Int J Technol Des Educ (2018) 28:685–699
https://doi.org/10.1007/s10798-017-9411-6

Development of a Technology Education Cascading Theory through community engagement site-based support

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Accepted: 27 May 2017 / Published online: 2 June 2017

Abstract If teachers are not equipped to teach Technology Education subject nationally and internationally, the continent of Africa will continue to bear the brunt of unsavoury results unless radical interventions are implemented to transform the situation. It is against this background that action research methods became a useful site-based support to empower Technology teachers at three sampled schools from Tshwane South Circuit in Gauteng Province of South Africa. The purpose of this study was to share fresh perspectives on how a sample of Technology teachers responded to content-related classroom practices during reflective action research activities that took place during community engagement contact sessions. These teachers, who are under qualified and unqualified to teach this subject, were engaged in circular and spiral action research cycles. The teachers' engagement brought forth the development of Technology Education Cascading Theory. It was evident that community engagement activities served as a podium to transform teachers' teaching of Technology Education and enhance learners' achievement. The study was underpinned by cooperative enquiry theory and engaged participants in reflective practices of developmental action paradigm. Interaction with Technology Education teachers further revealed that most of them need their schools to budget for this Technology subject they are teaching.

Keywords Technology Education Cascading Theory · Community engagement · Developmental action paradigm

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Introduction

Technology Education has developed over the past 50 years from a skills-based school subject that focussed on tool usage and product making that assisted learners with future employment to a programme for studying technological literacy that develops technological problem-solving skills through hands-on project designs (Ritz and Bevins 2016). Technology Education (TE), even though it took over half a century to develop, is now a stand-alone subject and is offered within the school curriculums of many countries. However, most of the teachers are still faced with the hurdles of TE pedagogy and didactics (Pudi 2007). It is against this background that the study purports to share fresh perspectives on how the action research approach, within community engagement with ill equipped TE teachers, has led to the development of a TE cascading theory. This study intends to respond to the following research question: *How did community engagement, site-based support with teachers constituted the development of a TE cascading theory?*

Even though Technology or Technology Education as a subject in South Africa (SA) is as old as the country's democracy, many studies are still confirming that the majority of teachers are still struggling with both the content knowledge and pedagogy of the subject. In support of the preceding statement, Mapotse (2017: 169) stressed that the situation for Technology teaching was exacerbated by many educational changes that had taken place in South Africa over the last few decades. These changes included the overhauling of curricula followed by a strategic and symbolic review which was also a sign of change since the first democratic election of 1994. For example, understanding educational transitions is vital to addressing basic skills shortages and improving the life chances of all South African learners (Isdale 2016). Williams (2012: 12) also emphasise that Technology Education has been around in some schools and in some countries for a long time. Technology Education even though it has been around in some schools and some countries have endorsed it in their national curriculum, but other countries in Saudi Arabia like Oman have not embrace this move. The country's Education Ministry still liken Technology to ICT (Information Communication Technology). It is therefore surprising that there is still no consensus about what Technology should be, how pupils learn when they study it, and what are effective teaching strategies in teaching the subject. Some of the notable problems that contribute to the education crisis in South Africa are numerous unqualified or under qualified teachers, large numbers of learners from disadvantaged backgrounds, incompetent teaching and poor learner results. This study intends to display how action research practitioners can actively involve their participants through community engagement practices as part of displaying participants' empowerment and how the participants benefitted from previous action research cycles.

Many TE teachers still lack Technology Pedagogic Content Knowledge (TPCK) to teach this subject with confidence and every chance of success, for example, judging by the plethora of letters and comments made in debates about Technology, it appears that the TE books that are imported from other countries, especially European countries, falls short of achieving the ideals of the subject from a South African perspective (Pudi 2007). The teachers in this study were taken through action research (AR) spiral cycles and I served as an AR practitioner. How the AR practitioner goes about presenting this report is first to frame the study within the co-enquiry theory also known as collaborative or cooperative theory and its application in the research study. Second, the practitioner discusses how the TE challenges were realised. The AR practitioner further proceeds by explaining the research methodology and finally presents findings of the study.

