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

Joseph Heimburger
PHY 690
SUNY Buffalo State College

Abstract

I 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 (DBR) and Action Research (AR) methods. I briefly review literature 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. I present data collected during a pilot study conducted as part of my graduate student exchange visiting Cologne, Germany from January – February 2015 and again in June 2015. The study follows one preservice teacher through her "Praxissemester", during which she developed classroom activities that incorporate topics from the medical field into the physics classroom and assessed them in an action research / design based research format. I report her findings and discuss the appropriateness of using action research / design based research in the context of the German Praxissemester.

Acknowledgement

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Introduction and Background Research

In Germany, as with the United States, there always movements to reform the way in which teachers are trained and assessed. Specifically, there have been pushes to encourage new and pre-service teachers to take a more active role in the education research community (AACTE, 2015). In the United States, many states have adopted the edTPA, an assessment that encourages student teachers to test out and evaluate research backed classroom methods and lessons (AACTE, 2015). In Germany, similar reforms have manifested as the "Praxissemester." The Praxissemester replaces the previous system in which students who became physics teachers took the Staatsexam (a written exam conducted by the state) after completing their university education. Upon successful completion of this exam, students would complete two years of teaching under the supervision of a mentor. In the current system, the Praxissemester follows a six-month long teaching internship and requires pre-service teachers to devise and carry out a research project in a school. The semester culminates in an extensive final paper reporting the student's findings. Upon successful completion of the Praxissemester, the students complete only one year of teaching under the guidance of a mentor (who happens to have also been the students mentor during the Praxissemester). The nature of this research project seemed like a perfect opportunity to pilot Action Research (AR) projects in German classrooms and lay the foundation for a trans-Atlantic action research network.

To begin this project, we conducted a literature review of published papers on AR and its related educational research for teachers (Design Based Research or DBR and Discipline-Based Education Research or DBER) in order to get a solid definition of these forms of research and to better inform how we conducted this pilot program. Action research, like most other academic

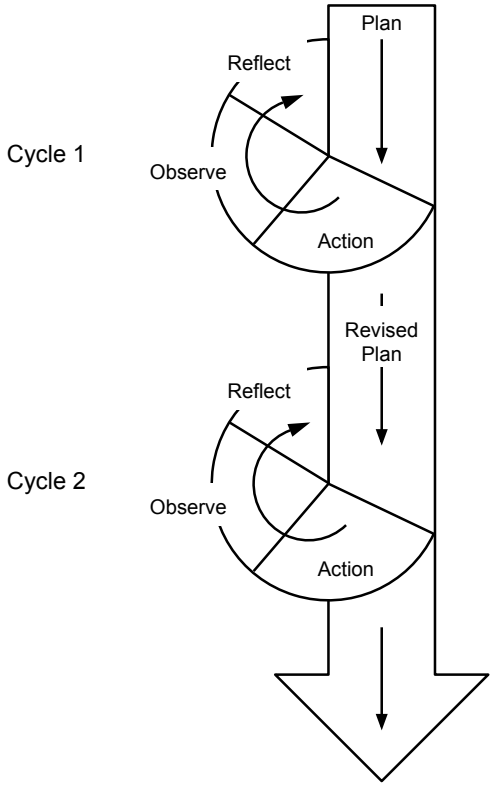

Figure 1:Two Action Research Cycles (MacIsaac, 1994)

research, is completed in cycles in which the researcher devises a plan, carries out the plan, observes, reflects, and repeats.

The real power of AR in an educational setting comes in the speed at which these cycles can be completed. The key here though is to maintain formal documentation of reflection and planning.

Another strength of AR in the classroom is that it is much more inclusive than traditional research. Action research involves all participants in the research process and empowers those who would typically have little input in the way research is conducted (Kemmis, McTaggert & Nixon, 2014, p. 4). This makes action research an ideal model for involving people with little research experience or those who wish to pursue education research further, such as pre-service or new teachers (Slater, Slater, & Bailey, 2010, p. 74).

