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Criteria for continuing professional development of technology teachers' professional knowledge: a theoretical perspective

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Abstract Continuing professional teacher development (CPTD) is generally accepted as an indispensable tool for the professional development of technology teachers. The current theoretical framework for CPTD comprises a variety of models. However, criteria underpinning these models are not explicit. If, in turn, the criteria were explicit, it could serve as part of the pre-determined criteria for the evaluation of the quality of CPTD programmes. The quality of higher education is important to its stakeholders and the assurance thereof should be a continuous process. The aim of this article is to determine criteria for evaluating CPTD programmes through an analysis of CPTD models in different educational settings. The article takes the form of a literature study to determine which CPTD models exist and which aspects of such models are most suitable for facilitating development of technology teachers' professional knowledge. A significant finding of this study is eight criteria for evaluating CPTD programmes.

Keywords Continuing professional teacher development · Technology education · Criteria for continuing professional development · Models of continuing professional teacher development

Introduction

The movement towards including technology education as a compulsory component in various educational systems has gained additional momentum since the 1980s (Mawson 2003, p. 117). Technology education was officially introduced in schools in England and

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Wales (called Design and Technology) in 1990, the Netherlands in 1994 and South Africa in 1998. Since its implementation, it has constantly posed challenges to higher education institutions (HEIs), in particular those engaged in teacher training. These challenges include preparing new teachers for teaching Technology through initial teacher training as well as equipping existing teachers to teach Technology through continuing professional teacher development (CPTD) (Ankiewicz 2013, p. 2).

With the rapid and progress of globalisation and technological development, new learning outcomes such as the development of creativity and innovation have become major driving forces in competitive societies. Technology teachers are required to facilitate these new learning outcomes within new technological contexts (Ankiewicz 2013, p. 2). In this instance CPTD has become an indispensable tool for HEIs equipping technology teachers for this challenging and daunting task (Engelbrecht et al. 2007, pp. 580–581). However, a variety of perspectives on and models of CPTD exists in different educational systems and the underlying criteria for these perspectives and models also vary.

For example, Stein et al. (1999) provide an illustration of CPTD in Australian schools through a theoretical model for professional development. This model highlights the need for technology teachers' prior knowledge and beliefs about teaching and learning and a synergy between theoretical, practical and reflective experiences to be built into professional development.

For Cavan (2007), multiple partnerships are important in CPTD. Cavan provides an example of teacher learning at Sheffield Hallam University in England where teachers are involved in projects in schools. These projects eventually determine teachers' portfolios for allocation of credits. The projects are guided by a network of advisers, subject associations and mentors as part of in-school CPTD and are extended through conferences and journals.

Although technology teachers in the USA have experienced success in developing their instructional methodology through trial and error, they lacked a powerful connection to or grounding in well-researched theories on learning and teaching (DeMiranda 2004, pp. 64–65). Presumably CPTD would be a relevant vehicle to establish this connection.

The vast majority of technology teachers in South Africa have had no formal training in the "… concepts, content and methods associated with technology education" (Potgieter 2004, p. 205). They also do not have the privilege of having a recorded best practice experience and a history of technology education which they can draw on and therefore, there is a dire need for support and guidance (training through CPTD) for these teachers (Potgieter 2004, p. 210).

Hargreaves in Day (1999, p. 56) is of the opinion that teacher development should not only focus on the technical competence of a teacher but should aim to develop the teacher holistically, also addressing the place of moral purpose in teaching, potential awareness, acuity, and adeptness among teachers and their emotional attachment to and engagement with their work. CPTD is generally accepted as an indispensable tool for addressing the above-mentioned issues. The current theoretical framework for CPTD (for example, Cavan 2007; Potgieter 2004; De Miranda 2004; Stein et al. 1999) comprises a variety of models. However, the criteria underpinning these models are not explicit (Reitsma 2006; Stein et al. 1999; Craft 1996; Edwards 1991). In turn, if the criteria were explicit, it could serve as part of the pre-determined criteria for the evaluation of the quality of CPTD programmes. The quality of higher education is important to its stakeholders including HEIs, Departments of education, schools, teachers and ultimately learners (Mishra 2007, p. 24). Quality assurance measures can be found in all types of HEIs (Harvey 1998, as cited in Mishra 2007, p. 31) and should be an ongoing process (Mishra 2007, p. 31).

The purpose of this article is to determine criteria for evaluating CPTD programmes through an analysis of CPTD models in different educational settings. The article aims to answer the following research question: Which criteria for CPTD can be derived from existing CPTD models for facilitating development of technology teachers' professional knowledge?

The article takes the form of a literature study to determine which CPTD models exist and which aspects of such models are most suitable for facilitating development of technology teachers' professional knowledge. In the course of the article we discuss several different models depicting the process through which professional development is designed and facilitated, as well as the implications thereof for the design and evaluation of CPTD programmes.

Theoretical framework for continuing professional teacher development (CPTD)

Defining CPTD

The terms continuing professional teacher development (CPTD) and in-service education and training (INSET) are often used interchangeably. Craft (1996, p. 6) states that "…both terms are used to cover a broad range of activities designed to contribute to the learning of teachers who have completed their initial training…" In this article, the term, continuing professional teacher development (CPTD) will be used as it is currently the term used most often to refer to the development of teachers who have completed their initial training. CPTD could be defined as ongoing education and training for practising teachers, with the aim of supporting them in keeping abreast of the rapid and numerous changes taking place in the school milieu (Collins 1991; Leclercq 1996).

The purpose of CPTD

CPTD mainly helps teachers to re-establish contact with theory and methodology to maintain the "extended professional" (Collins 1991, p. 69). CPTD can be instrumental in shaping teachers who are not just skilled in the classroom, but who have a grasp of wider thinking about the learning area/subject and about educational issues in general (Steyl 1998, p. 112). In many CPTD programmes the emphasis therefore falls on upgrading the qualifications of currently serving teachers, rather than providing newly trained staff (Steyl 1998, p. 94).

CPTD aims to develop content knowledge, instructional methodology and skills (Craft 1996, pp. 6; Hunsaker and Johnston 1992, p. 350, 351; Steyl 1998, p. 92) and, most importantly, CPTD endeavours to develop knowledge, skills and attitudes (Craft 1996, p. 6; Steyl 1998, p. 117). CPTD chiefly serves two purposes, namely the empowerment of unqualified teachers helping them to survive in a profession for which they are not yet qualified, and the further development of qualified teachers within a specific content area (Steyl 1998, p. 114). New curricula, different ways of evaluation and assessment of learners' progress and challenges from the political and social environment dominate the changes within the educational environment (Steyl 1998, p. 117). CPTD serves to develop all educational staff at all levels of the educational service, including classroom teachers, senior administrators and school principals.

The formal and less formal nature of CPTD activities and processes

CPTD activities include both formal and less formal processes. Formal processes are designed to enable development in specific target areas. Curriculum-based courses, as well as CPTD on instructional methodology and training in response to change, are regarded as formal CPTD activities. Formal CPTD activities are believed to provide a concentrated focus on the specifics of change. Formal CPTD processes imply the investment of time and money, as well as possible disruption of teaching time for learners concerned. Less formal CPTD processes are those activities that happen during the normal life of a school. Mentoring, coaching, delegating, team-teaching and rotating of responsibilities are regarded as less formal types of CPTD (Steyl 1998, p. 113).

The following aspects are usually addressed in both formal and less formal CPTD programmes:

- Equalisation of teachers through upgrading of academic and professional qualifications, as well as classroom skills and teaching strategies.
- Efficiency of classrooms and schools as microcosms through proper management training.
- Classroom competence through effective input on subject knowledge, theory, subject methodology and educational philosophy.
- Change brought on through curriculum development, social awareness programmes and CPTD for new roles such as multicultural teaching or religious and sex education.
- Empowerment through action research and teacher-led initiatives (Steyl 1998, p. 125).

