clarifying action research in a multi-national context. *Journal of Curriculum Studies, 37,* 465-481.

Laudonia, I., & Eilks, I. (2018). Teacher-centred action research in a remote participatory environment – a reflection on a case of chemistry curriculum innovation in a Swiss vocational school. In J. Calder & J. Foletta (Eds.), *(Participatory) action research: principles, approaches and applications* (pp. 215-231). Hauppauge: Nova.

Laudonia, I., Mamlok-Naaman, R., Abels, S., & Eilks, I. (2018). Action research in science education - An analytical review of the literature. *Educational Action Research*, 26, 480-495.

Mamlok-Naaman, R., & Eilks, I. (2012). Action research to promote chemistry teachers' professional development – cases and experiences from Israel and Germany. *International Journal of Mathematics and Science Education, 10* (3), 581-610.

Megowan-Romanowicz, C. (2010). Inside out: Action research from the teacher-researcher perspective. *Journal of Science Teacher Education*, *21*, 993-1011.

Price, J. N. (2001). Action research, pedagogy and change: The transformative potential of action research in pre-service teacher education. *Journal of Curriculum Studies*, 33, 43-74.

Radford, M. (2007). Action research and the challenge of complexity. *Cambridge Journal of Education*, *37*, 263–278.

Roth, K. J. (2007). Science teachers as researchers. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 1203-1260). Mahwah: Lawrence Erlbaum.

Taber, K. S. (2013). Action Research and the academy: seeking to legitimise a 'different' form of research. *Teacher Development*, *17*, 288-300.

Vaughan, M., & Burnaford, G. (2016). Action research in graduate teacher education: a review of the literature 2000–2015. *Educational Action Research, 24*, 280-299.

Warrican. S. J. (2006). Action research: a viable option for effecting change. *Journal of Curriculum Studies, 38*, .1-14

Wood, P., & Butt, G. (2014), Exploring the use of complexity theory and action research as frameworks for curriculum change. *Journal of Curriculum Studies, 45,* 676-696.

Zehetmeier, S., Andreitz, I., Erlacher, W., & Rauch, F. (2015). Researching the impact of teacher professional development programmes based on action research, constructivism, and systems theory. *Educational Action Research*, *23*, 162-177.

7.3 Supporting policy resources from the Internet

Action research to improve youth and adult literacy. Empowering learners in a multilingual world. Hassana Alidou and Christine Glanz (eds). United Nations: UNESCO 2015. unesdoc.unesco.org/images/0023/002322/232243e.pdf.

Supporting teacher educators for better learning outcomes. Brussels: European Commission 2013. ec.europa.eu/dgs/education.../support-teacher-educators_en.pdf.

Shaping career-long perspectives on teaching. A guide on policies to improve initial teacher education. Brussels: European Commission 2015. ec.europa.eu/dgs/education_culture/repository/education/library/reports/initial-teacher-education_en.pdf.

7.4 Methodological resources from the Internet

A toolkit for participatory action research.
www.dss.gov.au/sites/default/files/documents/06_2012/research_in_action.pdf.

Action research: a guide for associate lecturers - The Open University.
www.open.ac.uk/cobe/docs/AR-Guide-final.pdf.

Action research guide for Alberta teachers.
www.teachers.ab.ca/sitecollectiondocuments/ata/publications/professional-development/actionresearch.pdf.

Action research project tutorial
valenciacollege.edu/faculty/development/tla/actionResearch/ARP_softchalk/.

Classroom action research.
www.seameo-innotech.org/iknow/wp-content/uploads/2014/03/COMPETE-21.-Classroom-action-research.pdf.

Educational research terms. people.ds.cam.ac.uk/kst24/EdResMethod/Index.html

Research in action: A guide to best practice in participatory action research.
www.dss.gov.au/sites/default/files/documents/06_2012/research_in_action.pdf.

