Eurasia Journal of Mathematics, Science & Technology Education, 2014, **10**(4), 365-369

Learning Pathways, Learning Progression – the Process Matters: an Interview with Prof. Hans Niedderer about his Work as a Physics Education Researcher in Germany

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Received 29 March 2014; accepted 11 April 2014

Hans Niedderer (Figure 1) has contributed a lot to German physics education research. His work includes quantitative and qualitative studies about topics like the learning of physics concepts or the history and philosophy of science in science teaching, he has worked on theoretical issues as well as on textbooks. But it is not only his work that is remarkable. He was one of the physics educators in Germany who believed, from the early days of science education research on, in the need to conduct empirical studies. A closer look at his career provides insights into the development of the discipline of science education and into its establishment as a subject at German universities. In this interview, Hans Niedderer talks about the "leaning pathway" of the discipline of science education in general – and about the value of researching learning pathways and learning progressions for science teaching. For more information and a bibliography of his work please visit his website: http://www.idn.uni-bremen.de/mitarbeiter_eng.php?id=27. The interview with Hans Niedderer was conducted by Christoph Kulgemeyer in 2013 at the University of Bremen.

Keywords: alternative frameworks, learning processes

Prof. Niedderer, how did you get involved with science education research?

I took my first steps in science education research at the University of Tübingen in the early 1960s. I wanted to become a physics teacher and wrote my examination thesis about a new version of the Franck-Hertz experiment. During my work I accidentally became aware that in Kiel a new institute for science education research had been founded – the *Institut für die Pädagogik der Naturwissenschaften* (IPN). The first director of this institute was Prof. Karl Hecht and I decided to apply for a position. I was certain that I wanted to contribute to this new way of research because I was interested in physics – but even more in the way students learn. Luckily, I was successful and I happened to become the first research assistant at the IPN in Kiel in 1965.

Under which circumstances did you work these days? Which topics were important to you?

Science education research was rather new in Germany at that time and we were not sure in which direction we wanted to go. I knew I wanted to

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doi: 10.12973/eurasia.2014.1092a

ISSN: 1305-8223

Figure 1. Prof. Dr. Hans Niederer

contribute to the improvement of physics teaching, but how? I was not certain because I had no experience – but I had the feeling that it had to be through empirical research. Prof. Hecht, however, had a different perspective on the goals of the institute. He wanted to develop new experiments for teaching atomic physics, a topic he had already dealt with before he became director of the IPN. I learned a lot from him and first of all how to perform experiments – something that was very useful for my later work as a professor. But I was not entirely happy with my situation because of the lack of empirical evidence – I was never sure whether or not these experiments we designed really helped to learn physics. But I got the chance to conduct the kind of research I wanted. A new colleague, Stefan von Aufschnaiter, joined the institute and we became a very productive team. We started to develop the so called IPN curriculum on physics, a course from grade 5 to grade 10 with the main goal of showing closer connections between physics and everyday life. We worked on innovative curriculum materials for teachers and students, and their repeated evaluation. Related to this developing of teaching materials, we started empirical studies, including interview studies but also quantitative research with pre- and post-tests, mostly aiming at knowledge about students' alternative conceptions. In cooperation with experienced teachers, we also continuously taught the curriculum ourselves in schools in order to implement and to improve the IPN curriculum. It was the early 1970s and in Germany no one had experience with this kind of empirical developmental research. One example of this relation between development and research was my own doctoral dissertation (Figure 2).

How did you get your PhD?

