CONCEPTUALISING A GERMAN MATHEMATICS EDUCATION TEACHER PROFESSIONAL DEVELOPMENT COURSE BASED ON A SOUTH AFRICAN SUCCESS MODEL

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ABSTRACT–The purpose of this paper is to indicate how a successfully implemented Teacher professional development (TPD) course from South Africa, can be adapted to conceptualize a similar course for students to become mathematics teachers in Germany. This TPD course was designed for teaching teachers to use mobile technology to enhance their classroom practice. Through several studies which included Information and Communication Technology (ICT) in education it became obvious, that the teacher cannot be replaced by technology, but has to play a major role in the education process. As mobile phones are widely accessible in South Africa, concepts for teaching with mobile devices and teacher training have been developed and implemented in South Africa in a specific ICT for Development (ICT4D) initiative. Through teaching projects in South Africa and Germany a comparative study of the use of ICT in education to support mathematics education is conceptualized. This study is conducted to find synergies, identify transferable practices, identify best practice, and to establish research links and communities of practice between researchers and students in higher education institutions with relevant experience in both countries. In this paper a first draft for a teacher education professional development for teaching with ICTs in mathematics is presented, which is developed into a framework for the inclusion into teacher education at universities in South Africa and Germany.

Keywords: ICT4D, Electronic Teaching, Mathematics Didactics, OpenSource

1. INTRODUCTION

The CSIR, South Africa, and the University of Koblenz-Landau (UKL) have been collaborating since 2011. Based on this collaboration and exposure of UKL researchers to the ICT4RED initiative in South Africa, researchers from the UKL decided to use the experiences from this project to develop a mathematics education teacher professional development course based on the South African success model. Due to the option of one researcher from the UKL to give a course on the use of digital media in education at the University of Siegen (US) in Germany, a pilot course called "TPD4MathED@Uni" was developed and carried out. The developed TPD4MathED@Uni will be optimized, adjusted and applied in a course at the University of Pretoria (UP) in South Africa and/or UKL in Germany and so forth, in which the researcher who developed the course is included as lecturer, as well. We can tremendously benefit from synergy collaborations, because all three included Universities are focused on teacher education and the involved institutions are focused on mathematics education. The TPD4MathED@Uni will be optimized again and the course material will be made available for free in a way that enables reproducibility of the TPD4MathED@Uni in other courses in mathematics education at other Universities in German or English speaking countries.

This paper is structured as follows: first the questions "What are mobile devices and why should they be used in education?" and "How is the ICT4RED TPD designed?" will be answered, then the objectives are stated. We will go into the use of ICTs in teaching in South Africa and Germany and the Methodology that was used to develop the TPD4MathED@Uni will be outlined as well as results and business benefits. The paper closes with a conclusion.

1.1. What are mobile devices and why should they be used in education?

Mobile ICTs are new media, which could have the potential to transform education and student learning in both developed and developing countries, (Dutta et al., 2015). Schools should be cognisant that children are exposed at an early age to mobile ICTs in their family life and should therefore support children to apply ICTs in their learning in schools. Pavlik mentioned already in 1998 the fact that "Today's children and youth are the heaviest users of new media technology.", (Pavlik, 1998). This citation is still valid and can be verified by several studies like the KIM and JIM-studies in Germany on the importance of the media in everyday life of children or resp. youths (6 to 13 years or resp. 12 to 19 years), (MFS, 2000-2015). Thus, since children are exposed at a young age to using ICTs, the teaching of media skills should also start earlier. Through media education in school, we can prepare the youth for a future that will be shaped in all areas of life by ICTs and create also risk awareness about the usage of ICTs. (Bertow, 2008). Among others, Herselman & Botha (2014), state, that the teacher professional development (TPD) component of the ICT4RED initiative (http://www.ict4red.co.za/) implemented in South Africa made this initiative a success. "Attendance was high and teachers started their own co-creation of content, lessons plans and sharing this in communities of practice with similar teachers in their area." (Herselman & Botha, 2014). The main task of (digital) media in education is mainly to support the teacher and his/her teaching. It can provide a positive learning effect, if active learners are created, (Bachmair, 1979). This paper therefore seeks to address the following research question:

How did the ICT4RED TPD course in South Africa inform the development of a mathematics educator TPD course for students in Germany?