The gap identified in literature

UNESCO (2002) asserts that teacher education institutions also need to develop strategies and plans to enhance the teaching–learning process within teacher education programmes and to ensure that all future teachers are well prepared to use the new tools for learning. There is a need for TE teachers to be encouraged to teach, share and empower one another within a cluster. There are some scholars, listed below, who have embarked on a variety of research studies in order to attempt to alleviate deficiencies in Technology Education content, didactics and/or pedagogy.

These scholars in the fields of Technology Education have engaged in research targeting a variety of aspects of teacher professional development in the midst of teachers working in under resourced environments and encountering a lack of support. For instance Gunther and Chatoney (2016) have shown an interest in unpacking the study of Technology Education in France based on efficiency of tools from functional analysis in learning process for describing objects; Gumbo (2016) undertook a study focussing on an intervention into the teaching knowledge and content knowledge challenges of Technology teachers in Mpumalanga Province of South Africa; Järvinen and Rasinen (2015) embark on an enquiry about implementing Technology Education in Finnish general education schools: studying the cross-curricular theme 'Human being and Technology'; Love (2015) took readers through exploration of the preparation experiences that influence Technology and Engineering educators' teaching of science concepts; Hallström et al. (2014) examine the historical insights and methodological considerations of Technology as a field of knowledge in general education in Swedish, a case study within 1842–2010; Yager (2013) successfully investigated the implementation of the changes in professional development for teachers in the U.S.; whereas Jones et al. (2011) investigated the developing field of Technology Education: a review to look forward. This foregoing study of 2011 by the three scholars focussed on successful research projects and continuing challenges.

All the aforementioned scholars belong to both national and global communities and they have used some common instruments or similar approaches to gather their data. So far, little has been done to consider a cascading model (Dichaba and Mokhele 2012) through community engagement (CE) to empower unqualified and underqualified TE teachers. In this study, the action research (AR) practitioner wanted to fill that Technology incapacity gap experienced by Technology teachers at three sampled schools. This identified gap was filled by involving Technology Education teachers in a community engagement project using an action research approach. The AR practitioner will be underpinning this study through using the co-enquiry theory and sharing those Technology teachers' experiences using a developmental action paradigm.

Theoretical and conceptual frameworks

This study focussed on the challenges Technology Education teachers encounter in their classrooms when presenting their lessons plans due to lack of content knowledge. Carr and Kemmis (1986), Kemmis and McTaggart (1988), Zuber-Skerritt (1996), Smith (2001), Calhoun (2002) claim that maximizing the effectiveness of regular classroom teaching involves the need for constant studying of one's own situation in order to understand better the teaching process. During the reconnaissance study, data gathering instruments were administered to the participants so that they could better reflect on their Technology

teaching situation. This was a fact-finding mission prior to unfolding the AR process, in which participants could examine their own educational practice systematically and as cautioned Ferrance (2000: 7) the participants could carefully apply the techniques of research to bring about change in it.

Within all the definitions of AR there are four basic themes that stand out, namely empowerment of participants, collaboration through participation, acquisition of knowledge and social change. In conducting AR, the researcher structured routines for continuous confrontation with the data gathered on Technology teaching by senior phase teachers. Theory is needed to reveal and unpack the research question of this CE project which states that, how did community engagement site-based support, with TE teachers, constituted the development of a cascading theory?

Theoretical framework

Theory helped AR practitioners in their thinking and developing the required research decisions and sense of teaching and learning Technology. As an AR practitioner, I moved from the premise that theory is an explanation that enabled one to discuss, how a phenomenon operates and why it operates as it does, and it makes sense out of the current knowledge by integrating and summarising this knowledge. Hence, it can be used to guide research, for example, by making predictions (Johnson and Christensen 2004). Cooperative enquiry theory was adopted to ground the AR study in tackling the TE teachers' challenges around Technology Pedagogic Content Knowledge (TPCK) when they are presenting lessons.

