ASSOCIATION OF ATLANTIC UNIVERSITIES
ASSOCIATION DES UNIVERSITÉS DE L'ATLANTIQUE

Proceedings of the 2017 Atlantic Universities' Teaching Showcase

Volume 21 | Pages 137–143 | https://ojs.library.dal.ca/auts/index

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Association of Atlantic Universities/
Association des universités de l'atlantque
Editor-in-Chief: Donovan Plumb
www.atlanticuniversities.ca

Volume 21 | *Pages 137–143*

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Abstract

In initial teacher training, is there a bridge between theory and practice and, more importantly, does this bridge hold up when students find themselves in the labour market? For several years, this question has been at the heart of the work of authors who have studied the integration of research in initial training, and more precisely, in initial teacher training. At the Université de Moncton, undergraduate students at the faculty of education take one research course during their studies. However, that course alone does not seem to be enough to get students to really incorporate research both in their other courses and in their

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practicum. Therefore, in order to integrate research in initial teacher training, some changes were made to the mathematics education course. Our goal was both to have students develop a positive attitude towards research and to carry out their own research. In order to do that, the work that they had to do was organized to achieve all the learning outcomes through the implementation of a didactic engineering. Such an approach not only allowed students to make connections between theory and practice by working with pupils in the school system, but also to publish an article in which they shared their experience with other teachers.

Keywords

mathematics education; didactic engineering; research

Part 1 – The Point of View of a Mathematics Didactician

Integration of Research in Initial Teacher Training

On what are teachers basing their actions in the classroom or their decisions when they develop teaching and learning scenarios? What influence does the world of research have (if there is indeed an influence) on the teaching practices of teachers? In initial teacher training, is there a bridge between theory and practice and, more importantly, does this bridge hold up when teachers find themselves in the school system? For several years, such questions have been at the heart of the work of authors who have studied the integration of research in initial teacher training (Ax, Ponte, & Brouwer, 2008; Bergeron & Herscovics, 1980; Kansanen, 1991; Kosunen & Mikkola, 2002; Lysenko, Abrami, Bernard, Dagenais, & Janosz, 2014; Westbury, Hansén, Kansanen, & Björkvist, 2005).

Lysenko, Abrami, Bernard, Dagenais, and Janosz (2014) emphasize the importance of students doing research by specifying that the ones who do research during their initial training may use it more in their future practice. To integrate research with teaching and encourage students to be critical thinkers and to take independent decisions, three elements are essential. Prospective teachers must: 1) develop a general understanding of different methodologies; 2) have a positive attitude towards research; and 3) be able to carry out their own research project (Westbury, Hansén, Kansanen, & Björkvist, 2005).

At the Université de Moncton (New Brunswick, Canada), undergraduate students at the Faculty of Education take one research course during their studies. That course alone, however, does not seem to be enough to get students to really incorporate research both in their other courses and in their practicum. Therefore, in order to integrate research in initial teacher training of students enrolled in the Bachelor of Secondary Education (with a concentration in mathematics), some changes were made to the mathematics education course. Since all students enrolled in the class had previously taken a course on research in education, they already had knowledge about different methodologies. Our goals were thus to have them develop a positive attitude towards research, carry out their own research, and experiment with real pupils. Since we wanted them to develop an investigative attitude by doing research, research became a training objective (Ax, Ponte, & Brouwer, 2008).

Didactical Engineering

The work that students had to do was organized to achieve all the learning outcomes of the mathematics education course through the implementation of a didactic engineering (Artigue, 1996). This research methodology was created in order to take into account the work done in mathematics education during the implementation of specific projects (Artigue, 1996). In a didactical engineering, two elements are taken into account: "the relationship between research and action on the educational system" and "the role that 'didactic achievements' should play in the classroom, in the didactic research methodologies" (free translation, p. 244). A didactical engineering consists of an experimental representation of teaching structured around a case study design and allows someone to analyze, implement, and assess a situation according to four phases:

1) The preliminary analysis: becoming familiar with the didactic knowledge (epistemology of the learning content, teaching, students' conceptions, obstacles and difficulties, etc.) in order to nourish a first reflection and base the design of didactic situations on a general didactic theoretical framework.
2) The design and a priori analysis of teaching situations: targeting micro-didactic variables (local) and macro-didactic variables (global) that will be implemented in the didactic situation. This step includes the development of a didactic situation and the analysis of the challenge that this situation represents for the student. The a priori analysis leads to assumptions in respect, for example, to the actions that pupils could take during the didactic situation.
3) The experiment: carrying out the teaching situation in the classroom.
4) The post hoc analysis and assessment: analyzing the collected data and comparing the results to the assumptions made in the a priori analysis.

