The Impact of Using Geography Open Education Resources (OER) to Capacitate Natural Science Teachers Teaching the *Earth and Beyond* Strand in South African Schools

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Abstract

In 1994 South African curriculum developers decided to include aspects of Physical Geography in the Natural Science Intermediate and Senior Phase curriculum as a strand named *Earth and Beyond.* One of the complicating factors was that most in-service teachers that had to teach this strand had no training in post-school Geography or even worse, might not have taken Geography in the last three years of schooling. Research was undertaken to determine how the gaps in Geography knowledge, skills, resources and teaching skills amongst Natural Science teachers, with special reference to the *Earth and Beyond* strand in Natural Science teaching, could be overcome. A baseline survey was conducted and initial school visits were undertaken to determine what the situation was regarding the teaching of the *Earth and Beyond* strand in schools in a mostly poor rural school district in Kwa-Zulu Natal, South Africa. Findings indicated that none of the Natural Science teachers visited, had any post-school training in Geography. Classroom observations indicate that more than 90% of the teachers use only direct instruction when teaching the *Earth and Beyond* strand; they use only

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textbooks and less than 10% of classrooms have even the basic resources like a globe or an updated map. An intervention strategy aided by the use of needs driven purposefully designed Open Education Resources (OER) was undertaken and a pre- and post-test were written to determine the impact of the intervention. This was followed up by personal interviews and follow-up school visits to determine the possible sustainability of the impact in practice. Findings indicate that the intervention had a significant immediate impact and that some of that was sustained in practice because of the use of Open Education Resources (OER).

Keywords: OER, intervention, pedagogic knowledge, content knowledge, Natural Science, Earth and Beyond, Geography teaching

1. Introduction

In 1994 South African curriculum designers and developers decided to include aspects of Physical Geography in the Natural Science intermediate and Senior Phase curriculum as a strand named *Earth and Beyond*. The inclusion of Physical Geography in the Natural science curriculum that stems from the Outcomes-Based Education (OBE) curriculum has been retained in the subsequent National Curriculum Statements (NCS) and Revised National Curriculum Statements (RNCS) (Department of Education [DOE] 1997) as well as the current Curriculum and Assessment Policy Statements (CAPS) (Republic of South Africa [RSA] 2011).

This inclusion of Physical Geography in Natural science teaching had some perhaps unforeseen effects in schools. One of the complicating factors of the implementation of a Natural Science curriculum containing geographical elements was that many in-service teachers that had to teach the *Earth and Beyond* strand had no training in post-school Geography, since no teacher education programmes offered training in this strand when it was implemented. The *Earth and Beyond* strand is one of four strands taught in Natural Science Senior Phase (Grades 7 - 9) and as such should be allocated 25% of teaching time. Without Geography specific Pedagogical and Content Knowledge (PCK) it would be unreasonable to expect these teachers to teach the *Earth and Beyond* strand effectively.

As far as could be determined no research has been undertaken to esta-

blish what the situation is regarding the teaching of *Earth and Beyond* strand and if interventions to assist Natural Science teachers in teaching it had the desired effect. It was therefore the purpose of the study to undertake research by:

- determining what the status is regarding the teaching of the *Earth and Beyond* strand in a poor rural educational district in KwaZulu-Natal;
- purposefully designing needs-driven OER based on teacher needs;
- undertaking an intervention through intensive workshops using the OER focused on identified gaps in geographic knowledge and teaching skills; and
- determining if the intervention to empower Natural Science teachers to teach this strand had an impact in schools.

The research question therefore was: Will an intervention that includes focused needs-driven purposefully designed Open Educational Resources (OER) with the aim to improve geographical content and pedagogical knowledge have a positive impact on out of field/out of speciality teachers teaching the *Earth and Beyond* strand?

Open Educational Resources (OER) are freely accessible, openly licensed documents and media that are useful for teaching, learning, and assessing. It is the leading trend in the distance education/open and distance learning domain as a consequence of the 'openness' movement (Bozkurt, Akgun-Ozbek, Onrat-Yilmazer, Erdogdu, Ucar, Guler, Sezgin, Karadeniz, Sen, Goksel-Canbek, Dincer, Ari & Aydin 2015:330). Rural teachers have limited access to educational resources and this research endeavoured to determine whether the use of OER during interventions could enhance not just teacher Pedagogical Content Knowledge (PCK), but also expand their access to educational resources for their learners to benefit from.