Prerequisites for guidelines for successful CPTD

Although there are a number of prerequisites for successful CPTD, Steyl (1998, p. 123) identifies the following four important prerequisites for the success of any intended CPTD:

- A careful selection of appropriate participants who have the biggest need for this particular training and who are motivated to use it to their own and consequentially also learners' full advantage.
- Efficient organisation that is, the proper environment to enable effective learning to take place, the right time of day/school year and smooth administration. These aspects are frequently overlooked and may have disastrous effects on the quality of the CPTD provided, if it is not taken into account.
- Effective delivery of the content of a CPTD programme. Good trainers who are knowledgeable, credible and skilful at enabling learning must be used in CPTD activities. A common weakness in CPTD delivery is to invite trainers who are experts in their field but who cannot communicate effectively with their audience. Trainers must have the ability to involve and motivate audiences into full participation.
- It is also important to review the success of a CPTD intervention to improve the quality of activities and learning for future CPTD intervention activities (Steyl 1998, p. 123).

Authors use different terms when referring to CPTD. It is necessary to distinguish between training, development and growth. Training is concerned with the teaching of specific, factual, narrow—scoped subject matter and skills. It is a formal classroom learning activity. Development is a larger canvass which envisages modification of behaviour and personality. Professional development is concerned with a broader subject matter of a conceptual or theoretical nature and the development of personal attitudes. It comprises all

learning experiences, both on and off the job, including formal, classroom training. Growth refers to one's own "becoming a better person" and includes aspects of life not necessarily part of professional development. Growth could thus include professional development, but also includes other areas and aspects of life. "The wise adage of Lawrence Stenhouse (1975) that there can be no curriculum development without teacher development seems to have been replaced by the adage that there can be no curriculum implementation without training" (Day 1999, p. 7).

Gettly (2002, pp. 31–33) lists the following prerequisites for CPTD which, in this case, is referred to as training:

- Training should be aimed at the needs and expectations of teachers.
- Training should be practical.
- Training should occur continuously.
- Training should give teachers the opportunity for professional development and growth.
- Although the education authorities are not involved in the training, which could result in training becoming isolated, the HEIs' quality control of the training model will prevent this isolation.
- The school management team must be informed and supportive.

The need for well planned long-term CPTD programmes

Mouton et al. (1999, pp. 169–170) are of the opinion that a well planned long-term CPTD programme is the key to successful implementation of technology education. From a South African perspective, they have made the following useful recommendations for developing such a programme:

- CPTD should take place over an extended period and should include continued contact over a number of years.
- The content of the programme should include a mix of subject knowledge, pedagogical knowledge and co-operative learning facilitation.
- Training should be tailored to the needs of different phases and different groups of teachers.
- Scheduling of training should be informed by the fact that teachers have limited time and are usually reluctant to give up weekends for training.
- Teachers would be motivated if they received credits for training and if continual support was available.

A common complaint of technology teachers in South Africa is that previous CPTD interventions were too generic and did not help them deal with subject content and subject pedagogy (Ziqubu 2006, p. 46). To equip technology teachers with knowledge, skills and attitudes and values necessary to ultimately improve their learners' learning, they need CPTD that focuses specifically on technology content and pedagogy.

To ensure that CPTD programmes presented to teachers are of high quality, it is important to evaluate a programme after it has been delivered (Craft 1996, p. 61).

Aspects to be considered for the evaluation of CPTD programmes

According to Craft (1996, p. 61), the evaluation of CPTD is done rather haphazardly and usually only focuses on participant satisfaction. As far as the evaluation of CPTD is concerned, the following aspects need to be considered for evaluation:

- Teacher satisfaction
- Impact on teachers' knowledge, attitudes and skills
- Impact on teachers' practice or personal growth
- Impact on teachers' careers or roles
- Impact on school or team culture
- Impact on pupils' learning
- Impact on school or team management and organisation.

The above-mentioned aspects refer to the various stakeholders who have an interest in the CPTD and there are interrelationships between these aspects or possible areas of impact of the CPTD. Influencing teachers' knowledge, skills and attitudes for example, might have an effect on the teacher's practice and on the school itself. Where teachers disseminate what has been learned to other colleagues, the practice of those colleagues might also be affected. Through impacting on individual teachers, the school itself and the learning of other teachers' learners may also be affected (Craft 1996, p. 61).

Models for CPTD

Centralised, decentralised and cascade models for CPTD

There are several CPTD models (Gettly 2002, p. 26). According to Steyl (1998, p. 126) both centralised and decentralised structures are needed for effective CPTD delivery. The models most commonly used are a centralised or school-focused CPTD model (where training takes place at a central venue for teachers from different schools), a decentralised or school-based CPTD model (where training takes place in the teacher's own school) and the cascade CPTD model (where senior staff is trained at a central venue and expected to pass on the information to their colleagues at their schools)(Conner 1991, p. 50; Conzemius in Burke et al. 1990, pp. 180–190; Craft 1996, p. 12; Edwards 1991, p. 38; Gettly 2002, p. 26; Groenewald 1995, p. 32).

A CPTD programme based on these CPTD models is facilitated for teachers. The models refer to where the CPTD is facilitated, for example, in the school where the teacher teaches, or at a central venue away from the school. The model also determines who is responsible for facilitating the CPTD. Each of these models is discussed briefly in the following sections.

The centralised or school-focused CPTD model

Craft (1996, pp. 13–14) refers to centralised CPTD as training where teachers from different schools gather at a central venue for courses/workshops of a day or longer. The training personnel for centralised CPTD are normally associated with a higher education institution (HEI). The original notion is that centralised training should be managed by competent personnel from the HEIs who would ensure that the planning, presentation and training material are of high quality. However, during the evaluation of the training model,

the model was found lacking in many respects (Gettly 2002, p. 26). Although teachers do find such courses stimulating (acquiring new ideas and exchanging experiences with teachers from other schools), the centralised model has some disadvantages, such as gaps between theory and practice (Craft 1996, pp. 13–14). Craft (1996, pp. 8–14) and Gettly (2002, p. 29) describe the gaps in this model as follows:

- Inappropriate aims on macro level do not comply with the true needs and expectations of teachers.
- Inappropriate activities with no regard for the outcomes are planned.
- Teachers lack motivation because they are unwilling to attend training as there is very little perceived incentive (financial or other) for further qualifications.
- Finally, it is not very popular as teachers' private lives are disrupted and single parents struggle to fit training in.

The centralised model for CPTD is also referred to as school-focused CPTD, which indicates that although the CPTD is facilitated away from the school, it focuses on what should happen at the school. The term school-focused CPTD refers to training which usually occurs away from the school and is presented by agencies such as higher education institutions (HEIs) or educationalists (McBride 1989, p. 41). In order to ensure compliance with the needs of an individual school and its personnel, the compilation, planning and implementation, is key in school-focused CPTD. School-focused CPTD therefore needs to comply with the needs of the school as an organisation, including the needs and expectations of each individual teacher (Gettly 2002, p. 36).

According to Conner (1991, p. 54) school-focused CPTD should be based on needs identified by teachers themselves. Day (1999, p. 4) refers to school-focused CPTD as "… all natural learning experiences and those conscious and planned activities which are intended to be of direct benefit to the individual, group or school and which contribute, through these activities to the quality of education in the classroom. It is a process by which, alone and with others, teachers review, renew and extend their commitment as change agents to the moral purpose of teaching…"

Logistic problems, time constraints and a variety of other reasons could make it difficult to get teachers from various schools together at a central location for CPTD. Under these circumstances it might be necessary to use the decentralised or school-based CPTD model.

The decentralised or school-based CPTD model

According to Edwards (1991, p. 42) a school-based CPTD model has as basic point of departure that training occurs within the confines of the normal working milieu and is managed mainly, but not wholly, by the school's own personnel to fulfil the immediate and specific needs of the school (Gettly 2002, p. 31). The CPTD is thus facilitated for teachers at the schools where they teach and teachers do not gather at a central location, hence the term decentralised. Hargreaves is of the opinion that in order to improve schools, there has to be investment in professional development. If teachers are to be improved, their professional development should be set within the context of institutional development (Day 1999, p. 9).