Cooperative enquiry theory within action research process

The choice to ground this study within the cooperative enquiry theory also known as collaborative enquiry was motivated by the researcher's intent to equip the Technology teachers in terms of helping them to overcome the challenges that they face in contextualising their teaching of the subject Technology. By reflecting critically on their unfavourable status quo, Technology teachers could be helped to think about how they could free themselves from such unfavourable conditions and take action about those conditions, in order to be empowered. The nature of intervention in such involvement is facilitative rather than instructive, so that those students being helped by their TE teachers can later be self-reliant and become independent, in order to address their communities challenging situations. Specifically, the next section explains how co-enquiry theory which later was called cooperative enquiry theory found relevance in this investigation.

Cooperative enquiry, also known as collaborative enquiry, was first proposed by John Heron in 1971 and later expanded by Peter Reason. The major idea of cooperative inquiry is to research 'with' rather than 'on' people. It emphasizes that all active participants are fully involved in research decisions as co-researchers. Throughout the 1990s, a number of textbooks and guides on cooperative inquiry have been published, principally by John Heron's (1996) *Cooperative inquiry: research into the human condition* and Peter Reason's (1988) *Human Inquiry in Action* and (1994) *Participation in Human Inquiry.* These textbooks provide comprehensive accounts of the cooperative inquiry theory, including the guidance on implementing the theory. The research team (the senior phase Technology teachers and I) jointly outlined the plan of action to tackle what was regarded as hindrances to deliver Technology lessons. Mapotse (2012: 87) reiterate that cooperative enquiry creates a research cycle among four different types of knowledge and those are:

propositional knowing (with TE teachers as perceived to lack-TPCK), practical knowing (to help TE teachers to engage their learners with hands-on/practical work), experiential knowing (assist TE teachers to bring the world of work into the classroom) and presentational knowing (for TE teachers to present their lesson plans with confidence and every chance of success). The research process included these four stages at each cycle with deepening experience and knowledge of the initial proposition, or of new propositions, at every cycle. The AR practitioner/researcher engaged the co-researchers within the parenthesis of this theory as it stresses that the practitioner has to research with them. Through this collaborative/co-operative enquiry theory the research team (the participants and I) created knowledge within practical knowing and the experiential knowing domain to prepare learners for industry intake.

The concern for industry is whether schools are producing students who are ready to follow the Engineering Field. Students should be introduced to Technology earlier in their schooling so that they can start producing artefacts. Approaching TE theoretically is unfathomable, since TE is both hands-on and minds-on subject and that calls for the incorporation of a developmental action paradigm within the study.

Developmental action paradigm: application to technology teachers

By reflecting critically on the TE teachers' situation, intervention strategies could be devised to assist teachers to think about how they could take action in response to the challenges they face. The kinds of intervention that AR suggests is facilitative because of the co-participatory principles of teachers within AR. Therefore the intervention would be much more meaningful and empowering because it would not be instructive to the teachers. Instead, they would be helped to think out the solutions to their challenges and take action. Hence, an assumption is made that engaging teachers in a developmental paradigm has the potential to improve their understanding about the knowledge and pedagogy of TE within their context.

The developmental action paradigm is often regarded as the 20th century model used by industrialised nations to represent the most advanced form of society, and how other nations are categorised in terms of their approximation to this model based on similarities like gross domestic product (GDP); literacy; quality of education, industrialisation, good governance, etc. as compared to their differences including but not limited to unemployment; youth participation in the economy, mechanism to curb corruption, technology revolution. Hence these nations can be judged as either more or less developed, and their efforts should be directed towards achieving the 'developed' model in their political, social, educational and economic institutions (Bothamley 2004). South Africa is listed among the developing countries. It is also a member of BRICS, an acronym for the developing countries of Brazil, Russia, India, China and SA. The unemployment rate in SA is directly influenced by its struggle to produce acceptable results in Science, Mathematics and Technology. One of the biggest contributing factors is the presence of unqualified and under qualified teachers teaching TE.