The context where the research was undertaken was an extremely poor rural area in KZN in South Africa. The schools differed in terms of the infrastructure and available equipment, but all were under-resourced with predominantly poor learners and parents. All schools were fully staffed, but some of them were out of field/out of speciality teachers, teaching subjects they were not fully trained for, particularly in Sciences and Mathematics.

2. Literature Review

One of the most problematic issues impacting negatively on achievement of learners is the number of out of field teachers (Rotherham n.d.) which is a worldwide concern (Du Plessis, Carroll & Gillies 2017). Teachers teaching the *Earth and Beyond* strand in South Africa are effectively part of this group of teachers, because the strand they have to teach is new and relatively few Natural science teachers have received Physical Geography training to empower them to teach the strand. Rotherham (ibid.) postulates that it is a situation similar to what happened in the USA, where 66% of teachers in deprived schools have not been trained for the subjects they teach. This lack of training has hampered efforts to close the achievement gap in such schools.

In 2003 John Hattie published ground-braking research based on 500 000 studies to determine which variable has the greatest influence on learner achievement. The largest influence, except for the learners themselves, is by far that of teachers (Hattie 2003). Successful learning can directly be aligned with the quality of teaching received (Rotherham n.d.; Haycock 2007) and quality teaching in turn is directly dependent on the subject knowledge of the teacher (Buckingham 2005; Ball, Thames & Phelps 2008; Stronge, Ward & Grant 2011).

In his research Hattie (2003:7) also found that expert teachers can be distinguished from other teachers, because of their ability to 'organise and use' their subject knowledge (Hattie 2003:5). Very significantly, another finding was that excellent teachers are better at 'guiding learning through classroom interactions' (ibid.).

According to Sanders and Rivers (1996), Kain (1998), Fallon (n.d.) and Mondal (2014) good teaching mostly results in better learner achievement. Such achievements will improve even further if there is a continuation of good teaching. Even in cases where learners were subjected to poor teaching for a long time they will improve substantially when they are exposed to effective teaching. Moreover, when effective teaching continues year after year, the impetus is observed.

Findings by Haycock (2003) support this view and indicate that research has proven that:

- Substantial improvements in achievement are possible even for disadvantaged poor learners if they receive quality teaching;

- Receiving quality teaching four consecutive years can close the achievement gap between learners; and
- The influence of a quality teacher on learner achievement is 20% higher than any other variable, even when considering the size of the class and poverty.

Leigh and Mead (2005) similarly found that knowledge and teaching skills of teachers are the most important factors that influence learning. Efforts to improve learning should, therefore, take cognisance of these aspects (Fallon 2003). Pas, Bradshaw, Hershfeldt and Leaf (2010), who are of the opinion that targeted interventions should be used to support teachers towards improvement of Content Knowledge (CK) and skills to teach their subject, echo this.

The early history of teacher education was primarily focused on teachers' knowledge of subject content (Shulman 1988). CK alone is however, not enough for effective teaching. It is more important how CK is used during teaching than just having in-depth CK. In other words, what should be aimed for is expert PCK which can be described as a synergy between CK and PK.

The key to distinguishing the knowledge base of teaching is found at the intersection of content and pedagogy, and the capacity of teachers to transform the CK they possess regarding forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the students (Shulman 1987; Kleickmann, Richter, Kunter, Elsner, Besser, Krauss & Baumert 2013). The conclusion is that effective learning may be achieved through effective teaching by teachers equipped through targeted capacity building interventions with successful strategies that work (Rowe 2006), which was the intention of the intervention reported on in this article.

Yuan and Kueilan (2006) are convinced that technology and pedagogy should be 'married' in modern times. Mishra and Koehler (2005) go even further and assert that deep conceptual learning, requires the development of a complex, situated form of knowledge named Technological Pedagogical Content Knowledge (TPCK) which in essence is the complex interplay among three main components of learning environments: content, pedagogy, and technology.

The acronym was later changed to TPACK (Thompson & Mishra 2007) to emphasise the fact that knowledge of technology does not automatically transfer into effective teaching with technology (also called

instructional computer use by Sahin 2011). Teachers have to learn how best to utilise technologies that will support specific pedagogies in a particular subject (Thompson & Mishra 2007).