1.2. How is the ICT4RED TPD designed?

The Technology for Rural Education Development (TECH4RED) initiative by the CSIR (South Africa) aimed to contribute to the improvement of rural education via technology-led innovation in South Africa. It consisted of various components of which TPD was regarded as a crucial component for success. The aim of the ICT4RED TPD was to support and guide the development of relevant teacher knowledge and proficiency to enable rural classroom practice to portray a 21st century technology enhanced teaching and learning engagement, (Herselman & Botha, 2014). It is innovative as it presents a practical, free, practice based peer reviewed course and methodology of how teachers in rural, resource constrained contexts can be empowered and supported to integrate technology to address 21st century teaching and learning challenges. The significance of game design elements such as simulation and fun, technology endowment in need rather than in case (earn as you learn), adequate scaffolding, a clear learning path with interim learning goals articulated as badges and relevant ICT enhanced teaching strategies contribute towards the unique innovativeness, (Herselman

Botha, 2014). The implementation of a TPD in the manner of ICT4RED in schools and especially during teacher education can contribute to enhancing teaching with ICT in South Africa and in Germany. Of course, such a TPD course needs to be adjusted to the requirements, needs and constraints of both South African and German teacher education. Furthermore, collaboration and the sharing of ideas and lessons learnt are essential to make such a project a success. Specifically for teaching with ICT, guidelines for the use of ICT and concrete teaching material in this context should be created and provided for free to enable access to useful material and thus improve the teaching practices with ICTs and the use of ICTs in schools, (cf. Platz & Niehaus, 2016).

2. OBJECTIVES

Focusing on the research question, the objectives of this paper are to:

Describe the basis of ICTs in teaching in South Africa and Germany.

Propose a first draft design for a teacher professional development for mathematics education at university, which can be implemented in South Africa, Germany and other countries.

3. ICTS IN TEACHING IN SOUTH AFRICA AND GERMANY

3.1. ICTs and mathematics education in South Africa and in Germany

Comparing South Africa and Germany concerning the distribution of ICTs, mobile device penetration is higher in South Africa, while personal computers are currently used more frequently in Germany, (cf. Dutta et al., 2015). In both countries, the trend goes towards mobile devices.

In scholastic standards in Germany, the use of ICTs in teaching is only explicitly mentioned in the standards for Secondary Education I. Nevertheless, both the use of traditional media and ICTs can be found in numerous framework curricula. According to the "standing conference of the Ministers of Education and Cultural Affairs of the Länder in the federal republic of Germany" (KMK), modern education in school is unthinkable without media education, (cf. Schwarzenberg, 2012).
The 2005 curriculum of South Africa does not exclude the integration of ICTs, but "welcomes their use where they may be appropriate to achieving educational outcomes. However, this document for SA, does not make special provision for the use of ICTs, nor does it offer specific guidelines on the use of ICTs in the core curriculum.", (Holcroft, 2004). In 2004, the White Paper on e-education, which represents a new framework for the collaboration of the South African Government and the private sector in the provision of ICTs in education, was published. "Through this initiative, we hope that we will be able to turn our schools into centres of quality learning and teaching for the twenty-first century.", (DoE, 2004).

Dutta et al. (2015), classify the quality of the South African educational system on rank 139 of 143 considered countries and the quality of math & science education even on the last rank 143. The implementation of ICTs into education might lead to an improvement. A novelty to contribute to the optimization of math & science education will be to tailor the TPD to math & science education. As a first step, the TPD will be adjusted to mathematics education.

3.2. How and why is a transfer of the TPD supposed to work?

A successful project, the South African ICT4RED initiative (see Section 1.2), is chosen as basis. The ICT4RED TPD course endeavored to build a toolbox of skills, technology and competencies that would empower teachers to integrate technology meaningfully into their classroom practice in order to portray a 21st century engagement. Each module in the curriculum is *about* relevant content *through* a teaching strategy *using* technology to facilitate the teaching and learning interaction. In addition teachers would be exposed to: best practice in group work; different assessment strategies; concept of a reflective practitioner; and concepts regarding online learning and additional resources, (Botha & Herselman, 2015a).