Conceptual frameworks

Technology education

Technology was more an industry based as some of the skills were mostly learned in the field work but now just over few decades it has been officially introduced within school

curricula both locally and globally and therefore it has posed a number of different challenges as opposed to other subjects due to its research base pool. For example, this subject in question is called by various names in different countries, for instance in UK/Botswana it is known as Design and Technology, in the USA/New Zealand/Australia/Finland/France it is labelled as Technology Education and in Malawi/Bangladesh it is dubbed Science and Technology. In Sweden/Israel it is termed as Technology, but in South Africa it is has different names per phase. In the Intermediate Phase it is entitled Science and Technology; in the senior phase, the subject is branded as Technology and, in Further Education and Training (FET) band, it is identified as Technology Field/Education (Mapotse 2015). It is now over two decades since TE was introduced into the SA curriculum. There are other countries who gave the subject, Technology, a totally different name. For example, in Nigeria it is called Technical Education, and in Kenya it is pronounced as Art and Technology, whereas in Tanzania it is named Computer Integrated Education. The researcher still believes that in other countries in this part of this world TE will be identified differently as well.

Technology as a subject has been developed to solve problems associated with human needs, wants and desires. If there was no technological problem to solve, then Technology would not have been developed and/or needed. The Department of Basic Education in SA defines Technology as 'the use of knowledge, skills and resources to meet people's needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration' (DBE—Curriculum and Assessment Policy Statement 2011). Many of the TE teachers still lack Technology pedagogic content knowledge to teach this subject as said earlier on.

Community engagement

A general consensus around community engagement is that it refers to the process by which community, organisations and individuals benefit mutually by building ongoing, permanent relationships for the purpose of applying a collective vision, and collective skills and interventions to address what is perceived as a challenge for a community. Since this study is focussed on teachers, the AR practitioner therefore proposes the following definition for CE:

> Community engagement is a regular site-based support interaction process comprised of ill equipped teachers as a community of co-researchers during a community of practice involvement led by an action research practitioner for facilitation purposes in pursuit of new teaching skills, methods and approaches within their cultural context so as to enhance learners' performance and teachers' achievement.

One higher education institution in South Africa defined CE as, 'the continuously negotiated collaboration and partnership between the higher education institution and the interest groups that it interacts with, aimed at building and exchanging the knowledge, skills, expertise and resources required to develop and sustain society' (University of the Free State 2006). The next section outlines the research methodology.

Context of the research

In accord with the main research question, the research objectives including relevant questions sought to find out more about the participants' Technology teaching and focussed on the following aspects: (a) The nature of Technology teaching, (b) How senior phase Technology teachers at selected schools in the Gauteng Province teach Technology, and (c) How these teachers develop the AR-based intervention strategies that can be employed to improve other incapacitated TE teachers. The research team used the TE national policy as the benchmark for intervention. The AR practitioner or the researcher did arranged a contact sessions of a weeklong for three hours a day. The TE teachers were taking turns to present sections within a TE theme which they are just comfortable in delivering. The aftermath of their presentation was a joint growth and strength in TE which reflect collegiality among the research team. The researcher together with the TE teachers in Grade 8 and 9 were engaged in the following activities as they unpack the annual TE curriculum from the policy document:

- In term 1 of the year both grades embark on the theme 'Structures' were learners have to acquire the following skills: Investigation; Design; Making; Evaluation and Communication. The TE teachers need to give leaners projects which are supposed to incorporate all the listed skills when learners make an artefact.
- In term 2, the Grade 8 continue with the theme 'Structures' but add the component of 'Impact of Technology Processing'. It's here where the Grade 8 are introduced to the theme 'Processing'. The Grade 9, in term 2 handle the theme 'Mechanical systems and control'. The TE teachers are expected to engage their learners with Action Research around pneumatic systems and hydraulic systems. Mechanical system is also challenge to TE teachers. Adding to this conundrum is lack of resources for both teachers and learners.

As an AR practitioner, this is an opportunity to explain to the co-researchers how they should take AR as incipient in their classrooms. The TE teachers are brought to the basics of contextualising their teaching and to ameliorate learners' performance in their TE mid-year examinations (end of term 2 within an academic year). The three schools were encouraged to set a common examination paper and the researcher thoroughly moderated it for quality assurance purposes. A school excursions was also organised in term 2 and learners are organised to visit a company that is dealing with the theme at hand, namely, milling company for corn to meal–meal processing.