The school-based CPTD model was developed in an effort to overcome the problems of the centralised CPTD model (Craft 1996, p. 14; Gettly 2002, p. 31). According to Craft (1996, p. 14) the rationale for school-based CPTD is to "…achieve a better match of a CPTD course to the need and culture of a particular group of professionals". Craft (1996, p. 14) is of the opinion that all CPTD models should be school based. Edwards (1991,

p. 42) is of the opinion that the CPTD model that would be most effective in bringing about change in the classroom should be concrete, teacher-specific CPTD sessions that focus on practical problems, that involve teachers in project decisions and which includes classroom support and regular meetings that focus on practical problems.

When implementing the school-based CPTD model, aspects such as a lack of financial support and continuity may, however, be problematic because of a continuous change of personnel and new personnel needing regular training (Leckstein 1994, p. 41).

The cascade CPTD model

The cascade model is an effort to combine centralised CPTD and school-based CPTD. It is a training programme in which large numbers of teachers from different schools are trained during centralised CPTD (Craft 1996, p. 17). This approach differs from centralised CPTD as the message is cascaded from top to bottom. This implies that dissemination of a central message is built into the training (Craft 1996, p. 17; Gettly 2002, p. 33).

Although it is implemented successfully in other countries and contexts, the cascade model has been widely criticised in South Africa as an inadequate model for delivering effective training in the South African context (Chisholm 2000; HSRC 2000; Khulisa Management Services 1999). It failed to prepare either officials or school-based teachers for the complexity of the implementation of the new national curriculum. In the first instance the cascading of information resulted in the "watering down" and/or misinterpretation of crucial information. Secondly, trainers lacked confidence, knowledge and understanding to manage the training process (Khulisa Management Services 2001a, b).

In the following section the authors discuss four different models relating to CPTD activities, namely a CPTD model from a CPTD course developer's perspective, a model for conceptualising teacher professional knowledge and a model to guide CPTD interactions with teachers. After discussion of the models from around the world, we also discuss a model for the CPTD of technology teachers in South Africa through short courses. This model was specifically developed to describe the South African context. These models were chosen from an eclectic and pragmatic point of view because they were all underpinned by local and international technology education CPTD contexts.

Models depicting the process of professional development specifically for technology teachers

A CPTD model from a CPTD course developer's perspective

Stein et al. (1999) have designed the model from a CPTD course developer's perspective, who seeks to plan a programme for teacher development in technology education (see Fig. 1). According to Stein et al. (1999) the model in Fig. 1 presents a framework through which the needs and concerns of technology teachers could be addressed.

The model is divided into three main sections separated by dotted lines. These sections represent different areas of teacher professional knowledge (i.e. personal construct knowledge, subject matter knowledge, school knowledge, pedagogical content knowledge and curricular knowledge). These areas should be addressed or developed by taking cognisance of the particular focus of each section during any CPTD programme based on this model.

The first section of the model acknowledges the importance of a teacher's prior experiences of technology, such teacher's personal constructs or beliefs about technology and

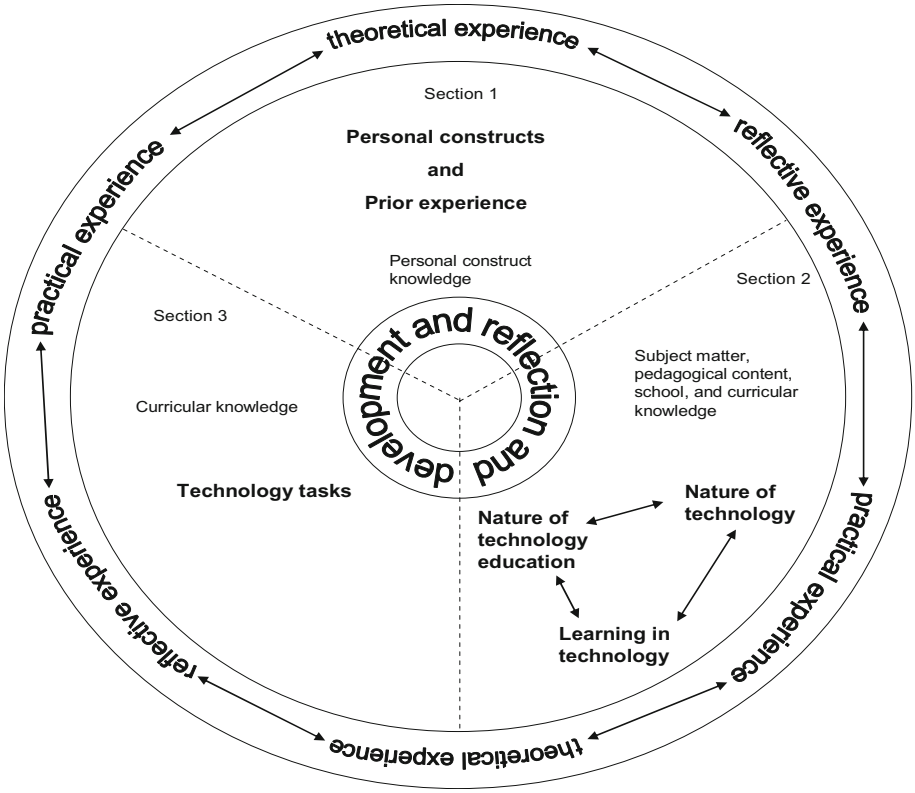

Fig. 1 CPTD model from a CPTD course developer's perspective (Stein et al. 1999, p. 11)

technology education and about teaching and learning in general, and how this can influence the way the teacher implements technology and evaluates what happens in the classroom. The teacher professional knowledge addressed and drawn upon in this section of the professional development model is mainly personal construct knowledge.

The second section of this model draws upon and addresses mainly subject matter, pedagogical, school and some curricular knowledge. The third section focuses specifically on the development of curricular knowledge. Combined, the second and third sections represent the nature of technology and technology education, learners in technology and technological tasks.

The second section of the model contains three interacting aspects of knowledge about technology and technology education. These aspects represent a large portion of the background knowledge that a teacher new to technology has to develop. The "nature of technology" aspect refers to the need for teachers to develop their understanding of technology as a concept and how technology works in different contexts. The "nature of technology education" aspect refers to a teacher's understanding of technology education as a key learning area in its own right alongside other more established learning areas. This part of the model also suggests a need to make teachers aware of the conceptual and procedural knowledge aspects that make technology unique. Exploring differences and similarities between technology and other key learning areas helps teachers to gain a sense

of what technology is and what it is not. This in turn helps them with the practical aspects of planning, teaching and assessing.

The third aspect in this section namely, "learning in technology", indicates the need to develop an awareness and understanding of learners and learning within technology contexts. Teachers need to develop a view of learning in technology that is different from, but related to their view of learning in general. They also need to develop an awareness of the factors that could influence a learner's abilities and capabilities in technology, such as their prior knowledge, their learning abilities and strategies and their cultural and social backgrounds.

The three aspects in section two of the model interact with each other and will help teachers to form a background that will inform practical implementation strategies and activities in the classroom. Teachers would thus consider the nature of technology, the nature of technology education and the nature of learners in technology to develop plans and activities for implementation in their classrooms.

The "technology tasks" aspect in section three of the model refers to the development of knowledge related to the practical implementation of technology education in the classroom. This includes all the strategies and methods used to plan, teach, assess and evaluate effectively.

This model describes the content of professional development in technology and how the aspects of content fit together. Through the elements contained in the outside border, namely "reflective, practical and theoretical experiences" and the centre labeled "reflection and development", it also implies a plan of action for professional development. The arrows in the border and central parts of the model indicate constant flow. Professional development only takes place through constant theoretical, practical and reflective engagement with experiences in the classroom, through the development of personal constructs and the broadening and deepening of knowledge.