Design-based research (DBR) and discipline-based education research (DBER) share similar structures as AR. All three follow a cyclic pattern of conducting research. However, DBR and DBER are often considered to be more rigorous and do not involve all participants as knowing participants (eschewing some of the empowerment and social justice elements) that AR does (Slater, Slater, & Bailey, 2010, p. 71). Another characteristic of these two frameworks that differentiates them from AR is that they both are conducted with the idea that at the end of the research, there will be some sort of product or piece of knowledge that is expected to be generalized and applied to education on the whole, whereas action research tends to remain more localized to the particular (immediate) environment in question (McKenney & Reeves, 2013).

First Trip to Germany

In my first trip to Cologne, Germany, I observed the weekly seminars for the students who would be among the first to undertake the Praxissemester as part of their path towards physics teacher certification. During the Praxissemester, students work with local teachers to devise and implement a research project in a real classroom. Though the Praxissemester final report is separate from the master's thesis, this research project typically becomes the topic of the master's thesis. Some example proposals of the cohort I observed included 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, the teacher candidates presented and defended their findings.

As part of my involvement in the program, I provided research support to students wishing to take an AR approach to their projects. This included working one-on-one with the students on structuring their lesson plans to fit the AR cyclic pattern and providing advice on

how best to document and record the implementations of the lessons. To help organize and record the AR cycles, students were provided with a simple worksheet to guide them through the steps of the AR cycle (Appendix A).

After I returned to the US, the students submitted their final proposals for their projects. Upon translating and reviewing several outlines, we picked one which seemed to fit the action research mold and decided to follow up with the project proposed and conducted by Ms. Jennifer Lorbach. Ms. Lorbach's research goal was to design and implement lessons that integrated topics from the field of medicine into the physics curriculum. She had a strong interest in the medical field and this project was a continuation of her bachelor's thesis. In our correspondence, we made suggestions for piloting her lessons with a friend or colleague before they were implemented in the classroom. This gave her another AR cycle to document. We requested that she send us instructional materials (i.e. handouts, detailed plans, and final assessments) that she planned to use so that we may review them and send feedback. This in itself also constitutes a preliminary or pilot AR cycle.

Ms. Lorbach was given the action research cycle worksheet to aid her 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 began their field observations in May, 2015 and completed their projects in late June, 2015.

Second Trip to Germany

In June, 2015, I returned to Cologne, Germany to observe the conclusion of the research project of one of the students I had supported during the winter seminar. After reviewing the

project proposals collected during my first visit, we decided that it would be most appropriate to focus on one particular project that most closely followed the action research structure. This research project was conducted by Ms. Lorbach and sought to create cross-curricular lessons that bridged physics and medicine. The school that Ms. Lorbach was working with had two sections of physics. Therefore, the designed lesson would be run first in one section (referred to as Class 1), re-evaluated, and then run in the second section (referred to as Class 2). Both versions followed the same general format. The students' level of interest in physics and medicine were measured on a scale of one to six (with one being "strongly disagree" and six being "strongly agree") using a questionnaire administered before and after the lesson (Lorbach, 2015, pp. 57-62). Ms. Lorbach then compared the change in the students' levels of interest in physics and medicine between the two classes.

The lesson that Ms. Lorbach designed consisted of an initial class discussion about the various topics to be covered in the learning segment. During this portion of the lesson, the class brainstormed how physics and medicine are related and the class created a mind map to help visualize their ideas. Prior to starting the lesson, Ms. Lorbach and her cooperating teacher decided that the main focus of the lesson would be waves and their use in ultrasound imaging. Therefore, once the class had concluded the first group discussion, the teacher steered the conversation more towards ultrasound and begin introducing its subtopics.

The next portion of the lesson consisted of three stages of collaborative group-work. In the first stage of the group-work, each group was assigned a subtopic related to ultrasound to research and become an expert in. There were six total topics:

1. The history of ultrasound in medicine
2. Characteristics of sound
3. How ultrasound images are generated
4. What can be investigated with ultrasound?
5. Obstetrics
6. Ultrasonic technology at a glance

Once the class formed their groups, each group received a worksheet packet that contained a short reading and follow-up questions (Lorbach, 2015, pp. 54-57). The students were given the rest of the class period to answer the questions in the packet. If the initial reading did not contain the information needed, the students were instructed to use the class set of iPads to conduct further online research.