In Germany, there exist several offers for teacher professional developments from central organisations, but they usually are not adjusted to the schools' or teachers' needs and many teachers do not find the time for participating in such TPDs beside their daily work in school.

Consequently, the implementation of a TPD in the manner of ICT4RED in schools and during teacher education can contribute to enhancing teaching with ICT in both countries. Of course, such a TPD needs to be adapted to local requirements and constraints. Differences between Germany and South Africa exist and need to be addressed. Furthermore, collaboration and the sharing of ideas and lessons learnt is essential to make such a project a success. Specifically for teaching with ICT, guidelines for the use of ICT and concrete teaching material in this context should be transferred to the local context to enable access to useful material and thus improve the teaching practices with ICTs and the use of ICTs in schools.

4. METHODOLOGY – The Development of the TPD4MathEd@Uni

A teacher professional development for mathematics education at university (TPD4MathED@Uni) is prepared in a project with collaboration partners of the countries Germany and South Africa.

4.1 Expansion of the TPD

Therefore, the TPD which was developed in the context of ICT4RED is expanded in the following way:

Difference	ICT4RED's TPD	TPD4MathED@Uni
Target Group	Teachers (implementation of tablets use in resource deprived schools)	Students at University, who want to become a mathematics teacher (implementation in Universities). This is done, because it is important that future teachers get educated about how to use ICTs in education and about how to convey media competencies to their future pupils as early as possible. As soon as they are teachers and work at schools, there exists the option to take part in TPDs on the use of ICTs in teaching, but most of the teachers do not confirm this offer, because they do not have the time or do not see the necessity to take part. Therefore, a mandatory implementation as study course at university could raise the awareness of the importance and the potentials of the use of ICTs in school education.
Country-Specific Curriculum	South African Curriculum (CAPS)	German Curriculum. The contents were adapted to the German curriculum and to German language, because lecturing in Germany is done mostly in German and students struggle a lot with English. The translation was done in order to avoid the obstacle of the language-barrier. The new developed content will be translated back to English to enable the use in English-speaking countries.
Content Focus	Subject-independent training	Tailored to mathematics education. The thematic focus was shifted and tailored to mathematics education, because it might be easier to implement a new course into the university structure and into the curriculum, if it is subject-specific. Furthermore, the expertise of the collaborating researchers is mathematics education. Media-competencies are especially important for mathematics, as most occupations, which require skills with ICTs also require mathematical skills.
Technology used	Android tablets were provided toteachers which they had to earnthrough evidence of application of their training in the TPD	Own mobile devices (any type)

Connectivity	TPD course was developed not to use the internet based on the context and infrastructure of schools	As not each school in Germany is equipped with internet, the course might implement sequences with internet use, but it should not be a necessity
Teaching strategies	Applied nine teaching strategies [12;13]	Until now, only six teaching strategies were applied, but others are supposed to be supplemented.
Earn-as-you-learn	Teachers were rewardedwith badges for completing with evidence all the modules (Botha & Herselman, 2015a)	The reward system still needs to be implemented and adapted, digital badges are supposed to be applied.
Simulations	Each module was presented to teachers with simulations e.g. storytelling was done through storytelling etc. (Botha & Herselman, 2015a)	The modules are presented to the students with simulations, furthermore, the Geocaching module implements the method learning by teaching based on Martin (2002).
Gamification	Educational Gamification was applied which is about learning and learning gains. The game	The Educational Gamification still needs to be implemented and adapted.

The TPD was discussed with students in a course at the US in Germany and some modules were chosen and adjusted in the way described above in collaboration with the students. Furthermore, a new module is currently developed. Therefore, in this course, the students act as content creators for capacity building in the field of Open Educational Resources (OER). Their target group are other mathematics students or teachers. This course will be described in more detail in Section 4.2. This course structure will be adjusted to the South African conditions and implemented again at the UP in South Africa. Afterwards, the developed TPD4MathED@Uni will be optimized, adjusted and applied in a course at the UKL and/or Siegen in Germany and so forth. We can tremendously benefit from synergy collaborations, because all three included Universities are focused on teacher education and the involved institutions are focused on mathematics education. The TPD4MathED@Uni will be optimized again and the course material will be made available for free in a way that enables reproducibility of

the TPD4MathED@Uni in other courses in mathematics education at other Universities in German or English speaking countries. The TPD4MathED@Uni shall then be enhanced and supplemented by lecturers and students, and an exchange between lecturers and students from the Universities in the manner of a community of practice can then materialise.