7.5 The Collaborative Action Research Network (CARN)

The Collaborative Action Research Network (CARN) www.carn.org.UK/?from0carnnew/

The journal Education Action Research www.tandfonline.com/loi/reac20

7. ARTIST Centers and contact points in different countries

Universität Bremen, Bremen (Germany)

The chemistry education group from the University of Bremen developed a broad, nationally and internationally highly recognized expertise in research and curriculum development in science and sustainability education. The special emphasis in curriculum development was and is student-active science learning through societal-oriented science curricula, hands-on lab activities and cooperative learning. Most of the developments in recent years were based on applying teacher-centered and collaborative action research. A specific model of Participatory Action Research was developed and popularized by the group and is now applied in different fields and countries. The group shares its theoretical contributions, expertise and experiences within ARTIST and acts as a facilitator and accompanier of the professional development, research and innovation process within ARTIST.

Our team

Prof. Dr. Ingo Eilks , Dr. Nadja Belova

Contact

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Ilia State University, Tbilisi (Georgia)

We develop, pilot and implement the ARTIST curriculum and establish networks with schools and industries in Georgia. We also helped to install digital equipment with partners to improve facilities for in-service and pre-service teacher trainings. Staff members of ISU disseminate the information about the project, support teachers, provide resources, and ensure the long-term sustainability of ARTIST.

Our team

Prof. Dr. Marika Kapanadze, Dr. Manana Varazashvili, Dr. Ekaterine Mikautadze, Ekaterine Slovinsky

Contact

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0162, Tbilisi, Georgia
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Alpen-Adria-Universität, Klagenfurt (Austria)

The Institute of Instructional and School Development (IUS) offers participants of university courses a framework for developing their competencies by collaborating and working on professional problems. Teachers are seen as reflective practitioners and are supported in investigating their professional practice using the methods of action research. We run currently 12 professional development university courses for teachers (one course is for science teachers). The institute conducts among others (i.e. in the fields of Education for Sustainable Development, School Leadership, Career Counselling for Teachers) the national large-scale project IMST (Innovations in Mathematics, Science and Technology Teaching). The project involves about 7000 teachers across all of Austria who participate in projects, attend conferences or cooperate in regional and thematic networks. The expertise gained in the professional development courses and the IMST project especially is shared in ARTIST.

The AAU ARTIST-Team
Prof. Dr. Franz Rauch, Dr. Diana Radmann

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University of Limerick, Limerick (Ireland)

We have a long history of pre-service science teacher education, and strong links with schools and teachers across Ireland. We have considerable expertise of networking with education and businesses and experience over many years in partnership activities with industries. An ARTIST key initiative is setting up local networks between industry, SME, HEI's and teachers. We have already a partnership with 22 industries across Ireland, and through its strong links with industry and Science Foundation Ireland, Enterprise Ireland and the Industrial Development Authority (Ireland's key funders and stakeholders with industry) is well positioned to deliver local and national industrial networks. The networks will contribute to the dissemination of ARTIST into the relevant sectors: schools and industry/SMEs. Our links to schools, HEI and industry partners are well placed for this role. To promote action research in schools and contribute to the training of teachers in schools and HEI's are primary goals, which we are well placed to deliver, given its major role in pre-service teacher education.

The UL Artist-Team
Dr. Sarah Hayes, Dr. Peter Childs, Dr. Aimee Stapleton

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Gazi Universitesi, Ankara (Turkey)

We are the oldest and biggest teacher training institution in Turkey and thus have a tradition of teacher education in Turkey with strong links with teachers and schools. We work in ARTIST to locally conduct action research, to promote them and provide wide access to action research by teachers and teacher candidates. We set up networks between industry, SME, HEI's and teachers in Turkey. Over the years, we have already established partnerships with the Ministry of National Education (MNE) and have continuing contracts and projects for in-service teacher education. This plays a key role for dissemination of ARTIST. Our involvement and positions in international organizations will help to promote both ARTIST and the ARISE journal in the global scale. Maintaining and managing the journal in the following years will also be a main task that we will undertake.

Our team

Prof. Dr. Mehmet Fatih Taşar, Prof. Dr. Yuksel Altun, Duygu Yılmaz, Jale Ercan

Contact

Gazi Üniversitesi Muhasebe ve Kesin Hesap
Prof. Dr. Mehmet Fatih Tasar
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Batumi Shota Rustaveli State University, Batumi (Georgia)

Batumi Shota Rustaveli State University aims to facilitate the development of competence-based learning. To this end, the university will engage in the planned cooperation with local factories, e.g. Kakhaberi LLC – a dairy products manufacturer, and will organize and conduct relevant workshops, discussions and demonstrative scientific experiments for the students. Site visits and similar close engagement with the production process of the manufacturer will definitely encourage and elevate motivation of science learning in general. Practitioners will gain hands-on experience which will be translated into practical teaching. Through reflection, the science learning curricula of various schools and universities will be improved through Action Research.