This model shows that professional development in technology is not static, but a continuing and developing process where change continues to happen. It does not have a definite beginning and end. It happens within certain contexts within which teachers can

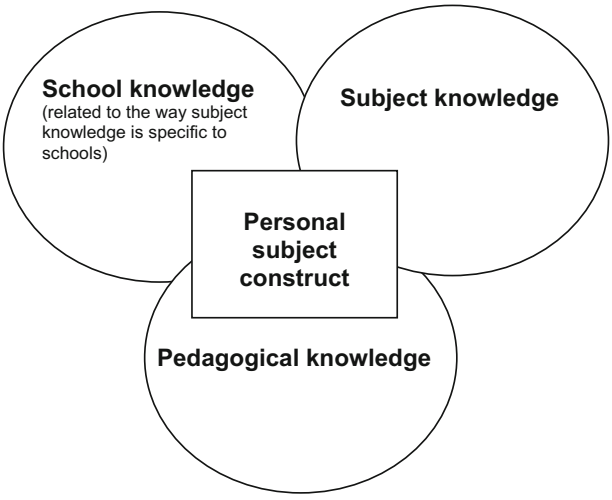

Fig. 2 A model for conceptualising teacher professional knowledge (Banks et al. 2004, p. 143)

find meaning and of which they form part. In the following section the authors discuss a model for conceptualising teacher professional knowledge by Banks et al. (2004, pp. 142–146).

A model for conceptualising teacher professional knowledge

Banks et al. (2004, pp. 142–146) present a graphic framework (Fig. 2) that helps to visualise the different aspects of technology teacher knowledge.

Three intersecting spheres represent school knowledge, subject knowledge and pedagogical knowledge respectively. A rectangle over the intersecting parts of the spheres represents a teacher's personal subject construct. The model indicates that a teacher's personal subject construct comprises a combination of school knowledge, subject knowledge and pedagogical knowledge. School knowledge can be seen as an intermediary between subject knowledge (knowledge of technology as practiced by different types of technologists for example) and pedagogical knowledge as used by teachers (powerful analogies, illustrations, examples, explanations and demonstrations). This would, however, negate the dynamic relationship between the categories of knowledge implied by the diagram. Teachers' subject knowledge is enhanced by their own pedagogy in practice and by their contextual expectations which form part of their school knowledge. Thus a teacher often understands a topic better after teaching it to learners.

The following are examples of a teacher's school knowledge:

- Facilities available in the school
- Appearance of school work rooms
- Expertise and history of other staff
- Status given to designing and making
- Interpretation of appropriate designing and making
- Prevailing ethos concerning issues such as pupil autonomy and staff-pupil relationships
- Sensitivity to political interpretations of technology and society.

The following examples of a teacher's subject knowledge of technology can be distinguished regarding facts and concepts in the domains:

- Food technology
- Resistant material technology
- Textile technology
- Electronic and communication technology
- Control systems technology
- Methods of construction and manufacture in the above domains
- Practical expertise in these methods of construction and manufacture.

The list below shows examples of a teacher's pedagogical knowledge:

- National curriculum requirements
- Published teaching and learning resources
- Forms of assessment
- Use of questions
- Modeling appropriate practice
- Demonstration technique
- Use of analogies
- Task design.

Personal subject construct is a combination of elements of school knowledge, subject knowledge and pedagogic knowledge which blend with other influences to provide a view of the aim, value, content and methods of technology as a school subject.

The dynamic intersection of subject knowledge, school knowledge and pedagogical knowledge is what constitutes teacher professional knowledge. At the centre of this process are the teacher's personal constructs, an intricate collection of learning experiences, a personal view of what "good teaching" entails and the teacher's own belief of what the purposes of the subject are. All these aspects combined, underpin a teacher's professional knowledge.

This representation of a teacher's knowledge relates to Shulman's work where he differentiates between three categories of "knowledge that grows in the minds of teachers", namely content knowledge, pedagogical content knowledge (PCK) and curricular knowledge (1986, pp. 9–10). With regard to Content knowledge he does not only refer to the knowledge of the facts and concepts of a domain but emphasises that it also requires understanding the structures of the subject matter. His term "PCK" refers to "the particular form of content knowledge that embodies the aspects of content most germane to its teachability, the ways of representing and formulating the subject that make it comprehensible to others". Curricular knowledge refers to knowledge and understanding of the curricular alternatives available for instruction and the appropriate implementation of these alternatives. It also includes knowledge of what learners have learned in previous years, as well as what they will learn in the coming years in the subject area. As part of curricular knowledge teachers are also expected to be familiar with the curriculum being studied by their students in other subjects in order for them to relate their content to other subjects (Shulman 1986, pp. 9–10). Shulman (1987, p. 8) later elaborated on these categories to include:

- content knowledge;
- general pedagogical knowledge (strategies for classroom management and organization, not subject specific);
- curriculum knowledge (relating to materials and programs that serve as "tools of the trade" for teachers);
- pedagogical content knowledge;
- knowledge of learners and their characteristics;
- knowledge of educational contexts (relating to the classroom, the governance and financing of school districts and the character of the community and the cultures in it) and
- knowledge of educational ends, purposes and values and its related philosophies and history.

A model to guide CPTD interactions with teachers

Banks et al. (2004) and Jones and Moreland (2004) are of the opinion that when a teacher has to teach technology for the first time, significant changes need to take place in the teacher's "professional knowledges". Jones and Moreland (2004) distinguish between three dimensions of knowledge namely, knowledge about technology, knowledge in technology and knowledge about teaching technology.

Stein et al. (2007, p. 180) use the following labels for the dimensions of a teacher's professional knowledge:

- School knowledge described as the teacher's understanding of how technology as a school subject differs from technology in the real world.
- Pedagogical knowledge or knowledge about teaching technology. This is the knowledge the teacher uses to make the subject content comprehensible to learners.
- Subject knowledge or a teachers' understanding of technology as a field of study.

The dimensions of knowledge are portrayed in Fig. 3 as the three intersecting circles. These dimensions of knowledge namely, institutional knowledge, discipline knowledge and pedagogical knowledge are inter-related and influence one another. None of these dimensions can be developed in isolation of the others. The small circle in the centre of the diagram portrays the teacher's personal subject construct knowledge, which refers to school knowledge, subject knowledge and pedagogical knowledge combined.

The model shown in Fig. 3 is used by Stein et al. (2007, pp. 180–183) to underpin and guide CPTD interactions with teachers. This model combines the Banks et al. (2004, pp. 142–146) and Stein et al. (1999) models with the aim to devise a clearer, simpler model than the original Stein et al. (1999) model.

Professional development that provides experiences of a reflective, practical and theoretical nature, reflected in the outermost circle, facilitates and frames any process or