4.2 The course on digital media in education at the US in Germany

Within a course on digital media in education (supplement on teaching methodology in mathematics didactics, 15 meetings with a duration of 90 minutes) at the US in Germany, the ICT4RED TPD was discussed with students who are studying to become mathematics teachers for primary schools. Following this, individual modules of the ICT4RED TPD were chosen by the students and adapted as TPD4MathED@Uni (see Section 4.1). Furthermore, a new module on Geocaching in mathematics teaching was developed.

In detail, the course structure is as follows:

Introduction to digital media: The term “ICTs”; Available hardware and software; Use of digital media in schools: Curricular and educational standards, Benefits and challenges/ risks

Teaching and Learning Organization: The ICT4RED initiative; Practical Phase: Transfer of the TPD-modules to mathematics teaching in Germany

Learning Apps: The term “learning app”; Criteria catalogue of evaluating apps; Presentation of some “good evaluated” apps

Project: The term “project”; Project: Geocaching; Practical Phase: Realization of a project: geocaching in Siegen

Conclusion and reflection

The results of this course are documented on a Wikiversity-page:

https://de.wikiversity.org/wiki/OpenSource4School

Using this tool, the teaching concept is supposed to be made available for everyone and the concept can be adjusted and modified and communication can take place via Wikiversity, which is a project of the Wikimedia Foundation for the collaborative creation OER (https://en.wikiversity.org/). At the same time, the students learn to deal with Wikis and how to share their knowledge (learning by being an author). Therefore, the documentation of the course is supposed to be made detailed to enable reproducibility. As trainee teachers are supposed contribute to the development of the page, who have never before worked with such a tool, the creation will be a process, which has to be monitored and supervised and maybe also corrected at some points. Initially, the students work in German language, after reviewing the contents of the page, the information will be translated in English by the supervisor (or lecturer).

This site is supposed to be extended to a course, which has the purpose of a knowledge repository for teaching with ICTs which shall be used by teachers as authors and recipients and that can be linked to the ICT4D knowledge repository developed in a project of Platz & Biljon (2015). In the repository, OER on teaching with ICTs are supposed to be aligned, shared and discussed.

5. RESULTS AND BUSINESS BENEFITS: PROFESSIONAL DEVELOPMENT

Consequently, two differently aligned course structures can be derived: In the structure presented in Section 4.2, the students act as OER creators who develop teaching material themselves. The idea is,

that the students learn by teaching: “If students independently develop a learner's section and present it to their classmates, if they also check whether the information has really arrived and if they ultimately make the material internalized through appropriate exercises, this is ideally typical of the method of learning by teaching.”, (Martin, 2002). Consequently, the first step of learning by teaching can be performed with the proposed course by letting the students develop their own TPD4MathED@Uni modules. The students also present the content to their “classmates” by sharing the developed content via Wikiversity. The next step would be to let the students (acting as teachers) test their developed modules with other students (acting as learners). On this basis, further courses can be developed fulfilling the whole process of learning by teaching. The co-creation element from ICT4RED TPD is therefore applied here.

The teaching material, which is developed in such courses can then be directly used by lecturers or teacher trainers. The students or attendees have then the role of consumers of knowledge.

By initiating a community of practice, an Open Community is supposed to be created. The concept of Open Community is used as measure and draft strategy for a participative communication and an efficient knowledge management, (Niehaus, 2013). Using this concept, already developed components of Open Source software and Open Content can be modified and adjusted. The advantage is faster development, improvement and distribution of the content, in our case, the TPD4MathED@Uni material. The course material can be provided free of charge.

A professional development of teachers and teacher trainees on the use of ICTs in teaching has the potential to lead to better teaching and education of students. Consequently, competent persons can be educated in schools which have valuable ICT-skills and media competences required by employers in all areas, industrial and non-industrial.