- In term 3, it is the Grade 8 turn to be taught on the theme Mechanical system were they revise levers and do some calculations on mechanical advantage. Whereas the Grade 9, according to TE policy of the country the TE teachers must teach their learners under the themes 'Electrical system and control' and 'Electronic system and control'. It was in Grade 9 were teachers are expected to know the resistor colour codes; apply Ohm's law; be able to connect series and parallel circuits; interpret logic gates, and identify electronic components (switches, resistors, transistors, thermistors, capacitors, cells, diodes and lamps).
- In term 4 the Grade 8 TE teachers are supposed to inculcate the theme learned by the Grade 9 during their term 3—'Electrical system and control' and 'Electronic system and control'. Whereas the Grade 9 focus their attention on the theme 'Processing'.

The researcher did organise these electronic components and conducted few demonstration lessons with the co-researchers as most have never seen how a real component looks like, save a picture in a text book. It was this time of the year, term 4, were learners are competing to come up with a technological solution to address the identified problem within their schools. Prices are awarded to the best projects, all this are sponsored by the researcher.

It was here in term 4 were the teachers' check their acumen of their learners from three different schools by jointly set up the common examination paper as it was done during mid-year. The AR practitioner still stand as the moderator to check if the paper content as to whether it has covered the theme well according to learners' level.

The objectives above are outlined for the purpose of addressing identified challenges. These reverberation consequences suggested AR approach as an intervention to equip Technology teachers to improve their Technology teaching practice within the South African context. This intervention brought forth the design of the Technology Education cascading theory.

Research design and methods

Sample of the study

The sample was drawn from the South Region of the Pretoria District of Tshwane South Circuit. The aim of delineating the scope of the study was to implement some intervention strategies to a manageable sample of ten TE teachers teaching grades 8 and 9 at three secondary schools.

Pseudonyms in Table 1 were assigned to the schools to conceal their true identity for ethical reasons.

The choice of Tshwane South Circuit was prompted by the lack of Technology knowledge and pedagogy observed when the teachers were engaged in an AR reconnaissance study.

Data collection methods

Data were collected from Technology teachers in sample schools. A variety of data collection techniques were incorporated on a small scale for this AR study. The tools used for data collection were observations, interviews, field notes, video recording of lesson presentations, and logs of meetings. Specifically, the techniques incorporated, which were also used to collect data in this study, were reflective questionnaires, non-participative observation and structured interviews. Action research with Technology teachers managed to close the TPCK gap. This community engagement study was underpinned by collaborative theory and guided by the developmental action paradigm. Integrated results from different data sources enabled the AR practitioner to explain in greater depth the extent of the challenges faced by Technology teachers in their teaching of Technology from more than one standpoint (Cohen et al. 2000). A day was spent at each school to observe Technology teachers giving lessons using the observation grid that was designed. Whilst observing the teachers, their lessons were video recorded. The observation was followed by interviewing the teachers using the interview schedule that was designed as well. This study is reporting on observations gathered and interviews conducted per school each year, over a three year

Table 1 Sampled schools and Technology teachers

Sample schools	Technology Education teachers per school			
	No. per school	Grade 8	Grade 9	Any technology qualification
SE secondary	3	2	1	None
SS secondary	2	1	1	None
ST secondary	5	3	2	1
Total	10	6	4	1

period. This means that the study will give an account of three years' interaction on the initial phase with the TE teachers.

Action research cycle and spiral activities to develop an instrument

AR emphasises teachers' involvement in problems within their own classrooms and has its primary goal as the in-service training and personal development of the teacher, rather than the acquisition of general knowledge in the field of education (Borg in Ferrance 2000). AR is a way of learning from and through one's practice by working through a series of reflective stages that facilitate the development of an acclimatised form of expertise (Riel 2010).

The AR cycle equipped the practitioner and co-researchers with a way of learning from experience that was potentially flexible, whilst for Riel (2010) this form of research is an interactive, cyclical process of reflecting on practice, taking an action, reflecting, and taking further action. The AR spiral activities were undertaken repeatedly within AR cycles to address challenges to teaching Technology. The AR recursive procedures of spiral and circular activities with TE teachers was a step ahead for their emancipation and readiness to take the process forward.