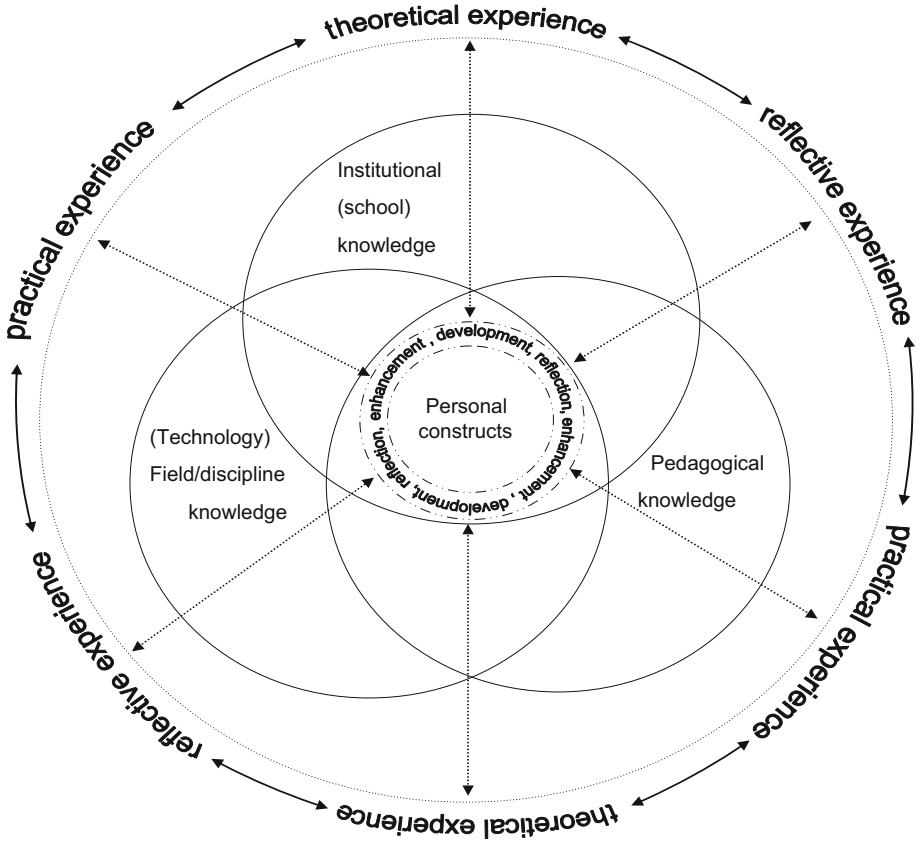

Fig. 3 A model to guide CPTD interactions with teachers (Stein et al. 2007, p. 182)

activity through which teachers are supported to articulate, challenge and reformulate their knowledge. Reflection plays a critical role in developing professional knowledge because it enables teachers to translate experiences and ideas gained through professional development activities and making it a part of their personal construct. Over time successful professional development activities will change a teacher's personal construct. This kind of change is a slow and gradual process, but by changing the teacher's beliefs and understanding of the subject, a much deeper and lasting change is achieved than when teachers simply observe certain practices (Stein et al. 2007, pp. 180–183). The lines connecting the practical, theoretical and reflective experiences in the outer circle and the lines crossing through to the central circle represent this need for professional development experiences to give teachers the opportunity to make explicit connections between professional development activities and their own personal construct.

According to the Stein et al. (2007, pp. 180–183) model, professional development should include activities that expose teachers to practical, theoretical as well as reflective experiences. It should be aimed at developing their school, subject and pedagogical knowledge through which they can enhance and develop their own personal construct. The latter is achieved by reflecting on the activities and making it their own. In the next section we discuss a model that focuses on the process of developing appropriate CPTD programmes for teachers in a given context. This model was specifically developed by Reitsma (2006, p. 276) for the South African context through an analysis and adaptation of the models of Stein et al. (1999), Bybee (2001), Milano and Ullius (1998) and Nadler and Nadler (1994).

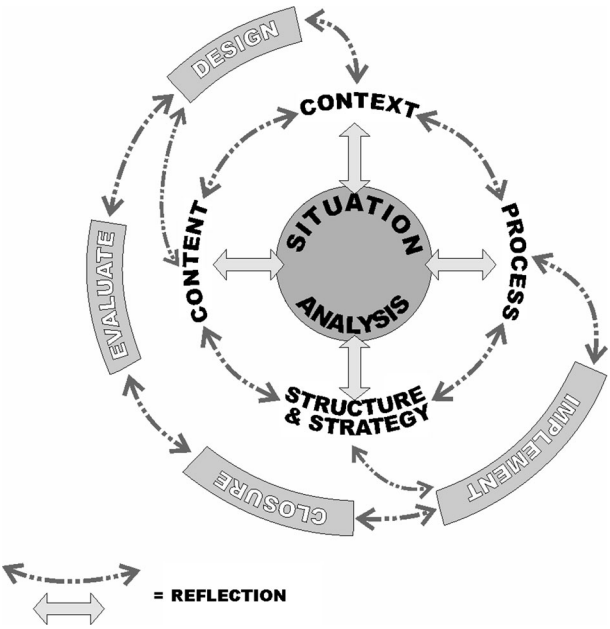

Fig. 4 A model for developing CPTD programmes for technology teachers in South Africa (Reitsma 2006, p. 276)

A model for developing CPTD programmes for technology teachers

Figure 4 shows a model for CPTD proposed by Reitsma (2006, p. 276). The model focuses specifically on the process of developing appropriate CPTD programmes for technology teachers in a South-African context. Four components need to be considered when designing good quality professional development experiences, namely content, process, structure and strategy and context (Reitsma 2006, p. 275). Although the four components are depicted as separate entities, it forms a unit in the sense that every variable influences and guides the others. For example, the content chosen will be informed by the context, process as well as the structure and strategy. Reflection takes place throughout to ensure the training is done effectively. Any problem or change in the situation can thus be rectified or addressed in time. The arrows between the variables and the following phases depict the interrelationship between variables and phases. Analysis of the situation forms the centre of the model to indicate that the situation in which the CPTD must take place, is the basis round which the experience is designed.

To define and describe the four components (content; process; structure and strategy; and context), it is necessary to do a situation analysis to determine the needs of the teachers concerned.

1. Situation analysis

Detailed information is needed regarding the individuals in need of professional development as well as the institutions they function in. One of the greatest criticisms of

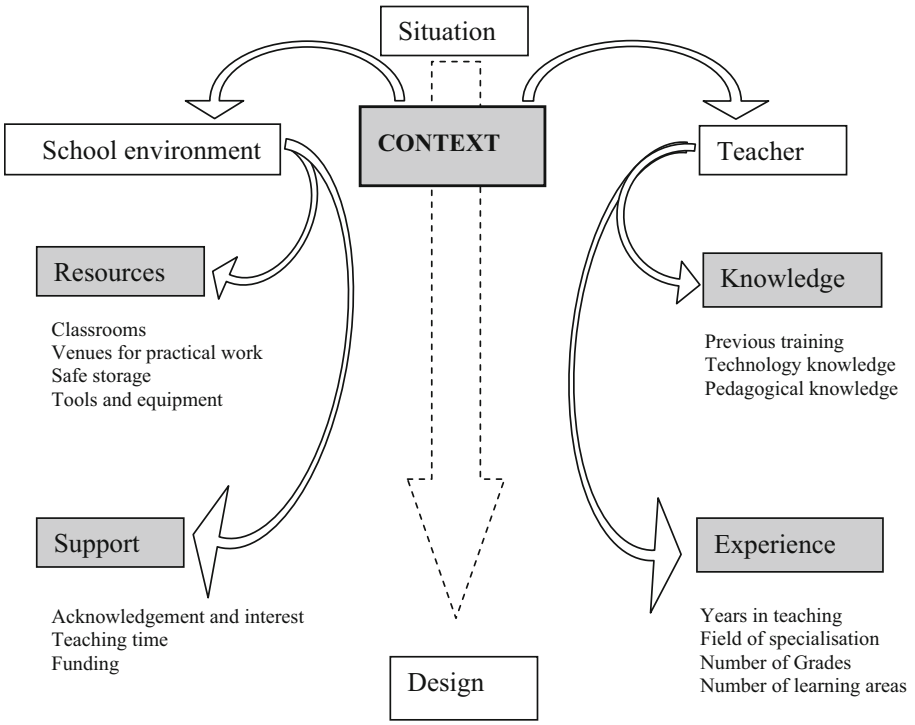

Fig. 5 A schematic representation of the context of CPTD (Reitsma 2006, p. 280)

current CPTD programmes is that it does not address the participants' needs and that the training does not relate to their school environment (Reitsma 2006, p. 278). A proper situation analysis before deciding on the content, process, structure and strategy and context of the professional development experience could address these shortcomings and provide CPTD based on teachers' needs.

2. Context

The context within which training takes place, describes the conditions under which the content is experienced. The context answers questions such as who, where, when and why with regard to the intended CPTD experience. Context can be described from the point of view of a school environment and from a teacher's perspective (Reitsma 2006, p. 279). Figure 5 gives a schematic representation of the context of CPTD.