6. CONCLUSIONS

One main issue for ICT in education projects that work is identified by Dutta et. al. (2015) as “delivering quality digital educational content, which must provide in-depth focus on the quality and availability in multiple languages, especially targeted at educators.” This issue will be addressed by developing a TPD4MathED@Uni based on the ICT4RED principles adjusted to local conditions. This can only be a success, if collaboration, co-creation and sharing takes place amongst teachers and learners in the form of communities of practice between schools, teachers and learners. In the present paper, the basis of ICTs in teaching in South Africa and Germany were described and a first draft design for a generative teacher professional development for mathematics education at university which is implemented in Germany and in South Africa and which can be used in other English- or German-speaking countries, as it is documented in Wikiversity to enable reproducibility, was proposed.

References

Dutta, S., Geiger, T. Lanvin, B. (2015). The global information technology report 2015. In Living in a Hyperconnected World. Geneve: World Economic Forum INSEAD.
Pavlik, J. V. (1998): New media technology. Cultural and commercial perspectives. 2nd [rev.] ed. Boston: Allyn and Bacon.
Medienpädagogischer Forschungsverbund Südwest (MFS) (2000-2015): KIM/ JIM-Studie 1999-2014. Kinder/ Jugendliche und Medien, Computer und Internet.
Bertow, A. (2008): Schüler, Lehrer und neue Medien in der Grundschule. Mediennutzung im Kontext von Entwicklungstendenzen sowie technischer Voraussetzungen. Hamburg: Kovac (Schriftenreihe Medienpädagogik und Mediendidaktik, Bd. 14).
Herselman, M. & Botha, A. (2014). Designing and implementing an Information Communication Technology for Rural Education Development (ICT4RED) initiative in a resource constrained

environment: Cofimvaba school district, Eastern Cape, South Africa. Pretoria, South Africa: CSIR Meraka.
Bachmair, B. (1979): Medienverwendung in der Schule. Analyse- und Planungsbeispiele für den Unterricht mit audiovisuellen Medien. Berlin: Volker Spiess.
Platz, M. & Niehaus, E. (2016): What can we derive from South Africa in the field of mobile learning?, in Beiträge zum Mathematikunterricht 2016.
Schwarzenberg (2012): Medienbildung in der Schule. Ständige Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland (KMK).
Holcroft, E. (2004): SchoolNet South Africa, in: Information and Communication Techonologies for Development in Africa, Volume 3, Networking Institutions of Learning – SchoolNet. International Development Research Centre, Council for the Development of Social Science Research in Africa.
Department of Education (DoE) (2004): White Paper on e-Education. Transforming Learning and Teaching through Information and Communication Technologies (ICTs).
Platz, M. and Van Biljon, J. (2015), May. Design of an open ICT4D knowledge repository. In IST-Africa Conference, 2015 (pp. 1-11). IEEE.
Botha, A & Herselman, ME. 2015a. ICTs in rural education: Let the game begin. Submitted to ACM Symposium on Computing for Development (DEV-6). London, 01-02 December 2015. http://acmdev.org/program.php.http://delivery.acm.org/10.1145/2840000/2830646/p105botha.pdf
Botha, A. & Herselman, M.E. 2015b. A Teacher Tablet Toolkit to meet the challenges for 21st Century rural learning environments. South African Journal of Education. Vol 35, No4. Doi: 10.15700/saje.v35n4a1218. E-ISSN 2076-3433.
http://www.sajournalofeducation.co.za/index.php/saje/article/view/1218/609.
Martin, J.-P. (2002): Weltverbesserungskompetenz als Lernziel? in: Pädagogisches Handeln – Wissenschaft und Praxis im Dialog, 6. Jahrgang, 2002, Heft 1, S. 71–76
Costello, B & Edmonds, E. 2007. A study in play, pleasure and interaction design," in Proceedings of the 2007 conference on Designing pleasurable products and interfaces, 2007, pp. 76-91.
Niehaus, E. (2014), Definition: Open Community - Action Team 6 Follow-Up Initiative. http://at6fui.weebly.com/open-community-approach.html , retrieved: 22/11/2016.