Mays (2011) is of the opinion that teachers need to be capacitated to use technologies that are most appropriate to their contexts and needs and many OER are available to accomplish just this. Although OERs have been used for almost a decade they are relatively new in South Africa (Czerniewicz & Goodier 2014) and teacher education institutions could benefit from modelling and using OERs in their programmes and interventions. The use of OERs enriches the learning experience (White & Manton 2011) and the materials are more up to date, but more importantly they:

- Address teachers' specific needs through providing opportunities for supplementary learning, skills development and presenting content in different ways to address students' interests and preferences;
- Save teachers effort, through enabling them to offer their students learning materials where they lack the skills or the means to create these themselves;
- Enable teachers to teach topics that lie outside their current expertise;
- Stimulate networking and collaboration among teachers (Masterman & Wild 2011).

Taylor and Vinjevold (1988) conducted research on teachers and teaching in South Africa and made two very significant findings: teachers did not know the curriculum content therefore making numerous mistakes when teaching it and teachers almost exclusively used direct instruction as their mode of delivery. More recent research in South Africa by Spaull (2013) indicates that the lack of CK remains a big concern. Natural Science teachers have great difficulty in teaching geographical aspects (the *Earth and Beyond* strand) if they do not have sufficient knowledge of the subject. They are therefore, unable to transfer accurate in-depth knowledge (Lane & Catling 2016) even if they have the skills to teach.

Although research has shown the benefits and importance of initial direct instruction (Rowe 2006), this could be built on, followed by or combined with constructivist approaches to try and ensure deeper and richer conceptual

learning. There is a concern that teachers may however exclusively use only direct instruction in their teaching.

Du Plessis (2015) did some informative research on out of field teaching in South Africa and the challenges associated with this phenomena, but no research was found specifically dealing with Natural Science teachers who have no training in Geography, but have to teach the *Earth and Beyond* strand dealing with Physical Geography. There is also a dearth of research on the influence of OERs in teacher professional development in South Africa. In Africa and India respectively TESSA and TESS-India projects are run by the Open University in the UK, where OERs are being utilised to upgrade teacher knowledge and skills with very positive results (Buckler, Perryman, Seal & Musafir 2014).

The theoretical framework for the study was informed by a Theory of Change, the spiral model of supporting learning interventions (Sguazzin & du Toit 2000) and a conviction based on experience and research that participants must be consulted before an intervention regarding the approach and structure of the intervention and that their real needs must be determined beforehand (Dreyer 2014).

A theory of change is a 'plan' of how a desired change is to be achieved in a particular context. It maps the way in which an intervention and its associated activities are going to take place to achieve its desired goal or outcome. In this research the desired change that was aimed for as a result of an intervention utilising purposefully developed needs driven Geography OER is the improvement of Geography subject content knowledge and teaching skills of teachers teaching the *Earth and Beyond* strand as part of Natural Sciences in the Senior Phase.

The spiral model makes provision for several interventions spread over time. This makes it possible to implement what was learned at a first workshop of an intervention and to then come back for a second workshop to discuss successes and challenges with other participants and reflecting on their practice (Dreyer 2014) before receiving additional training, going out to try it out in practice and coming back for further training. In this way, participants can reflect on their practice as 'The learning and understanding that grow within a particular context are a direct response to local realities' (Du Toit, Pollard, Dlamini & Chuma n.d.:14). In the intervention reported on in this article there were four workshops conducted over two years representing four cycles or spirals of training, implementation and reflection. Real needs of participants

that were going to be involved in the intervention were determined through pre-intervention school visits and a baseline survey, which are discussed later in this article.

3. Empirical Research

Research was undertaken over a period of three years and in a number of different ways. To start off Senior Phase Natural Science teachers in a school district in KwaZulu Natal were invited to take part in an intervention that would aim at improving their CK and teaching skills in Natural Science. Lecturers of the University of South Africa presented the workshops for the duration of one full day each. Ten workshops were held per year. Four of the workshops presented (the intervention) were reserved for the *Earth and Beyond* strand. The twenty teachers that enrolled for the workshops were the participants in this research.

The OER used during the intervention were purposefully designed and focused on areas of teacher needs identified during pre-intervention school visits and the baseline survey participants completed during registration for the workshops. They consisted of the following:

- A description accompanied by a video on doing group work in Geography (it was determined in the pre-intervention observations that teachers did not know how to do this effectively);
- A description accompanied by a video on doing an experiment in Geography: the example used was how to demonstrate the forming of clouds (it was determined in pre-interviews that teachers believed that it was difficult and expensive to do experiments and the example indicated how it could be done without incurring any costs); and
- A description accompanied by photos of geographical features on how to use images in Geography (it was determined in pre-intervention observations that there was a lack of resources, particularly visual images of geographical features in classrooms and the OER are downloadable on cell phones so that they can use it continuously).