Findings and reflective cycle activities

The accounts below are extracted from both observations and the interviews with TE teachers. AR aims to generate findings that are useful within a specific context rather than findings that are applicable across many different situations (Jantan 2010). The generated findings of this study were as follows:

From Table 1 the researcher can deduce that out of ten TE teachers from three different schools only one teacher has a Technology qualification. One teacher suggested that the department should, 'intensify the training of teachers offering this Technology subject through in-service programs.'

As the researcher made some observations around all three schools, there was no ordered environment earmarked for Technology teaching, learning and practices. As one teacher stressed, 'if possible the National Department of Basic Education should provide the schools with technological workshops and laboratories, or Technology centres.'

It was further observed that teacher–learner ratio impedes the 'hands-on' nature of Technology asclasses are a bit overcrowded, and class management and assessment were negatively affected. One TE teacher during the interview recommended that, 'learners

must always be given projects and report back must be done immediately, so as to encourage learners.'

TE teachers declared that some of the Technology themes within their annual work schedule were not given any attention as they serve as a challenge to them. One teacher recalled and reflected that, 'since I was given an opportunity to sharpen my skills on Technology drawing and indeed it brought light to me gradually, so by that I believe as well that I have gained some strategies on orthographic (3D) and 2D drawing that I may use with my learners to improve their drawing skills. I can now teach my learners resistor colour coding and resistance calculations which I never done before'.

During some interviews, teachers acknowledged that the subject was not allocated a budget by the financial committee of the school. In support of a TE budget and to curb the issue of lack of resources, one teacher mentioned that, 'schools must have an annual budget for the subject. Every Technology class must resemble a Technology class.'

Action research came at the right moment for these teachers, as they can now observe that they have been empowered to teach the subject with confidence and are able to share pedagogy and knowledge with their colleagues. All structured AR contact sessions were used as a stage to empower Technology teachers and sustain their desire to learn more, hence attendance was very good, and their TE classroom practice challenges were addressed.

Discussion and implications

Most of the Technology teachers within this study from the three sampled schools are under qualified to teach this subject. TE classes are conducted in a normal classroom with all other subjects. No practical engagement and related activities within the TE class are possible as the schools are without Technology laboratories or workshops. Teachers raised a concern about resources and support from their schools' management teams. Action research was rolled out once a week per term to equip these TE teachers.

Report on the research cycles

Site-based support in the form of workshops and/or seminars were conducted with the teachers at a common venue, SE secondary school, which was central to all TE teachers of other schools. A TE theme for the term was addressed and any challenges teachers raised about the theme were dealt with. Todd (2010: 01) stressed that, 'one problem with action research is that the term means different things when used by different authors.' For example, Hopkins (1985) treats action research and classroom research by teachers as synonymous; Wallace (1991) argues that the main criterion for action research is practicality; Brown (1994), Robinson (1991) suggest that any action undertaken by teachers to collect data and evaluate their own teaching can be termed action research; and Somekh (1993) highlights the participatory insider nature of action research.

Despite the notable differences among these interpretations of action research, there does appear to be a common core which distinguishes action research from research in general, as emphasised by Todd (2010). Who remarks that action research occurs within a specific classroom situation, and is usually conducted by the teacher, or with a teacher as classroom participant, and aims to improve the situation and develop the teacher as a researcher (Todd 2010). It is a common practice in AR that it does not intend to generate

additions to the pool of human knowledge but to solve a particular problem in a particular context. In this study, facilitation was happening outside the classroom with TE teachers in empowerment cycles, enabling them to implement the knowledge gained from the contact sessions in their classrooms. As cycles evolve and themes addressed per term, as displayed in Fig. 1, the TE teachers had a chance to collectively provide help for each other. Challenges around their classroom practice were highlighted and solutions were sought by the team as they shared their practices in their individual schools.