In the second stage of the group-work, the students were reassigned to groups consisting of at least one expert from each of the six main themes. The students took turns explaining their area of expertise to their classmates while the others took notes. During this portion of the lesson there were no questions for the students to answer. Therefore, it was imperative that the students engaged their classmates in discussion and take thorough notes.

In the final phase of group-work, the students returned to their original groups and were given a final set of questions to answer. This question set covered all six topics, so it was imperative for the students to compare notes from the previous group phase and come to a consensus as group. The class then came back together for a final discussion of what they learned and fill in any gaps the groups may have had. I had the opportunity to observe the final two phases of the group-work. Though the two classes that Ms. Lorbach ran the lesson in followed very similar procedures as what have been described, there were some changes made

between the first and second classes and they are outlined in Table 1. Upon analyzing the results of the pre- and post-surveys, Ms. Lorbach concluded that there was no significant change in the interest levels of Class 1 even though interest remained higher in that class. Class 2 showed a positive increase in interest with an increase in mean score of 0.14. The data is summarized in Table 1.

Class 1				
	Average Score	**n**	**Standard Deviation**	**Error**
Pre-Test	3.8122	18	1.27425	0.30034
Post-Test	3.7772	18	1.23273	0.29056
Class 2				
	Average Score	**n**	**Standard Deviation**	**Error**
Pre-Test	3.4410	20	1.00040	0.22370
Post-Test	3.5820	20	1.15394	0.25803

Table 1: Summarized data from pre- and post-tests

Ms. Lorbach points to the change in how the concept map (Figure 2) is generated by the class and how the students were grouped (Table 1) as the strongest factors in Class 2's increase in content interest. Appendix B contains Ms. Lorbach's completed action research worksheets for the first two iterations of her project with English translations and annotations.

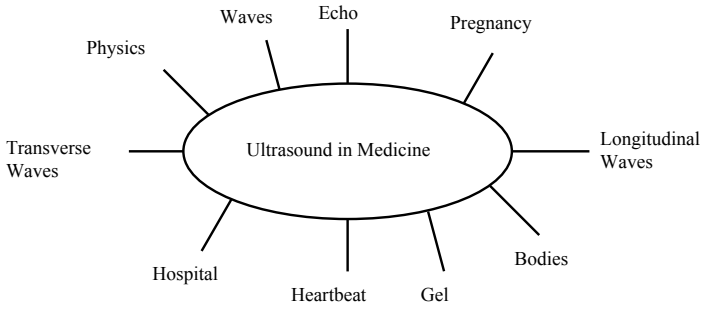

Figure 2: Concept map generated by Ms. Lorbach's class

Lesson Phase	Class 1	Class 2	Reasons for Changes
1: Home Groups	Students create mind map in notebooks before the class discussion.	Students create concept map on an overhead projector.	Some students in class 1 were not correcting their concept maps. Class discussion in class 1 felt repetitive and unnecessary. The mind map in class 2 could be saved for the final class discussion at the end of the lesson.
2: Expert Groups	Students chose their own groups in both phases.	Students were free to choose their own groups in phase one but were assigned groups in phase 2.	Class 2 was much larger than class one. Therefore, it was much more efficient for the teacher to group the students since phase two has the requirement that each group must contain an expert from each theme.
3: Home Groups	Students asked questions individually during the final class discussion.	Questions could only be asked as a group during the final discussion.	Encourage more thoughtful and enriching discussion within the groups.

Table 2: Changes in Lesson Between Class 1 and Class 2

Upon reviewing Ms. Lorbach's final report, it is not clear whether these supports (the AR templates) were useful in conducting the project or if they presented themselves as simply more irrelevant work to an already overworked student teacher. There appears to be no evidence of the usage of AR templates in her final report and the fact that they were returned much later than her report indicates to me that Ms. Lorbach may not have found them very useful. The templates would most likely have been more effective if they had been given to the students earlier in the semester, but I believe that a more effective form of support is direct consultation, either in person or via video messaging. Much like student teachers in the United States, these student teachers are highly stressed and would rather just talk to someone instead of filling out more paperwork.