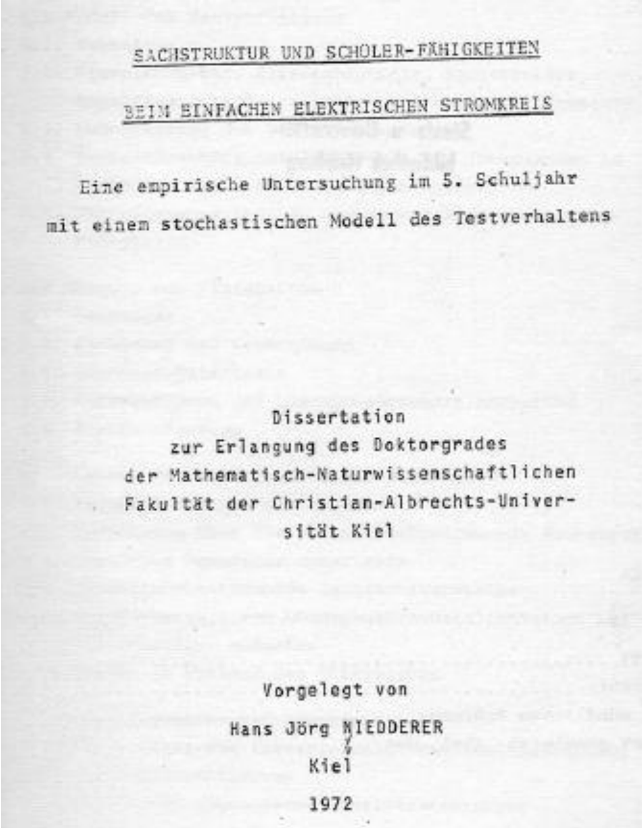
It was not at all usual to get a PhD with a thesis in the field of science education – actually I was the first one in Kiel. My supervisor was Prof. Kroebel, an applied physicist who took a basic interest in this kind of research – but had no experience in it at all. So it was me who worked out the design and who found the methods and their application. I had to work pretty much on my own, even though he discussed with me intensively, often he tried to keep me focussed. Actually I even decided about the topic on my own. My study dealt with teaching basic principles of the electric circuit. The topic occurred to me while I was teaching in schools. Without teaching in parallel I guess I would never have found what is worth being researched; at least I would have had a different picture of it. In the end, I conducted a quantitative study about the understanding of the simple electric circuit in grade 5 (about 10-year old students). The students had to formulate a hypothesis and to conduct relating experiments. Afterwards I taught them basic principles of the electric circuit and highlighted the relationship between the symbols and the actual equipment they could work with. A high level of participation and also a high level of activation were some of the aspects I focussed on during teaching. Finally, I conducted a pre-test, which was similar to the post-test. I could compare the results between the two tests, and also the quantitative results with the hypotheses the students had formulated initially. By this method, I was able to give a quantitative description of the learning process about one aspect of knowledge ("learning curve").

How did your PhD-study affect your later research?

My doctoral dissertation was in my opinion a very important step – not only for me but also as a signal for science education research in Germany since it was one of the first studies and therefore somehow an example. I finished my work in 1972 (Niedderer, 1972). In 1974 I took the next step and became a professor for physics education in Bremen. During the next years I developed my own way of thinking about physics education research.

I am sure there were many colleagues that influenced this way of thinking. Could you name a few?

Sure, there were many colleagues that influenced me a lot when I started to work as a researcher. To name just a few, there were Wolfgang Bleichroth, Walter Jung, Klaus Weltner from physics education, and the psychologist Dietrich Dörner. They were the ones who


SACHSTRUKTUR UND SCHÜLER-FÄHIGKEITEN

BEIM EINFACHEN ELEKTRISCHEN STROMKREIS

Eine empirische Untersuchung im 5. Schuljahr
mit einem stochastischen Modell des Testverhaltens

Dissertation
zur Erlangung des Doktorgrades
der Mathematisch-Naturwissenschaftlichen
Fakultät der Christian-Albrechts-Universität Kiel

Vorgelegt von
Hans Jörg NIEDDERER
Kiel
1972

Figure 2. The title page of Hans Niedderer's PhD thesis from 1972: Content structure and abilities of students with simple electric circuits - an empirical study in grade 5 with a probabilistic model of test behavior

strengthened me in my opinion that thinking about cognition needs a certain level of psychology. I could benefit a lot from the research methods in psychology. In my opinion, science education research basically has two directions – and I am sure we need them both. The first one is very close to the university subject we come from, in my case physics. Researchers of this direction would e.g. work on new experiments or the elementarisation of physics concepts. In my point of view, Udo Backhaus was of the first researchers doing a doctoral dissertation in this direction of science education research. I however felt more comfortable with the second direction, even though I also worked in the first one. Researchers of the second direction are interested in the way learning occurs and most of them are working empirically.

How would you see the German research these days compared to the international research?

Well, later on, I had a more international perspective in my work. For example I twice went as a visiting professor to the United States – both times in San Diego with Fred Goldberg – and once to Monash University in Melbourne, Australia. It was one of the main centres of science education research and I was working with Peter Fensham, Dick White and Dick Gunston. I could benefit a lot from the discussions we had. Much later, after retiring in Bremen, I started working in Sweden and in 2011 I was a visiting professor in Nigeria at the Nasarawe State University in Keffi. The English-speaking countries, as I saw them, had slightly different interests in research than we had in Germany. German science education was always very much interested in a systematic approach to plan teaching and this of course is strongly related to the German notion of "Bildung".

What was in your opinion the most important topic you were working on?