Experience Lived in the Mathematics Education Course

Initially, a teacher agreed to open the door of his classroom to us. He identified two key concepts on which the university students could work. Individually, each student decided the concept he or she preferred and made preliminary analysis of the latter. The university students then identified pupils’ conceptions, as well as difficulties and obstacles encountered by students when learning the targeted mathematical concept or mathematical concepts underlying the central concept. They not only described these concepts, difficulties, and obstacles, but also explained why pupils have these conceptions or are faced with these difficulties and obstacles. The university students then developed a diagnostic assessment instrument (a test) based on their preliminary analysis. This test had at least one question for every type of understanding seen in the mathematics education course: intuitive understanding, procedural understanding (logical-physical or logical-mathematical), abstract understanding, and formal understanding (Pepin & Dionne, 1997). The students had to explain the relevance of each question by making connections with their preliminary analysis. The study of the results obtained from these questionnaires allowed them to identify the concept with which they wanted to work until the end of the session. The number and type of errors made by the pupils on the diagnostic evaluation influenced their choice. After targeting the key concept, they developed, as a team, a teaching and learning scenario taking into account both the preliminary analysis and the errors found on the diagnostic assessment instrument. Thus, they developed activities to help students overcome difficulties identified in the preliminary analysis and activities to simply foster the learning of the key concept.

The university students experimented their teaching and learning scenario in a Grade 10 classroom and collected the work done on paper by pupils in order to formatively assess their learning. Subsequently, they did a microdidactic and macrodidactic post hoc analysis of the didactic situation. In the microdidactic analysis, the students described the observed phenomena by making connections with Brousseau’s (1998) theory of didactic situations. They also explained some adjustments that could be made to improve the teaching and learning scenario they had experimented. In the macrodidactic analysis, the students focused on the interpretation of the data collected during the experimentation of the teaching and learning scenario by giving information on the concepts that seemed to be mastered by the learners or on the concepts that proved to be problematic. The interpretation of this data allowed them to make connections with the a priori analysis by identifying the main solutions submitted by the pupils, the knowledge underlying these solutions, as well as any difficulties or obstacles they faced and the errors they committed. Finally, they narrated their experience in a text that they published in a professional journal.

The following section recounts the experience lived by the three mathematics education students. They present what they have discovered or developed through the didactic engineering and what they got out of this unique experience in their academic journey.

Part 2 – The Point of View of Three Mathematics Education Students

Personal Experience: Student Reflections

Throughout this process, we learned that there are many different ways of teaching. In mathematics, it is important for pupils to truly understand the concepts they are learning rather than memorize formulas. This made us wonder if it is possible to make concrete connections between different mathematical concepts (construction of knowledge) and made us realise that traditional teaching methods are not always better, because they are mostly based on intuition rather than research. This sent us on a journey to find a more concrete way of teaching a math concept to pupils. Within the context of our mathematics education course, we learned how to use a didactic engineering in order to create a teaching scenario. As future teachers, it was important for us to find ways to step outside of the box and elaborate a scenario that would engage pupils in the learning process. Not every pupil has the same way of learning and it is obvious that the standard way of teaching leaves some learners to fend for themselves. We wanted to change this by finding ways to elaborate a scenario that would, among other things, allow students to move around in the classroom or even outside of the classroom.

An important aspect of being a good teacher is being able to predict common mistakes and analyze these mistakes. This overall experience made us realise the importance of doing so in order to help the pupils grow as active learners; something that is usually learned with years of teaching can be understood sooner with some research. We realize that there is still a lot of work to do to improve the teaching process in relation to mathematics, but this experience has given us the motivation to keep doing research in this field of study.

Final Thoughts: Issues of Pedagogical and Didactical Order

The interest developed by the university students for research was visible, not only during the mathematics education course, but also after the course had ended. Indeed, students from the session that ended in April 2013 decided to participate in the Colloquium for young researchers at the Université de Moncton almost one year later in March 2014, and proudly won the third prize in the Human and Social Sciences category (undergraduate studies).

Moreover, one of the students who participated in this project decided to enroll in graduate studies, in part because of the experience lived in the mathematics education course. The same phenomenon was also observed 2015 and 2017, wherein students published their article in a professional journal and won the second prize in the Human and Social Sciences category (undergraduate studies) in the Colloquium for young researchers. Furthermore, they both decided to enroll in graduate studies. Thus, it seems that the integration of research in initial training for students enrolled in the Bachelor of Secondary Education not only allowed us to reach the learning outcomes in the mathematics education course, but also had repercussions on graduate recruitment, interesting students enough in research for them to enroll in graduate studies.

Consequently, what we experienced within the framework of the mathematics education course was very positive, both for the students and for the professor. Nevertheless, several questions remain. It should be noted that only three or four students were enrolled in the secondary mathematics education course when this project was done. It is largely the low number of students that led us to attempt something different with them. Indeed, the size of the group allowed us to better support students throughout the semester by assessing formatively the various stages of their didactical engineering, following them closely, but without suffocating them in their learning. Would it be realistic to think that we could do as much with a class of 25 or 50 students? Furthermore, would the management of partnerships with teachers become problematic with a larger number of students? Indeed, it could be difficult to find enough teachers who would be ready to welcome students into their classroom.

Developing a teaching and learning scenario based on research and experimenting it with high school students seems to be very enriching for university students, but could possibly be difficult to manage for professors based on the number of students to oversee. How could we allow more students to live such an experience during their undergraduate studies, an experience which is very relevant from a didactical and educational point of view, but which could turn out to be problematic from a logistical point of view?

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