Reflections and Next Steps

My brief look into the German Praxissemester has given me an interesting perspective when reflecting back on how teachers are prepared here in the United States. Recently developed evaluations, such as the edTPA are pushing new teachers to be smart consumers of education research (AACTE, 2015). The Praxissemester seems to take this idea a step further by giving new teachers a voice in the production of education research. The motivating force here is that innovation in the schools is partially owned by all teachers, including these new teachers. For this reason, I believe that AR projects are an appropriate fit for students completing the Praxissemester.

However, in this first year, there seems to be a disconnect between what is happening in the university and what goes on in the schools (in both Germany and New York), which makes it difficult to conduct AR, though this is intended to protect the students. Another challenge to AR project in Germany is the way in which students are assigned to their schools. Rather than working with schools that the university may already have a relationship with, the students are assigned by a centralized computer system. Therefore, it is likely that a student may get assigned to a school that may be unwilling to participate in an AR project. I did, however, see some hope during a post-project interview with Professor André Bresges, of Cologne University, Ms. Lorbach, and her cooperating teacher. During the interview, the cooperating teacher expressed interest in pursuing more action research projects and was willing to comment on these projects, a key aspect of AR (triangulation and face validity). I believe that there are still more innovative teachers out there who would also be willing to contribute to these projects. The challenge is connecting the students to these teachers. It will be interesting to see how this form of evaluation evolves over the coming years.

This first exchange is just the beginning in what we hope to build as a Transatlantic Design Based Research / Action Research Network for physics teacher preparation in German and U.S. schools. In the summer following my own visits to Germany, Buffalo State College hosted two German graduate students from the University of Cologne to conduct research and provide instructional support related to the implementation of iPad-based video projects in the physics teacher preparation courses.

Beyond the valuable physics education research experience that I gained from these international trips, I believe that travelling to a foreign, non-English speaking country has helped me grow as an educator. During my stay in Germany, I had the opportunity to attend several lectures on physics (in German of course). In doing so, I was given a brief look into the struggles of being a foreign language learner inside the classroom. Between my well-founded knowledge of physics and my tenuous (at best) grasp of the German language, I was only able to vaguely follow along with the class. While this experience does not offer any solutions or best practices for working with English language learners in the classroom, it does give me a sense of empathy for new learners. For any teacher in a major metropolitan school district, such knowledge can prove to be invaluable. This is one aspect of the Transatlantic Network that should be taken advantage of more in future exchanges; in addition to providing research opportunities for education researchers, opportunities should be given to new or pre-service teachers to gain research experience and a new perspective on the daily experiences of some of their students.

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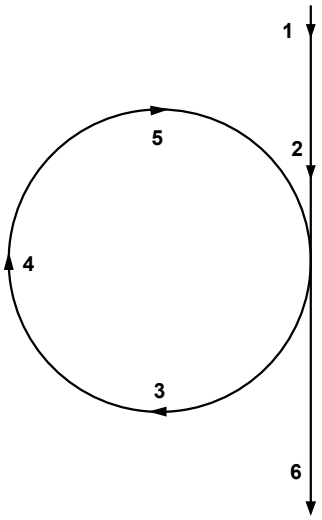
Appendix A

Name: _____

Kreislauf Nr.: _____



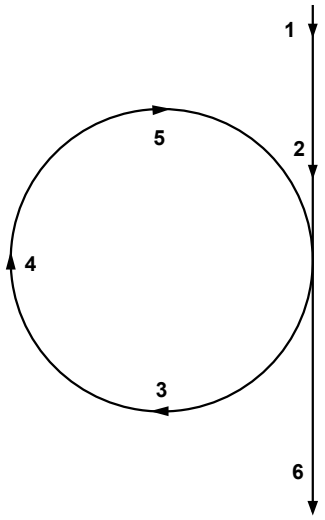
1. Untersuche

Beschreiben Sie die Aufgabe, Vorkenntnisse, und relevante Forschung.

2. Planen

3. Aktion

4. Beobachten



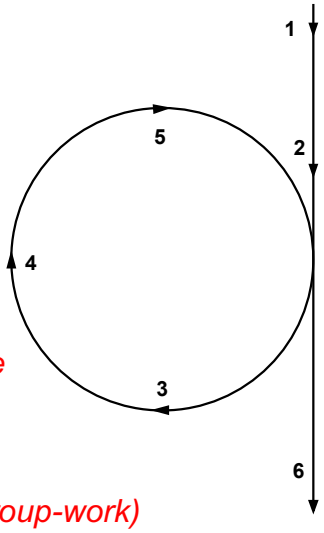
5. Nachdenken

Was funktioniert? Wie kann man den Plan verbessern?