Other elements of the workshops included all CK needed to teach the *Earth and Beyond* strand. It also included aspects of getting to know your school

environment, effective teaching methods associated with the teaching of the strand with an emphasis on learner-centred pedagogies, the use of sources other than only the textbook (newspapers, books, artefacts), integrating technology in teaching and learning and 'geographying' your classroom. These were all areas identified in the pre-intervention school visits and the baseline survey.

At registration of the intervention teachers had to complete a questionnaire that was used as a baseline survey to determine what the situation was in their schools regarding the teaching of the *Earth and Beyond* strand. The objective was to determine the training background of Natural Science teachers and whether the teaching of the *Earth and Beyond* strand received the required attention in their teaching. They were also asked what their needs were regarding the proposed intervention so that lecturers could focus on these areas during the workshops. When attending the first workshop they wrote a pre-test to determine the level of geographic knowledge and skills they had before the intervention took place. After the intervention which spanned a period of two years (in the form of workshops employing amongst others a number of OER), they wrote a post-test to determine the immediate impact of the intervention.

Before the intervention personal interviews and observations during five school visits were undertaken to determine how the *Earth and Beyond* strand was taught and the intended reasons were probed. Five schools were purposefully selected for this part of the research. They included better-resourced and lesser resourced schools; some were rural and some were town schools; both genders were well represented, since some teachers at the schools were male while others were female. The motivation of the researcher was to include schools and teachers representing different contexts and genders. The coordinator of the workshops furthermore knew the teachers teaching in this area and assisted in identifying five that would in his opinion be able to provide rich information from different perspectives. An interview schedule and an observation schedule were used to gather data.

The same teachers were visited again a few months after the two year intervention programme. Five interviews were held and five classroom observations were done with the same teachers at the same schools using the same interview and observation schedules utilised before to determine if actual changes took place in practice and if the initial knowledge and skill gains after the workshops were sustained.

School one was a school on the outskirts of a rural town and had good infrastructure in terms of enough classrooms and furniture for all learners. The

Natural Science teacher had no education in post-school Geography. School two was a school on the outskirts of a tiny village and had adequate infrastructure in terms of enough classrooms and furniture for all learners. The Natural Science teacher had no education in Geography. School three was a very remote rural school with inadequate infrastructure. The Natural Science teacher had no education in Geography. Schools four and five were very old rural schools where infrastructure was deteriorating and in desperate need of repair. The Natural Science teachers had no education in Geography.

4. Research Design

Because the researcher wanted multiple sources of data to determine if the intervention that took place was effective, and these sources involved methods from different paradigms, it is believed that a pragmatist paradigm was best suited to this research. A fully mixed sequential equal status design was therefore employed as described by Leech and Onwuegbuzie (2009).

As is often the case when one wants to determine the effectiveness of interventions the type of research chosen was experimental – a quasi-experimental single group pre- and post-test design – within the quantitative research approach (De Vos, Strydom, Fouché & Delport 2011). The motivation was that only one group of participants was available and it was not possible to have a control group. The pre- and post-tests were used to determine if there was an increase in knowledge and skills directly after the intervention within this one group. Because the researchers also aimed to determine if the gains in knowledge and skills were employed in classrooms it was decided to also do pre- and post-classroom observations and interviews with teachers which resorts under the qualitative research approach. The results were expected to indicate if there were longer term gains in knowledge and skills several months after completion of the intervention.

Even if one accepts that the lived experiences of teachers and their actual classroom performances provide authentic, truly context associated and thick information, the disadvantage of such research is that the participants are too few to make any generalisations possible. The findings are, however, still valuable and similar research might be replicated in similar contexts to contribute to the corpus of knowledge on a topic.

The research process is demonstrated in the following flow-diagramme (Figure 1).