With regard to the school environment, it is important to see the teacher as part of the school system and not only as an individual functioning on his/her own. If the professional development focuses only on the individual, the implementation thereof is problematic. Approaching the individual as part of an organisation, minimises obstacles regarding implementation as the individual and organisation support each other. Teachers do not always receive the support and resources they need from their schools to teach technology in a meaningful way. With regard to resources, teachers face particular challenges at their schools such as lack of services like running water, sanitation and electricity, classrooms that are in disrepair with a lack of furniture, no suitable venues to do practical work, lack of safe storage facilities and lack of tools and equipment. Teachers also experience a lack of support regarding acknowledgement of, and interest in Technology as a learning area from colleagues and management. This causes a continuing struggle for sufficient teaching time and funding (Reitsma 2006, p. 279).

Before deciding on content for professional development, the fact that individual teachers have different training needs must be taken into account. Teachers' levels of knowledge may vary with regard to previous training, subject knowledge and pedagogical knowledge. Experience with regard to number of years in teaching and field of specialisation also vary from teacher to teacher. The fact that some teachers teach a number of grades in a number of learning areas result in excessive workloads for the incumbents and this influences the time available for CPTD. Individual teachers' training needs might thus vary from a teacher in dire need of subject knowledge and pedagogical knowledge, to a teacher with sufficient subject knowledge and teaching experience but who has a need for further enrichment (Reitsma 2006, pp. 279–282).

3. Process

The process influences how content is presented. This includes the way in which activities are planned, organised, executed and followed up. The process followed needs to be informed by the following:

- Teachers (the learners in the training situation) in need of the training
- The knowledge, skills and values needed
- Assessment and certification of the training
- The community (Reitsma 2006, pp. 283–286).

The diagram in Fig. 6 (Reitsma 2006, p. 284) gives a schematic representation of the process of CPTD. The teachers should be the determining factor when choosing activities for particular training. The situation within the school and what is known to the teacher need to be used as a point of departure. Teachers' prior knowledge and experience need to

be taken into account when training activities are planned as it will have a direct influence on their training needs. Training activities should address technology teachers' need for subject knowledge and pedagogical aspects.

The knowledge, skills and values needed should be taken into account and appropriate aspects of subject content and pedagogical knowledge should be chosen to fulfill teachers' needs. Training activities addressing different areas of content knowledge and pedagogy need to be organised in such a way that teachers can decide which specific areas they need training in. This implies that not all teachers will attend all training sessions, for example a Technical Drawing teacher will not need a training session on graphic communication skills, but might have a need for a training session on processing (Reitsma 2006, pp. 283–284).

Assessment refers to the way teachers are assessed during and after training. Holistic assessment of teachers could be done by assessing their prior knowledge and their knowledge after training. Teachers' classroom practice could be observed and the learning outcomes for the training could be assessed. Certification is either done based on the teacher reaching the CPTD's outcomes or for attendance. The ideal is to award certificates based on reaching the CPTD's outcomes and not only for attendance. Through accreditation of the CPTD training, teachers can ultimately be awarded a qualification for attending the CPTD. This would motivate teachers to attend the CPTD sessions (Reitsma 2006, pp. 284–285).

With regard to community, it is necessary to involve the school community in which teachers must work in the CPTD to make implementation as achievable as possible. In order for the teacher to apply the new knowledge gained in the training, he or she needs the support of colleagues as well as school management and subject advisors. Principals could also become involved by attending information sessions and helping with school-based CPTD (Reitsma 2006, pp. 285–286).

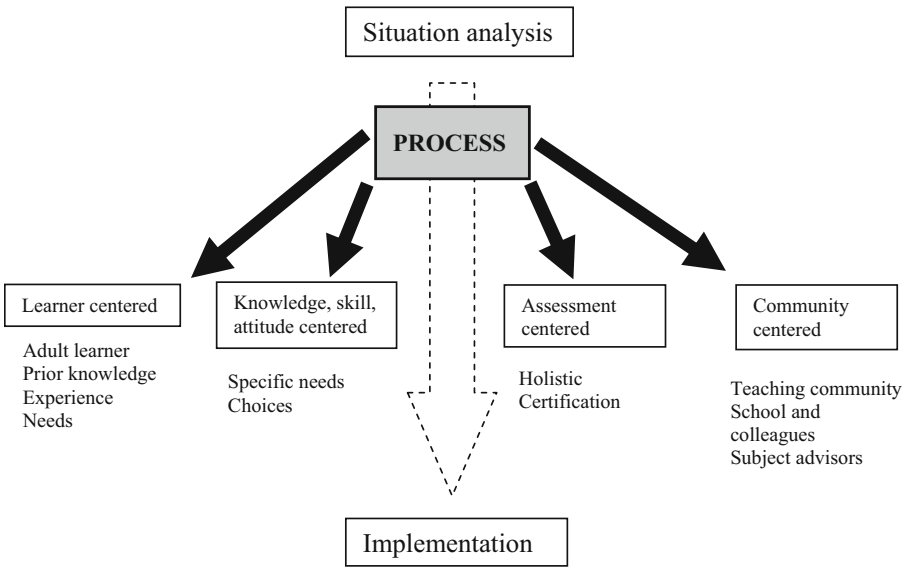

Fig. 6 A schematic representation of the process of CPTD (Reitsma 2006, p. 284)

4. Structure and strategy

The situation analysis and the aspects identified in the context and process must be taken into account when planning the structure of professional development. Figure 7 shows the structure and strategy of CPTD in schematic form (Reitsma 2006, p. 287). The format of training should allow for adequate contact time so that the required skills and knowledge can be developed, but it must also be possible to implement it in a sustainable manner over a long period of time. There should be a balance between school-focused and school-based CPTD experiences. By supporting continuing school-focused training with school-based training, the teacher gets the necessary support to make implementation more attainable.

With approach seen as an aspect of structure and strategy, a constructivist approach that takes the experience and prior knowledge of the teacher into account, should be used to develop new knowledge and skills. Teachers could be trained in groups that will facilitate their learning from one another, especially where they come from different fields of specialisation. Training should be as focused on practice as possible, with workshops in which practical demonstrations are given, classroom practices observed and the implementation thereof discussed (Reitsma 2006, p. 288).

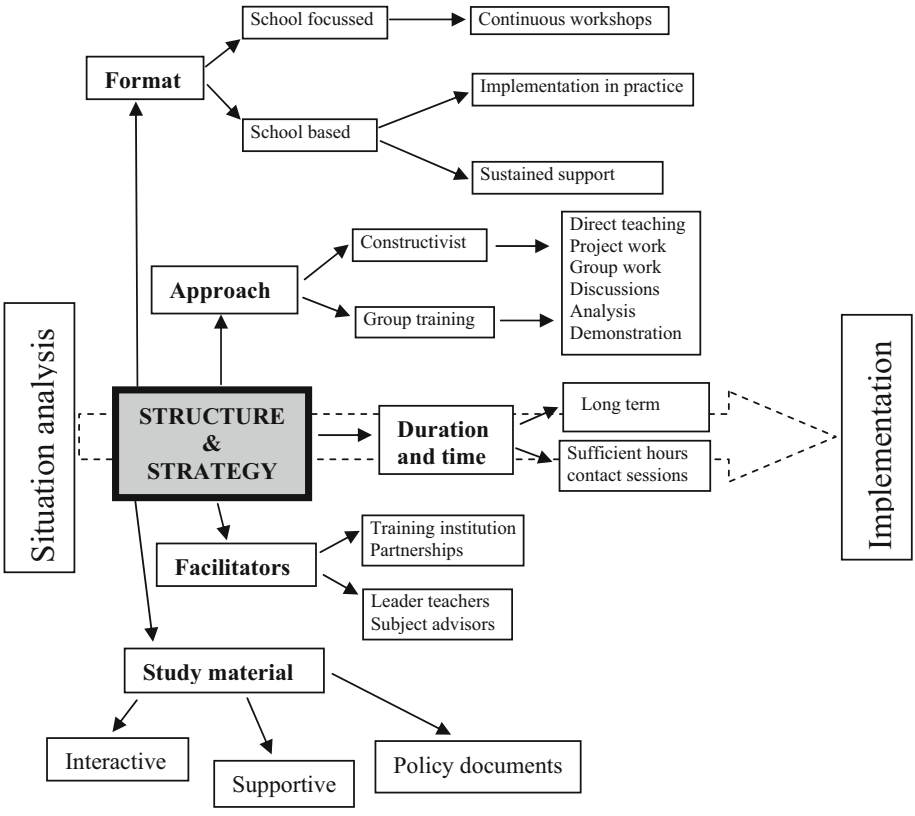

Fig. 7 The structure and strategy of CPTD in schematic form (Reitsma 2006, p. 289)