In 1991, we invited a group of leading researchers to Bremen for an international workshop about "Physics Learning – Theoretical Issues and Empirical Studies". We from the Institute of Physics Education at the University of Bremen organized this workshop in cooperation with Fred Goldberg (San Diego State University) and Reinders Duit (IPN Kiel). That workshop was a real highlight of my work. I focussed on what was really important to me during my whole career: learning processes, respectively learning progressions, as we might call it today

Learning progressions and the process of learning – that was in my opinion one of the most important fields of research. Not only for me, of course! I somehow hoped that the workshop in Bremen might be kind of a "kick-off" for this kind of research, an event that might lead to a focus of science education research on learning processes. And there was a lot of important research in this field: Phil Scott comes to my mind, also Dimitris Psillos and Jürgen Petri, one of my doctoral students. Later there were John Clement and Mel Steinberg, or Keith Taber and many more.

Why did you regard the research on learning processes as crucial?

I still expect a lot from this kind of research. A very detailed picture of different ways that learning occurs is a very good way to give research-based advice for better teaching. One example from atomic physics might illustrate how this could work. For example, even if you do not teach Bohr's atomic model explicitly, the research indicates that you should expect this model to be present in students' way of thinking anyway. It is especially present as an intermediate conception – there is the planetary model of the atom on the one hand and on the other hands there are more modern conceptions like the uncertainty principle. A very important intermediate conception a teacher has to be aware of, is the concept of fuzzy paths an electron might take in students' views of the wave model. I am still sure that a teacher who knows about these conceptions is able to deal better with students' answers – well, only by knowing this he will be able to understand what the students actually mean.

And this is a totally underestimated problem. If a teacher simply does not understand what the students actually mean, he or she just regards their answers as wrong and repeats the physics explanation the students had not understood initially. But if he or she knows about students' conceptions and especially those conceptions, which occur in typical learning pathways, the teacher is able to react much more appropriately. That is why I regard this kind of research to be that important. There is no doubt for me that research on alternative frameworks and misconceptions has led to the most important results of science education research in general, but especially when it comes to improving the actual teaching and teacher education. And even though there is the Duit's bibliography (Duit, 2009) – I still do not see the one really good basic literature that summarizes the results of this research in a brief way. I tried to do it myself together with Christoph von Rhöneck for Helmut Mikelskis' "Physikdidaktik" (v. Rhöneck, & Niedderer, 2006) and together with Reinders Duit and Horst Schecker for the "Handbook of Research on Science Education" (Duit, Schecker, Höttecke & Niedderer, 2014). I know what a challenge it is.

If you had to name one other researcher who influenced you the most – who would it be?

In my work as a science educator the researcher that probably influenced me most was Rosalind Driver. I remember her as an incredibly strong person and she had an influence on science education that simply cannot be overestimated. She wrote and edited, together with for example Edith Guesne and Andrée Tiberghien, the best books I know about student's misconceptions, including "children's ideas in science" (Driver, Guesne, & Tiberghien, 1985) and "making sense of secondary science" (Driver, Squires, Rushworth, & Wood-Robinson, 1993).

What do you think are the recent trends in German science education research? What do you think about it?

When German research in science education started, there were mostly quantitative tests conducted. My own thesis was a quantitative study with 160 students, which included a probabilistic model of students' behaviour. Later this kind of models became very important and the more sophisticated Rasch model became popular. After that, in the 80s, there were great qualitative studies in German science education; in my group there were for example Horst Schecker (1985), Thomas Bethge (1988) and Heinz Meyling (1990), but also Jürgen Petri (1996), Marion Budde (2004) and Susann Hartmann (2005) with their doctoral dissertations based on qualitative research. A bit later, in the 1990s, there was also more and more qualitative research in the USA; namely Ken Tobin had a great impact. We somehow had some advance in it. This is also true when it comes to history and philosophy in science teaching – our first project WITOP (epistemological oriented physics teaching) was already in the late 1970s.

Now there is a shift back to a strong notion of very well designed quantitative research, often large-scale assessments. For instance, the groups of Hans Fischer and Elke Sumfleth in Essen are working like that but also Horst Schecker's group in Bremen. I have to say, I see a need for a more balanced relationship between qualitative and quantitative research. The quantitative research also has limits, with this research you simply cannot find out what really happens in learning processes.

Regarding this, what advice would you give a young researcher?

If I had one advice for further empirical research I would say that finding this balance is crucial. If I was a young researcher I would work on intermediate conceptions, learning pathways and learning progressions – I think there is a lot of work to be done. This research should go hand in hand with curriculum development in order to have an impact for the actual teaching. I taught a lot in parallel to my research and that gave me a lot of inspiration.

What would you say is important for further research in science education?

Science education research should in my opinion always be oriented towards a specific content. I would even go so far and say: we should leave research that is not oriented on the content to psychologists, they can do it better. It has always been a part of my paradigm that learning is content-specific. I do not think that there are many general – not content-specific - principles that describe learning; the content matters more. "The learning is learning of something" as Ference Marton once stated. Science education research basically is content-oriented research.

Prof. Niedderer, thank you very much for this interview.

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