The AR practitioner outlined the existing assumptions after a reconnaissance study was conducted among the new cohort of TE teachers on a yearly basis. New knowledge on assumptions and guiding values during the contact sessions were tabled. As the cycle was rolled out, it was a good opportunity to re-examine, renew and revise the assumptions as outlined in Fig. 1. It is a well known fact that action research does not aim to increase knowledge, therefore issues of research reliability and validity can generally be down-played in action research, while practicality, trustworthiness, and immediate usefulness become more important. For this reason, action research often seems an attractive option for new and old teachers' empowerment. It looks easy—action researchers do not have to worry about creating valid research designs, statistics, or concepts like triangulation and replicability, as its purpose is to change the immediate situation to a more conducive learning environment and ensure a growth benefit for the practitioner and the participants. Engaging TE teachers yearly with the new cohort in a series of contact sessions has yielded the development of TE cascading theory, as described in the next section.

The Technology Education Cascading Theory: 'each one, teach one'

The theory developed in this study is Technology Education Cascading Theory in the sense that co-researchers end up running the project with, or without, an AR practitioner. During the initiation of the project, the researcher took the first TE teachers from School A (SE Secondary School) and spent the whole year with them on the AR spiral cycle's facilitation of observation, planning, action and reflection per term, covering all the annual TE themes.

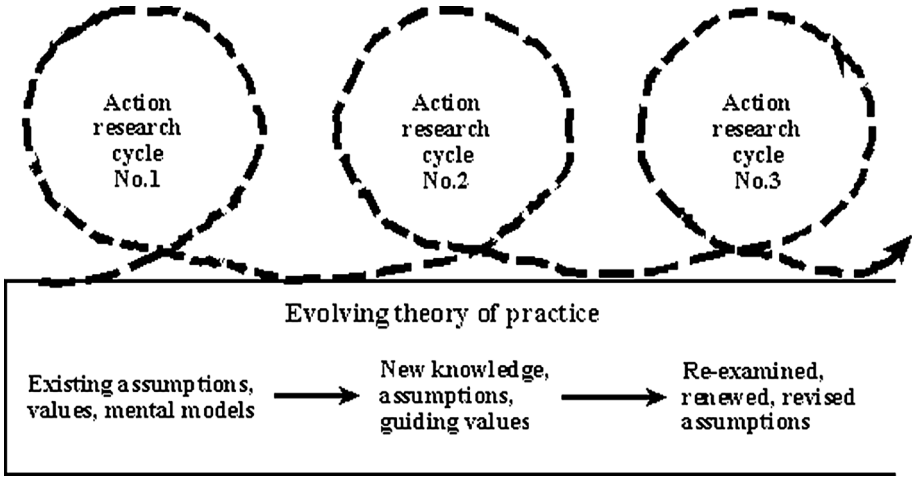

Fig. 1 AR cyclical and spiral cycles with TE teachers (adopted from Allen 2001)

The researcher served as an AR practitioner and TE teachers served as participants. As the researcher adopted a new school each year, the TE teachers from the adopted school served as participants. The equipped teachers from the previous year were elevated to be the practitioners and the researcher became the facilitator. In short, each year the TE team members changed their role as new cohort of teachers are added into the programme, as displayed in Fig. 2, Table 2 below.

Figure 2 displays the TE cascading theory in a picture format. It starts with one school at the apex and grows yearly as a new cohort of TE teachers are added, as reflected in the three columns. The community engagement project in 2016 was in its third year. The project started in 2014 with one school, SE Secondary, which had only three TE teachers. In 2015, SS Secondary School was recruited to join the team as AR participants and SE Secondary School teachers served as AR practitioners while the researcher continued to assume the role of an AR facilitator. In 2016, the team recruited the third school, ST Secondary School to be the AR participants. When the new school was recruited all the team members changed their roles. When ST Secondary School join the team in 2016, then my role as a principal researcher turned to that of an AR observer. TE teachers from SE Secondary School became AR facilitators whilst the ones from SS Secondary School have taken a role of AR practitioners. This is an ongoing study which will depend on the availability of funds to cascade even further.