Our team

Prof. Dr. Marina Koridze, Prof. Dr. Rusudan Khukhunaishvili, Tea Koiava

Contact

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Oranim Academic College of Education, (Israel)

The college provides the highest level of academic and professional training, and addresses a range of educational, pedagogical and social dilemmas and topics. Master Degree programs are for individuals who seek professional and intellectual advancement with an emphasis on practical implementation, and come from the fields of education and teaching. We work to develop graduates who are knowledgeable, intellectually curious, mature and socially responsible, and have the highest personal ideals and values. The M.Ed. program in Science Education provides expert academic and pedagogical training for in-service high-school teachers. It trains them to be expert leading teachers, skilled in curriculum development and able to head science programs in schools. In this framework, teachers are encouraged to perform action research in order to evaluate their own teaching. We share our experiences and techniques with teachers to develop corresponding courses and activities.

Our team

Prof. Dr. Ricardo Trumper, Dr. Rachel Cohen, Dr. Amos Cohn, Dr. Osnat Eldar, Dr. Iris Gershgoren, Dr. Shirley Miedijensky

Contact

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The Academic Arab College for Education, Haifa (Israel)

Most science teachers in primary, middle and high-schools in the Arab sector in Israel teach science with limited experiments, demonstrations and simulation for their students. The main reason for this is that they have a problem with research and prefer traditional frontal methods of teaching. This reduces the motivation for students to learn science and the result is fewer students chose to learn sciences in universities and higher education institutions, especially in the Arab sector. As a partner in the ARTIST project, we help many of our in-service and pre-service teachers to practice action research in their classrooms to improve science education and make it more relevant for the students by focusing on career orientation and the application of science in businesses and industry. In our college, we have a distinguished young team from all science fields who are highly motivated and who work to succeed in the implementation of this attractive, unique and challenging project. Our team is involved in action research studies in collaboration with partners from the Weizmann Institute of Science.

Our team

Prof. Dr. Muhamad Hugerat, Dr. Ahmad Basheer, Dr. Naji Kortam, Dr. Riam Abu-Mukh, Dr. Naim Najami, Dr. Fadeel Joubran, Salem Saker

Contact

Acadamic Arab College of Education
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Ateneo de Manila University (Philippines)

The Philippines has recently adopted a new Basic Education curriculum wherein two more years were added to what used to be a ten-year Basic Education. During the last two years, called the senior high school, students have the option to take a technical-vocational track wherein they can find employment upon graduation or an academic track wherein they can proceed to university education. The courses offered in the academic track are what used to be first two years of fundamental college-level courses. The shift to the new curriculum is laden with challenges especially in the senior high school science courses. In ARTIST, we review science education programs, with inputs from the ARTIST partners in order for these programs to be better cognizant of the challenges of the new Basic Education System. We incorporate action research in to the curriculum and utilize it for curriculum innovation. We develop courses which will empower the graduate students to perform research-based innovations in teaching in their respective classes.

Our Team

Ivan Culaba, Dr. Joel Tiu Maquiling, Dr. Maria Obiminda Cambaliza, Johanna Mae Indias

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De la Salle University, Manila (Philippines)

As a university in South-east Asia, we act as a hub for the implementation of the project in this region. Our science education programs in the masters and doctoral levels serve as the platform for the evaluation of efficacy and applicability of the developed modules for science teachers. Through the participation of our graduate students (science teachers) richer and more diverse data are obtained that lead to further enhancement of the teacher education modules. Through the university's extensive connections with the different higher education institutes across the country, a vast network of teacher researchers as well as education administrators nationwide was set up.

Our team

Dr. Lydia Roleda, Prof. Dr. Maricar Prudente, Dr. Minie Rose Lapinid, Prof. Dr. Socorro Aguja

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