According to Reitsma (2006, p. 290) successful CPTD takes place over a long period of time. No clear guidelines about the duration and time of ideal CPTD opportunities are available and teachers themselves have widely varying opinions on how long training sessions should be. It is, however, clear that CPTD which takes place over time has a better effect than once-off CPTD opportunities. This will address teachers' concerns about the incompetency of facilitators of some CPTD programmes in the past. Leader teachers and subject advisors should offer support to teachers with regard to implementation in the classroom (Reitsma 2006, p. 291).

Reitsma (2006, p. 293) states that it is important for successful CPTD that the study material be developed to address teachers' needs and that such developed material is of high quality. The curriculum could be used as a point of departure for developing study material which should be interactive and aimed at practical application in the classroom. Teachers struggle to develop their own suitable study material and it is, therefore, important to support teachers in this regard. It is important, however, not to make teachers dependent on the study material during implementation. The study material should leave room for the teacher's own creative interpretation and adaptation during implementation.

5. Content

The content component refers to what needs to be presented to teachers that would enable them to reach the outcomes and develop the necessary knowledge, skills and

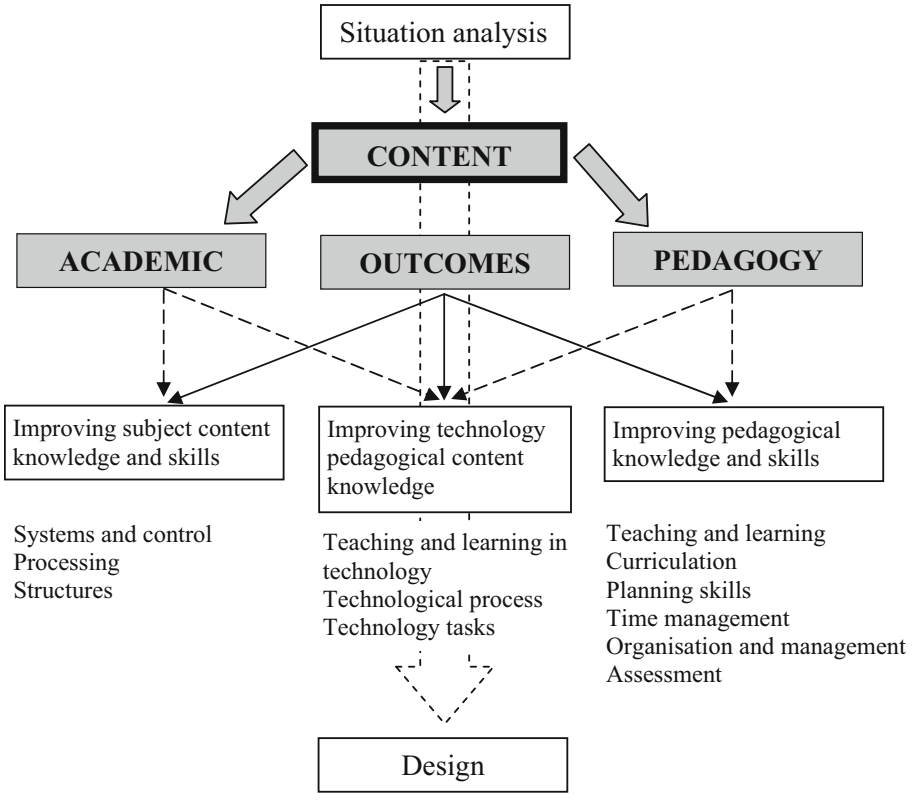

Fig. 8 Proposed core content relating to the outcomes for CPTD (Reitsma 2006, p. 296)

understanding. Reitsma (2006, p. 294) identifies the following proposed core content relating to the outcomes for CPTD (refer to Fig. 8).

With regard to academic content, teachers and subject advisors alike feel that CPTD programmes usually focus too much on generic aspects and that CPTD should focus more on the subject content of technology. Another concern is that CPTD programmes usually lack practical training. The academic content should not only focus on theoretical knowledge but should also include practical skills relating to the theory (Reitsma 2006, p. 295).

Pedagogical content could be based on the needs of teachers as determined in the situation analysis. Some teachers have little teaching experience and need a larger part of generic pedagogical content. The pedagogical content of the CPTD programme should form the basis of the subject-specific pedagogy required in technology education (Reitsma 2006, p. 297).

It is important that the pedagogical part of the training is not purely generic, but that it is aimed at the unique features of the learning area. Some teachers have serious gaps in their knowledge regarding the methodology of technology education, yet CPTD programmes usually offer very little training in the practical implementation of the theory. The subject content should be focused on practical implementation and be presented in conjunction with the related methodology necessary for implementation in the classroom (Reitsma 2006, p. 297). Custer and Daugherty (2012, pp. 60–62) also supports the notion that with regard to content it is important to focus on conceptual knowledge, as well as practical design-based activities to facilitate the practical implementation thereof.

6. Design, implementation, evaluation and closure of CPTD programmes

Reitsma (2006, p. 298) argues that once the outcomes are determined and the content is chosen, the programme can be designed further. This design will be based on the context and content. The design phase is where the information gathered in previous phases are realised into a programme that can be implemented.

The implementation of the designed programme will be based on the chosen process, structure and strategy (Reitsma 2006, p. 298), and workshops should be combined with school-based support strategies. A long-term approach should be followed during which the opportunity is created for teachers to acquire new knowledge and skills and apply such in their classrooms with resultant problem identification, reflection and discussion. This will then be followed by a revision workshop for feedback and assessment. Workshops planned for CPTD should be long enough, time wise, to allow for effective learning to take place. Opportunities for discussion, demonstration and problem solving should be planned as part of the workshops. Evaluation should also form part of the implementation process where, for example, the teacher's classroom practice is continuously observed and discussed afterwards. With regard to the pedagogy of CPTD Custer and Daugherty (2012, pp. 60–62) emphasise the importance of active engagement in hands-on activities. They also stress the importance of reflective strategies and meta-cognitive approaches to help teachers in CPTD programmes identify learning goals and monitor progress toward attaining these goals. They are of the opinion that guided reflection is crucial as it impacts the transfer of learning back into the classroom.

The evaluation phase should include the evaluation of the process followed during the programme as well as the impact of the programme. The programme should thus be adapted and developed further on the basis of the needs expressed through the programme evaluation. Reitsma (2006, p. 301) proposes that various formative strategies such as

teaching analysis, diaries and discussion groups be implemented and then followed up with summative assessment such as tests and examinations.

During the closure phase an overview of the programme can be obtained and possible action plans for future activities could be formulated. Reitsma (2006, p. 304) suggests that certification should only take place after teachers have proven that they have reached the outcomes of the CPTD programme through formative and summative assessment.

Findings and discussion

In an attempt to answer the research question an analysis of the theoretical framework for CPTD was undertaken. The analysis yielded broad criteria that underpin the development of technology teachers' professional knowledge.