6. Neu Planen

Appendix B

Kreislauf Nr.: ___1____



1. Untersuche

Lernen im Kontext (*Learning in Context*: *how to teach physics In the context of medicine*)
Sach- und Fachinteresse *(Professional interests)*
Action research *(Action Research: what is it and how can it be used in the classroom?)*

2. Planen

Planung der Unterrichtseinheit *(Lesson Plan: jigsaw puzzle group-work)*
Tests erstellen *(Create Tests: Questionnaire administered before and after the lesson)*
Termine mit der Schule koordinieren *(Coordinate dates with the school)*

3. Aktion

Durchführung der geplanten Unterrichtseinheit durch die Lehrkraft *(Implementation of lesson by teacher in class 1)*
Beobachtung der Unterrichtseinheit *(Observation of lesson: Ms. Lorbach sat in on the lesson as an observer)*
Datenerhebung mit Hilfe von Pre-/Posttests *(Data Collection with the help of pre/post-tests)*
Befragung der Lehrkraft *(Interview with cooperating teacher to discuss possible changes for the lesson in Class 2)*

4. Beobachten

Verhalten der SuS *(Behavior of students)*
Verhalten der Lehrkraft *(Behavior of teacher)*
Dynamik in den einzelnen Gruppen *(Dynamic in each group)*
Übergangsstellen *(Crossing points (?))*
Ergebnisse *(Results of post-survey)*

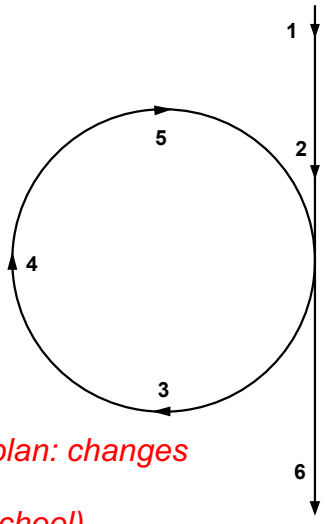
5. Nachdenken

Einteilung der Gruppen *(Division of groups: change the way the students are grouped in phases 1 and 2 of the lesson)*
Schwierigkeitsgrad des Materials *(Difficulty of the material: some students found the material too simple while others were challenged)*
Einstieg (Mind-Map) *(Introduction (Mind-map): create mind map together as a class and save for revisit during final class discussion)*

6. Neu Planen

Veränderte Einteilung der Gruppen *(Change classification of groups)*
Veränderter Einstieg *(Change introduction (mind map))*

Kreislauf Nr.: ___2____



1. Untersuche

Analyse der erhobenen Daten und der Beobachtungen *(Analyze the collected data from class 1's pre- and post-surveys, and observations of class 1)*

2. Planen

Planung der veränderten Unterrichtseinheit *(Updated lesson plan: changes outlined in Table 1)*
Termine mit der Schule koordinieren *(Coordinate dates with school)*

3. Aktion

Durchführung der geplanten Unterrichtseinheit durch die Lehrkraft *(Implementation of lesson by teacher in Class 2)*
Beobachtung der Unterrichtseinheit *(Observation of lesson in Class 2: Again, Ms. Lorbach is in the class as an observer)*
Datenerhebung mit Hilfe von Pre-/Posttests *(Data Collection with the help of pre/post-tests)*
Befragung der Lehrkraft *(Interview with cooperating teacher to discuss possible changes for the lesson)*

4. Beobachten

Verhalten der SuS *(Behavior of students)*
Verhalten der Lehrkraft *(Behavior of teacher)*
Dynamik in den einzelnen Gruppen *(Dynamic in each group)*
Übergangsstellen *(Crossing points (?))*
Ergebnisse *(Results of post-survey)*

5. Nachdenken

6. Neu Planen

Differenziertere Fragen auf den Arbeitsblättern *(Differentiated questions on the worksheet to accomodate different skill levels)*