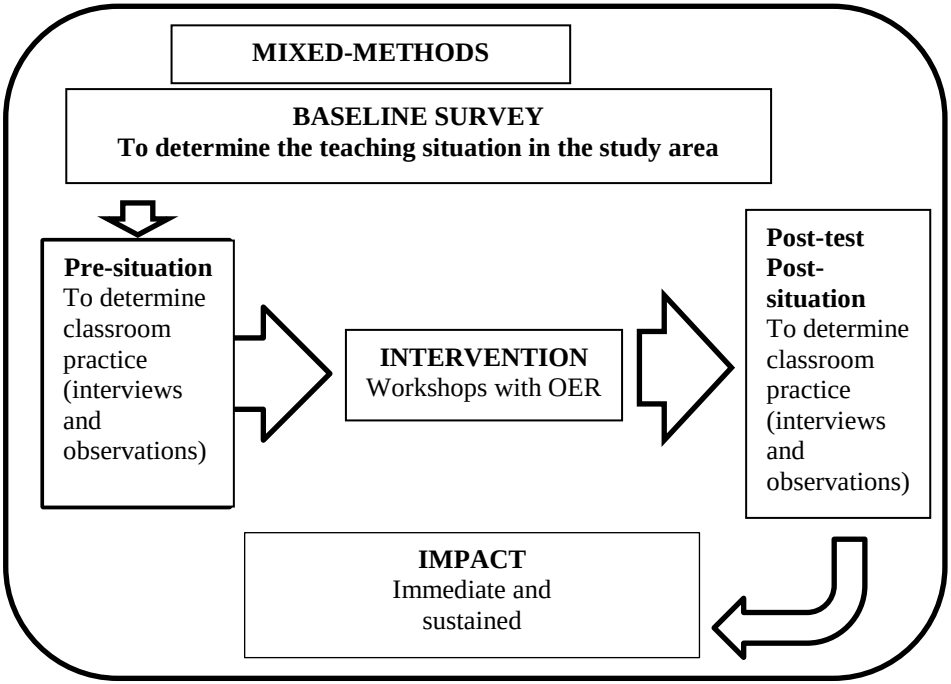

Figure 1: Research design

5. Data analysis

The pre- and post- test results are presented as a combined comparison graph to indicate the improvement of knowledge and skills that resulted from the intervention. The interviews and observation data were analysed as described by Elliott and Timulak (2005) and Cresswell (2017) and started by reading and re-reading the interview transcripts and the observation notes. The researcher identified meaning units that were aligned to the objective of increasing Geography knowledge and skills. These units were assigned to broad domains after which data that had similarities and connections to one another were sorted into categories. The categories were examined for significations (that is, the meaning and the implications of what Natural Science teachers were conveying in the interviews and what was observed in the classrooms). From the categories a number of themes emerged.

Themes regarding interviews were: time spent on teaching *Earth and Beyond*, teaching strategies, Geographical knowledge, teaching and learning materials and the use of technology and OER. Themes regarding observations were: classroom environment, use of teaching and learning materials and media, use of OER, Geographical concepts and Physical Geography curriculum.

6 Findings

6.1 Baseline Survey

It was established that only 8% of Natural Science teachers studied Geography at level four (matric) and none at level five or higher (post-school studies). Furthermore only 24% of them did any Science education in their post-school studies and that just at level 5 (first year at college or university). Areas of need listed previously were identified to facilitate the intervention and to highlight real teacher needs and preferences.

6.2 Pre-test and Post-test

Pre- and post-test scores are represented on the following graph (Figure 2):