CPTD for technology teachers should aim to develop teachers' professional knowledge with regard to school knowledge, subject knowledge and pedagogical knowledge. The development of these different kinds of knowledge should ultimately develop and enhance the teacher's personal subject construct. This is accomplished through a combination of theoretical, practical and reflective experiences. Table 1 summarises the criteria that underpin CPTD:

School knowledge can be seen as an intermediary between subject knowledge and pedagogic knowledge. This includes knowledge of the specific school and its context as well as how discipline knowledge is adapted to appropriately facilitate the school subject. Discipline knowledge refers to knowledge of technology as practiced by different types of technologists for example.

A teacher's pedagogic knowledge refers to knowledge used by teachers in teaching the subjects to learners in a class (for example powerful analogies, illustrations, examples, explanations and demonstrations). Teachers' subject knowledge is enhanced by their own pedagogy in practice and by their contextual expectations which form part of their school knowledge.

The teacher's skills, attitudes and values referred to in C4 are the aspects of content that would complement the various kinds of knowledge of a teacher. Personal subject construct (C5) is a combination of elements of school knowledge (C1), discipline knowledge (C2)

Table 1 Criteria for CPTD

No.	Criteria for CPTD
C1	CPTD should develop a teacher's school knowledge
C2	CPTD should develop a teacher's discipline knowledge
C3	CPTD should develop a teacher's pedagogic knowledge
C4	CPTD should develop a teacher's skills, attitudes and values
C5	CPTD should develop and enhance a teacher's personal subject construct
C6	CPTD should include theoretical experiences
C7	CPTD should include practical experiences and take a teacher's prior experiences of technology into account
C8	CPTD should include a teacher's reflective experiences

and pedagogic knowledge (C3) which blend with other influences to provide a view of the aim, value, content and methods of technology as a school subject.

The dynamic intersection of subject knowledge, school knowledge and pedagogical knowledge is what constitutes teacher professional knowledge. At the center of this process are the teacher's personal constructs, an intricate collection of learning experiences, a personal view of what "good teaching" entails and the teacher's own belief of what the purposes of the subject are. All these aspects combined, underpin a teacher's professional knowledge.

Due to the unique nature of technology as a subject CPTD opportunities should include theoretical (C6) as well as practical (C7) experiences. Teachers should also be encouraged to reflect (8) on their experience of the CPTD. The achievement and further development of broadly defined competences are part of the challenge of good teaching and being a good teacher are not only the responsibility of each individual but also that of the employing organization. Continuing professional development is a joint responsibility (Day 1999, p. 57).

The criteria can serve as part of the pre-determined criteria for the evaluation of CPTD programmes. The evaluation of CPTD programmes against the identified criteria might inform its relevance for practice and will most probably contribute to its refinement as well. The authors believe that some practice-based research is also necessary to complement the theoretical perspective on the criteria for CPTD.

It is necessary to link the practical (C7), theoretical (C6) and reflective (C8) experience of teachers because it gives them the opportunity to make explicit connections between the professional development activities aimed at developing their school (C1), discipline (C2) and pedagogical (C3) knowledge and making it a part of their personal subject construct (C5). Thus, the professional development of technology teachers takes place only through constant theoretical, practical and reflective engagement with experiences in the classroom, developing personal constructs and broadening and deepening knowledge about a learner's abilities and capabilities in technology (their prior knowledge, their learning abilities and strategies and their cultural and social backgrounds). Day (1999, p. 49) states that teacher development must take account of teacher experience and expertise; professional knowledge, as well as competence and capability when designing suitable development programmes.

The dynamic intersection of subject knowledge, school knowledge and pedagogical knowledge, the teacher's personal constructs and the teacher's own beliefs combine to underpin such teacher's professional knowledge. The three dimensions of professional knowledge, namely institutional knowledge, discipline knowledge and pedagogical knowledge (knowledge about technology, knowledge in technology and knowledge about teaching technology) are inter-related and influence one another in guiding CPTD interactions with teachers. To equip technology teachers with the necessary knowledge, skills and attitudes and values (C4), they need effective CPTD programmes that should focus on technology content, subject pedagogical knowledge and co-operative learning facilitation, providing incentives such as credits for training.

When CPTD experiences are developed for teachers, the situation analysis informs the following four variables which form the basis for the development of good quality CPTD:

- The context within which the training takes place
- The process through which the content is presented
- The structure and strategy of the professional development taking into account the situation analysis

- Content that would enable them to reach the desired outcomes and develop the necessary knowledge, skills and understanding, needs to be presented to teachers.

With regard to context, CPTD should take teachers' teaching environment as well as their experience and existing knowledge into account. Any contextual situation of CPTD should consist of two perspectives, namely a school perspective which includes material resources and support and a teacher perspective which includes knowledge and experience.

The process should be learner, knowledge, skill and attitude centered and community focused. Regarding the process through which the content is presented, the following have been identified:

- The teachers' prior knowledge and experience should be taken into account when training activities are planned as it will have a direct influence on their training needs.
- The training activities should address technology teachers' need for subject and pedagogical knowledge. Holistic assessment of teachers could be done by assessing their prior knowledge and their knowledge after the training.
- Teachers need the support of colleagues and management in their schools to develop professionally.

The process of CPTD should include the teacher's specific needs, the knowledge, skills and values needed, assessment, certification and the role of the community so that teachers can decide which specific areas they need training in.

The following is important regarding the structure and strategy followed by the CPTD:

- The format of the training should allow for adequate contact time and should provide a balance between school-focused and school-based CPTD experiences.
- A constructivist approach taking the experience and prior knowledge of the teacher into account should be used to develop new knowledge and skills. Teachers could be trained in groups where they could learn from one another. Training should be as focused on practice as possible.
- CPTD should take place over an extended period and each session should provide sufficient contact time. Day (1999, p. 48) is of the opinion that many "short burst" training opportunities do not fulfil the longer term motivational and intellectual needs of the teachers themselves. They fail to connect with the essential moral purposes that are at the heart of their professionalism or to address directly the needs of teachers seeking to improve the quality of pupils' learning in changing circumstances.
- Study material should address the curriculum, be supportive and interactive. The study material should be applied interactively and be aimed at practical application in the classroom. This should leave room for the teacher's own creative interpretation and adaptation during implementation.

There is a need for the active involvement of technology teachers in the development of learning programmes. School-focused CPTD through collaboration between colleagues and motivation from the principal and school management team provide the opportunity for teachers to be trained in the development of learning programmes (curriculum development) and support their need for active involvement in their own professional growth.

The facilitation of CPTD should be approached as a partnership between various institutions so that the collective resources and strengths of the parties concerned could be utilised to benefit teachers maximally. The collective resources and strengths of leader teachers and subject advisors could be utilised to benefit teachers over time.

General outcomes for CPTD activities should develop teachers' expertise in the Technology learning area and equip them with the necessary pedagogical knowledge and skills and the necessary pedagogical content knowledge through sufficient practice, implementation and support. The outcomes for CPTD should contain academic content that include practical skills relating to the theory, pedagogical content as well as technology-specific pedagogical content.

The content of CPTD should aim to develop technology teachers to:

- be able to function as experts in the Technology learning area;
- have the necessary pedagogical knowledge and skills to function as competent technology teachers in the school environment;
- have the necessary pedagogical content knowledge through sufficient practice implementation and support.

CPTD should highlight the need and culture of a particular group of professionals and the practical classroom problems involving teachers in project decisions. CPTD should be seen as part of the education system and it should provide teachers with the necessary support and resources to teach technology in a meaningful way. Individuals or institutions wanting to develop quality CPTD programmes need to take existing models for the development of CPTD into account before deciding on content or choosing activities.

Conclusion

This article comprised a literature study to determine which CPTD facilitation models exist and to use these models to compile criteria for developing and facilitating suitable professional development experiences for technology teachers. The authors discussed several models for depicting the process through which professional development is designed and facilitated and its implications for the design and evaluation of CPTD programmes. A significant finding of this research is eight criteria for evaluating CPTD.

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