Action Research and Design-Based Research for Physics Teacher Preparation in Germany: A Pilot Study

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Abstract

We describe preparations and initial pilot activity undertaken in collaboration with pre-service physics teachers, their instructors and mentors at the Universität zu Köln making use of Design Based Research and Action Research methods. A literature review was prepared to inform and guide our scholarly exchanges creating a Transatlantic Design Based Research / Action Research Network for physics teacher preparation in German and U.S. schools. AR projects have been widely used in the US for teacher development, notably by physics teachers enrolled at Arizona State University, but not yet in Germany. We present interim data collected during a pilot study conducted on graduate student exchange visiting Cologne, Germany January – February 2015. We are currently supporting ongoing DBR/AR projects with German physics teaching students via Skype during spring of 2015, with intentions of further scholar exchanges in spring and summer of 2015.

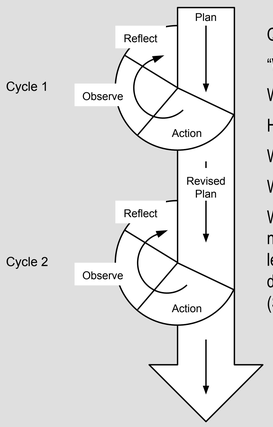
Action Research (AR)

"At its core, action research provides a framework for faculty-led inquiry and dissemination aimed specifically at enhancing the learning environment," (Slater, Slater & Bailey, 2010, p. 71)

Two major features:

- "The recognition of the capacity of people living and working in particular settings to participate actively in all aspects of the research process; and
- The research conducted by participants is oriented to making improvements in practices and their settings by the participants themselves.

This shift to owning a way of doing research is often regarded as a source of empowerment for participants," (Kemmis, McTaggert & Nixon, 2014, p. 4)



Questions to consider:

"What did the pupils actually do?

What were they learning?

How worthwhile was it?

What did the teacher / researcher do?

What did the teacher / researcher learn?

What will the teacher / researcher do now to maximize the teaching and learning benefits and minimize the disadvantages and inconveniences?" (Slater, Slater & Bailey, 2010, p. 71)

Design Based Research (DBR)

"Design-based research is premised on the notion that we can learn important things about the nature and conditions of learning by attempting to engineer and sustain educational innovation in everyday settings," (Bell, 2004).

"There is a tension between the desire for locally usable knowledge on the one hand and scientifically sound, generalizable knowledge on the other," (Sandoval & Bell, 2004). "Once we have developed and studied an educational intervention in a particular setting, it is becoming standard practice to bring it to a broader, scaled use," (Bell, 2004).

"… situated in real educational contexts, focusing on the design and testing of interventions, using mixed methods, involving multiple iterations, stemming from partnership between researchers and practitioners, yielding design principles, different from action research, and concerned with an impact on practice," (McKenney & Reeves, 2013).

Discipline-Based Education Research (DBER)

"… science education researchers make systematic observations of learners and their environments in order to develop predictive and explanatory models of education. DBER also endeavors to make connections between observation and education theory; as in scientific research, the two influence each other greatly," (Slater, Slater & Bailey, 2010, p. 2).

"… DBER does not have any priori 'laws' or 'formulae' that predict how all people learn for a given set of initial conditions in the same way we do with physical processes in the natural world," (Slater, Slater & Bailey, 2010, p. 3)

Common Characteristics

Both action research and design-based research are premised on the close relationship between researcher and participant. They both feature a cyclic approach to solving a problem .

"The two main characteristics of action research that distinguish it from DBER are that it is conducted by active participants in the teaching/learning process and that it is expressed in the language of its participants," (Slater, Slater, & Bailey, 2010, p. 71).

"… we view action research as a doorway through which many enter as instructors, and exit as education researchers," (Slater, Slater, & Bailey, 2010, p. 74).

Example AR and Master's Project Topics for Teachers

- Implementing Modeling Discourse Management in High School Physics – John Crookston
- Developing Kinematic Concepts Graphically – Jim Archambault, Theresa Burch, Michael Crofton, Angela McClure
- Teaching Math Concepts within a Science Context – Adrian Boyarsky, Russ Bray, & Mark Henrion
- Spreadsheets in Physics: Computational Modeling in Regular and AP Physics – Jason Stark and David Wirth
- Using Gravitational Analogies to Introduce Elementary Electrical Field Theory Concepts – Susan Saeli
- A Hands-on Introduction to Displacement / Velocity Vectors and Frame of Reference through the Use of an Inexpensive Toy – Gwen Saylor

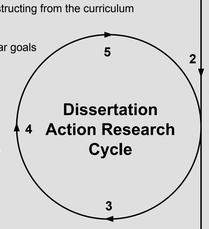
More projects can be found at:

http://modeling.asu.edu/Projects-Resources.html

http://physicsed.buffalostate.edu/pubs/PHY690/

http://www.physikdidaktik.uni-koeln.de/10209.html?&L=1

Example of Action Research Cycle



1. Reconnaissance
Researchers background, describe previous research and relevant literature, briefly describe PHYS 152L curriculum

2. Plan
How can we improve the quality, worth, and justice of the Physics 152 Laboratory experience for students by modifying the curriculum and practice of that course?