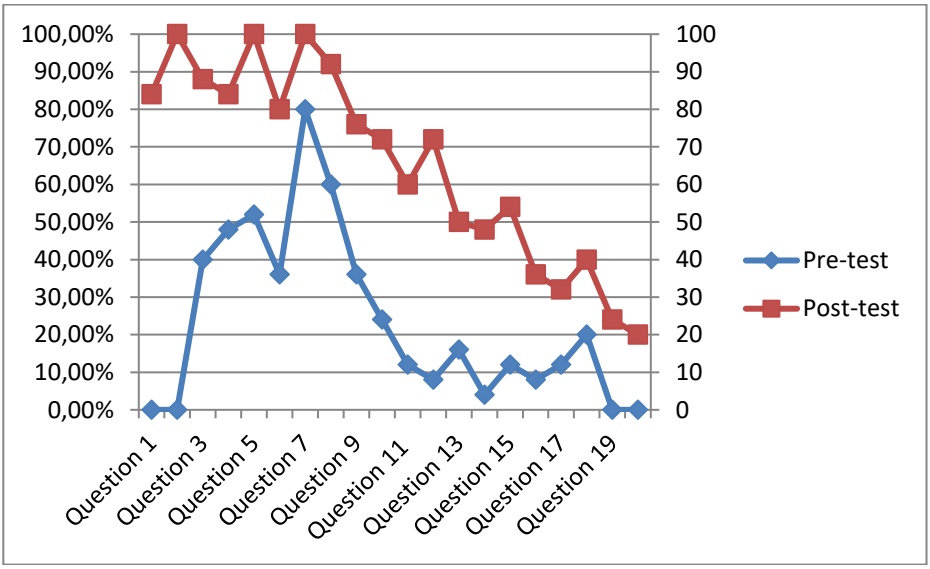

Figure 2: Graph of pre and post-test scores

The comparative graphs indicate an increase and development in knowledge (first 10 questions) and smaller skill improvements were also detected (question 11-20 from simple to more complex skills) in terms of Geographic knowledge and skills. It is clear that there has been an immediate positive impact on the Geography knowledge and skills of the teachers after the workshops.

6.3 Interviews

Because there were before and after interviews it was thought best to use a table (see Table 1) to present the findings according to emerging themes:

Emerging theme	**Interview before intervention**	**Interview after intervention**
Time spent on ***Earth and Beyond*** (supposed to be 25%)	Only 8% of teachers spent 25% of their time on *Earth and Beyond*. Reasons given: 'I only know what is in the book (teacher guide)'. 'We are not trained'. 'They tell us teach this and teach that but do not show us'.	30% of teachers spent 25% of their time on *Earth and Beyond*. Reasons given: 'I learned much like making models'. 'I started by telling them about their own place – I did not know to do it before'. 'For many things I am still not sure'. 'If I can learn more, I can be able to do more'.
Teaching strategies	88% of teachers used only direct instruction and 12% did some group work where learners participated. Reasons given: 'We had only one day training – they	72% of teachers used only direct instruction, 16% used group work, 4% did some outdoor learning and 8% used experiments and/or model building. Reasons given: 'We now throw nothing away so we can make models'. 'We go outside and look at the clouds'.

	tell us what to do but do not show us'.	'I use group work different now as I never knew how before'. 'I show them the experiment we saw on the video (part of the OERs) … the one of the ice and the clouds'. 'Once you know yourself, you can show the learners'. 'I tried the example (from the OERs) and the learners they participated and enjoy the task'.
Geographical knowledge	Most teachers received one day of training which covered all four strands of Natural Science and some also attended irregular cluster training. Comments: 'The trainer also did not know about the planets and the climate'. 'They said we must read to know the content'. 'At the cluster training they could not answer all our questions'.	The teachers attended the intervention which constituted 4 one-day workshops. Comments: 'I am able to answer many questions'. 'The learners and I know many facts because we prepare for the Geography quiz against other schools. It is the first time we decided to compete after the workshop which opened my eyes'.
Teaching and learning materials	Used only text books (teacher guides and learner guides) supplied by the	Used mostly only text books (teacher guides and learner guides) supplied by the Department of Basic Education. Some exceptions occurred:

	Department of Basic Education. Reasons: 'The books have everything we need'.	'They (the learners) bring newspapers and we talk about (Geographical) things in there'. 'I use the poster with the pictures of the planets'. 'The learners created all the planets as we learned from the workshop and we hang them from the ceiling'.
Use of technology and OERs	No use of any technology.	Some use of technology took place (notably cell phones and video shown on a computer). 'I take photos (of geographical landmarks) with my cell phone and show the learners'. 'We played the cell-phone scavenger hunt game about pollution and they (the learners) enjoyed it very much'. 'I showed them the video on the computer and then it was easy to do it' (the experiment on the video included in the OERs).

Table 1: Results of the before and after interviews

From Table 1 it is clear that there was a lack of geographical (*Earth and Beyond*) knowledge and skills amongst the research participants before the intervention. This was evidenced by a lack of time spent on the teaching of *Earth and Beyond*, poor or no training in Geography as well as Science and no use of teaching and learning materials (other than text books) and technology. It was however encouraging to see important improvements on the time spent on the *Earth and Beyond* strand in the school time table (an increase of 22%), extended geographical knowledge, some use of active learning methodologies and the use of technology (especially related to the OERs) after completing the intervention workshops.