Conclusions

This small scale study sheds some light on the challenges TE teachers have for not possessing any pedagogic content knowledge. This makes it difficult for them to deliver lessons covering all the themes of Technology in one academic year within their classrooms. The majority of teachers in this study said that they do not have any qualification to teach this subject. It is not surprising because the subject was introduced in South Africa's new educational dispensation, meaning that during their training at different higher institutions or colleges the TE course was not yet offered. There is a need for stakeholders to embark on a massive training program for these TE teachers nationally, by whatever means. In this study, AR was sought to empower these TE

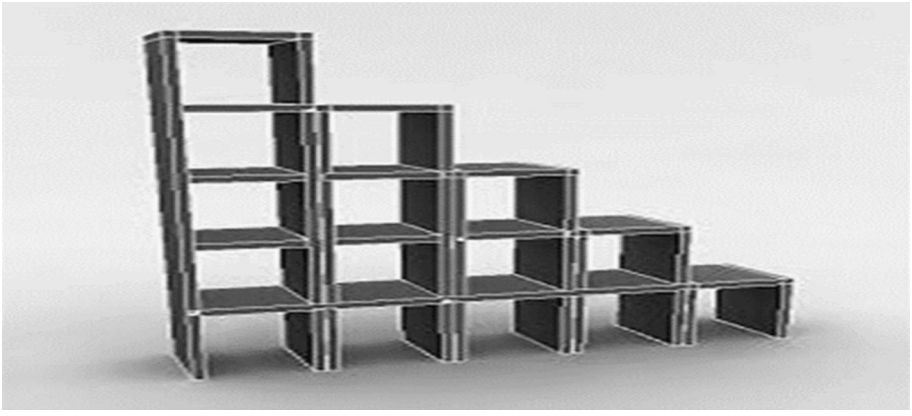

Fig. 2 Picture portraying Technology Education Cascading Theory

Table 2 Depiction of Technology Education Cascading Theory

Year 1; 2014 SE Secondary School 3 AR Participants		
Year 2; 2015 *Assuming new roles* 3 AR Practitioners	Year 2; 2015 SS Secondary School 2 AR Participants	
Year 3; 2016 *Assuming new roles* 3 AR Facilitators	Year 3; 2016 *Assuming new roles* 2 AR Practitioners	Year 3; 2016 ST Secondary School 5 AR Participants
Year 4; 2017 *Assuming new roles* 3 AR Observers	Year 4; 2017 *Assuming new roles* 2 AR Facilitators	Year 4; 2017 *Assuming new roles* 5 AR Practitioners

teachers from three different schools. It is also clear that teachers need sufficient training and time to be empowered with the pedagogy, didactics and content knowledge of Technology Education. Both collaborative enquiry theory and developmental paradigm have the potential for innovation, depth and reliability of research outcomes that manifest in the process of mutual learning. Mutual learning is also one of the core values of action research in the sense that it embraces different ways of knowing in order to enhance collective knowledge and overcoming epistemological barriers that see one way of knowing as better than the other.

Prachagool et al. (2016) support this study's conclusion by highlighting four ways that the Education Council/Department of Education could enhance the quality of education through professional development. Firstly teachers need a system and mechanism to promote teaching skills, managerial skills, and a support system that can be flexible enough to provide effective instruction. Secondly, teachers need a system that propagate and refine teacher competency in classroom management. Thirdly, teachers need a friendly teaching environments that promote teacher's decision making in schools. Finally, teachers need incentives and/or any psychological factors that enhance their teaching. Hence, the AR practitioner resorted to awarding the Technology teachers within this project with bursaries from the practitioner's community engagement funding to register for a one-year certificate for TE teachers' professional development. This adds value to this CE project in the sense that at least there is the possibility that these TE teachers can have a Technology Education qualification at the end of their CE participation. This AR journey contributed to the development of TE cascading theory of 'each one, teach one' in this site-based teacher professional development study. This was made possible based on the time spend in the field (three consecutive years) by the research team as outlined in Fig. 2, Table 2.

Acknowledgements I acknowledge the funding received from University of South Africa under Community Engagement (CE) of the College of Education to sponsor my CE project number CN3500 bearing the title, "Sustaining the teaching of Technology Education through Action Research".

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