How do students construct meaning during their Physics 152 Laboratory experience?

3. Action
Follow selected students through the curriculum

Assess each and every curricular activity

4. Observe
Audiotapes and field notes from interviews with participants before and after all activities.

Videotape and field notes from participant observations of all activities.

Ancillary materials (e-mail, lab reports, other comments from students, instructors).

5. Reflection
Formulate general knowledge claims that will guide revisions to curriculum (materials, goals, activities, and instructions) for use in next cycle of curricular innovation and evaluation. Validate these claims through participant review and commentary.

What meanings are students constructing from the curriculum and why?

How can we better match curricular goals and outcomes?

6. Revised Plan
Building on general knowledge claims, generate and implement specific innovations and revisions to curriculum materials, goals, activities, and instructions for refined practice.

What additional questions can more appropriately guide our reflective practice in Physics 152L? How can we better assess the impact of our curricular revisions?

Study Participants

Two student participants did all activities with their regularly assigned section and were interviewed after each activities.

Eight student participants completed activities while videotaped with researcher and were interviewed before and after each activity. Of these, two went back to their assigned sections to complete one single activity, then completed the study with the researcher. Four of these participants worked alone, and four with partners in pairs of two during activities.

Two student participants dropped out of the study due to previous time commitments and scheduling difficulties.

One student participant offered unsolicited general commentary on the lab experience; another student participant offered unsolicited commentary on the lecture course experience.

One Graduate Teaching Assistant and on Undergraduate Grader participated in itinerant interviews.

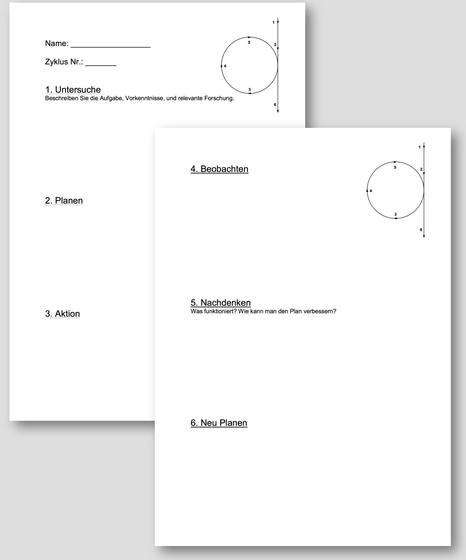
(MacIsaac, 1994)

Research Support for German Pre-Service Teachers

In my first (Jan-Feb 2015) trip to Cologne, Germany, I observed the weekly seminars for students who would be among the first to undertake the "Praxissemester" as part of their path towards teacher certification. During Praxissemester, students work with local teachers to devise and implement a research project in a real classroom which becomes the topic of their master's thesis. Example proposals include teaching medicine in a physics class, exploring the benefits of experimentation before the introduction of theory, and conducting a plenary discussion on climate change. At the end of the semester, teacher candidates present and defend their findings.

As part of my involvement in the program, I provided research design support to students wishing to take an Action Research (AR) approach to their projects. This included working one-on- one with the students on structuring their lesson plans to fit the AR cycle pattern and providing advice on how best to document and record the implementations of the lessons. Students have been provided with a simple worksheet to guide them through the steps of the AR cycle.

After I returned to the US, the students submitted their final proposals for their projects. After translating and reviewing several outlines, we picked two, which seemed to best fit AR design and decided to follow these students. In our correspondence, we made suggestions for piloting their lessons with a friend or colleague before they are implemented in the classroom. This gives the students one more AR cycle to work with. We have requested that students send us instructional materials (i.e. handouts, detailed plans, and final assessments) that they plan to use so that we may review them and send feedback. If properly documented, this in itself constitutes an AR cycle.


Name: _____
Zyklus Nr.: _____
1. Untersuche
Beschreiben Sie die Aufgabe, Vorkenntnisse, und relevante Forschung.
2. Planen
3. Aktion
4. Beobachten
5. Nachdenken
Was funktioniert? Wie kann man den Plan verbessern?
6. Neu Planen

The teacher candidates were all given the worksheet shown above to aid them in documenting their experiences. The worksheet is meant to simplify the steps in undertaking an action research project, while also allowing us to easily see the evolution of the project as it goes through successive cycles. The students in Germany are expected to begin their field observations in about a month, which I will return to observe in Cologne (May-June 2015).

References

Bell, P. (2004). On the Theoretical Breadth of Design-Based Research in Education. *Educational Psychologist, 39*(4), 243-253.

Kemmis, S., McTaggart, R., & Nixon, R. (2014). *The Action Research Planner: Doing Critical Participatory Action Research.* Singapore: Springer Science +Business Media.

MacIsaac, D. L. (1994). *Curricular Reformation in Computer-Based Undergraduate Physics Laboratories via Action Research.* PhD Thesis, Purdue University.

McKenney, S., & Reeves, T. C. (2013). Systematic Review of Design-Based Research Progress: Is a Little Knowledge a Dangerous Thing? *Educational Researcher, 42*(2), 97-100.

Slater, S. J., Slater, T. F., & Bailey, J. M. (2010). *Discipline-Based Education Research: A Scientist's Guide.* New York: W.H. Freeman and Company.

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