6.4 Observations

Because there were before and after observations it was thought best to use a table (see table 2) to present the findings:

Emerging theme	**Observations before intervention**	**Observations after intervention**
Classroom environment	There were very few posters, pictures, etc. on the walls. Only one classroom had anything that could be associated with the *Earth and Beyond* strand. Two classrooms were neat and clean and without any broken windows.	Some geographical newspaper articles and a few posters were added to walls in two classrooms. In three classrooms there was at least one map. Two classrooms were neat and clean and without any broken windows.
Use of teaching and learning materials/media	No use of materials/media in observed lessons. Textbook used by all teachers.	Materials/media used by two of the five teachers in observed lessons. Textbook used by all teachers.
Use of OERs	No use of OERs	One teacher used Geographical images from an OER and integrated them well in her lesson. One teacher used group work as demonstrated using an OER reasonably well.
Geographical concepts	In one instance the teacher made a mistake with content when she could not identify indigenous plants and gave wrong examples.	In one instance the teacher made a mistake with content regarding landforms (fluvial processes).

Physical Geography curriculum	Only one of the teachers had curriculum documents and could identify the origin of the lesson.	Four of the teachers had curriculum documents and could pinpoint the origin of the lesson.

Table 2: Before and after observations

The initial observations revealed poor conditions in the classrooms with a lack of equipment, lack of teaching and learning materials/media and wall decorations and even some content mistakes in the presentations of lessons. A lack of use of OER was observed. Observations after the interventions revealed some improvement in the use of learning materials/media and wall decorations and other resources but content knowledge and the use of curriculum documents still posed a problem. There was some evidence of the use of the OER provided.

7. Discussion

From the pre- and post-test it was clear that a focused intervention which included integrated technical PCK can have an immediate impact on what teachers know and can do. There were significant gains in Geography CK and fewer developments in skills by all participants in the intervention. Gaining CK is all-important as it is a prerequisite for gaining PCK, as also indicated by Rollnick (2017) in her research. She found that the extent of CK of teachers that have to learn to teach an unfamiliar topic determines the teaching strategies they prefer and their learning of CK goes hand in hand with gaining insight into how to teach the topics.

Even if teachers have the skills to teach a lack of CK would severely hamper their transfer of correct knowledge that helps learners understand the subject. Similar findings were made by Lane and Catling (2016). They state that if teachers do not know and understand the subject matter, they will be unable to transfer accurate in-depth knowledge even if they have the skills to teach.

It is therefore, necessary to combine the acquisition of CK with appropriate strategies to teach the content when planning an intervention as

both are required to develop an informed and knowledgeable teaching ability. Mitchell (2018), who suggests that Geography education should always pair content with appropriate pedagogic strategies supports this sentiment. Earlier research by Larson &, Murray (2008) also advocates the inclusion of teaching skills in interventions especially in developing countries.

From the above-mentioned research, it has become clear that we should ask participants what their needs are and investigate their lived experiences so that we can provide them with customised, purposefully designed resources and focused intervention. This view is supported by du Plessis, Gilllies and Carroll (2014) who assert that lived experiences of out-of-field teachers, influence their professional development. Teachers have specific needs related to the content and methodology required to teach an unfamiliar field.

The intervention reported on here made use of OERs purposefully developed for teachers in poor rural under-resourced schools, because they have specific needs and they are low-skilled in teaching the *Earth and Beyond* strand/ Physical Geography of Natural Sciences. This approach is supported by a lesson learnt from impact evaluations of interventions in schools from 56 poor countries namely that '… low-skilled teachers need specific guidance to reach minimally acceptable levels of instruction' (Ganimian & Murnane 2016:179).

The use of OERs that models good teaching practice was valuable for teachers who were oblivious of how certain teaching strategies could be applied in their contexts. In the purposefully designed OERs of this intervention participants were presented with visual examples (videos) of good practice, e.g. how to conduct an experiment or how to do group work effectively. Teachers need such examples to guide them and to avoid resorting to traditional ways of teaching (Reitano & Harte 2016). These researchers assert that good practice should be modelled to help teachers move away from the imprinted observed practices they themselves experienced. This argument is further validated by findings from a study by Lane (2015) showing that teaching as you were taught is a continuing problem in teacher education and teaching practice.

Because the examples of good practice are in the form of visual OER they are always available and can be consulted whenever teachers need guidance on how to utilise OER in the classroom environment. The purposefully designed OER were even more valuable, because they were

designed taking into account the context in which the participants taught. This increases its utilitarian value and furthermore, OER may be useful resources to teachers who find themselves in similar circumstances and have similar needs. Their use can therefore extend way beyond the small intervention undertaken. Ally, Grimus, and Ebner (2014) also emphasise that OER can have long-term benefits and may influence teacher behaviour.

In post-intervention interviews and classroom observations a number of improvements in teaching the *Earth and Beyond* strand were observed, but in practice the impact of the intervention seemed to be still somewhat limited. Some teachers still mostly taught using direct instruction as teaching strategy, some relied mostly on only textbooks as resources and only some classrooms changed for the better. In other words, there were some positive indications of sustained improved practice in the teaching of the *Earth and Beyond* strand, but not for all participants.

Research of a similar nature and context on the impact of interventions (Haßler, Hennessy, Cross, Chileshe & Machiko 2015; Hennessy, Haßler & Hofmann 2016) also indicated gains in knowledge and positive changes in teaching strategies used by teachers after the intervention. There was however, no longitudinal study in these cases to find out if teachers maintained these practices or permanently changed their teaching approach.

The three OER units including videos (one on group work and one on an experiment to indicate how clouds form) and photos of geographical landforms were found to be very useful by teachers as they could see how teachers and learners in a real classroom environment could teach and learn effectively.

Some teachers reported using the intervention activities because they now:

- knew how to do them as they observed them being done in a real situation (on video);
- could make use of some of the technology suggested to vary their teaching and make it more interesting;
- were confident that they could do the activities with learners (and could fall back on the videos or photos if needed);
- could make use of them because it required very few and easily accessible resources (most of them waste materials);

- could teach things in their out of field subject/out of speciality strand which they could not do before;
- could construct teaching materials which they did not know how to do before (there was a step-by-step guide with photographs and a video).

The use of OER therefore contributed to the deepening of knowledge and skills of the teachers. Some teachers also reported that where they loathed doing it before, they now enjoyed teaching the *Earth and Beyond* strand as they felt more knowledgeable, prepared and confident. They furthermore noticed geographical things all around them which they were not aware of before. Because of this they also knew more about their local area and could use examples from it that made more sense to learners. They obviously became and felt more able to teach the *Earth and Beyond* strand.

What also emerged was that teachers could use the activities involving the OER (which is conducive to learning) but did not go beyond that and developed their own activities based on the knowledge and skills they acquired. They seemed to still feel that they did not know enough and did not feel confident enough to try doing something new on their own. They were of the opinion that further focused interventions could help them to eventually design and develop their own learning activities.

8 Recommendations

Because the research was limited to twenty teachers it is recommended that more of the same or similar research should be replicated to gain more insights and a larger base of knowledge on which interventions can be planned and undertaken. It is also recommended that OER purposefully developed to be used in focused interventions to improve teacher knowledge and teaching skills should be included in interventions to assist not only the teachers that were part of the research but also other out of field/out of specialisation teachers teaching the *Earth and Beyond* strand. The Department of Basic Education could play a major role in making OER available to facilitators of training workshops for Natural Science teachers. This can be done in partnerships with institutions (such as universities) which can assist in the development of the OER.

The theory of change used for this research has to be revisited, as the desired changes were not all completely achieved by it. The intervention

achieved some very positive short-term outcomes in terms of the increase in knowledge and skills in Geography. The intended long-term outcome of a change in teaching strategies however fell somewhat short of its target as only some of the participants sustained their use of strategies aimed at greater learner participation and active learning. Participants indicated that aftercare or continued school-based support might see more sustained changes in teaching strategies. Interventionists should take note of this when they plan future interventions.

The spiral model of using four interventions spread over a two year period had some benefits but it seems as if another spiral or two (aftercare in the form of continued contact with participants and additional school-based support) may have had an even bigger impact. Future interventions may draw on these findings when planning their actions.

9. Conclusions

OER that include visual images such as videos and examples of activities such as doing group work and experiments can have an impact on the PCK of teachers. An intervention employing OER as described in the article can have an immediate impact on the Geography knowledge and skills of teachers but the long-term changes of teaching practice to a more learner oriented, active learning approach still seems to be somewhat limited. It also does not seem to enable some teachers to develop and design their own activities or to significantly change their classrooms or expand their repertoire of teaching strategies. If interventions can be followed up by school-based support and/or follow-up interventions to strengthen the gains or build on them, the impact may be more sustainable.

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