The CRAR^{3}FS^2 framework for developing teachers' ICT skills for Science Education through Cyberhunts

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ABSTRACT

This paper investigated the use of a cyberhunt approach on the promotion of the critical learning outcomes required of South African science teachers by the national curriculum. The focus of this paper is on how the teacher development process for Information and Communication Technology (ICT) integration by means of cyberhunts, should be managed. The case study was conducted within the interpretive paradigm underpinned by a post-positivist critical realist position and made use of qualitative data gathering methods. The data generated suggested positive results regarding the perceptions of the participating teachers towards the cyberhunt strategy. The quantitative and qualitative data suggest that the CRAR^{3}FS^2 model seems to be a successful framework to develop teachers for the cyberhunt Internet-based teaching and learning strategy. It is proposed that teacher-development facilitators should take note of the CRAR^{3}FS^2 framework when they plan and implement Internet-based teacher development sessions which teachers can implement as teaching and learning strategies within their classrooms.

Keywords: *CRAR^{3}FS^2 framework, Teacher development, ICT, e-Education, Cyberhunts, Internet, Science education*

INTRODUCTION

Learner performance in the annual South African grade 12 exit examinations has been generally and consistently poor for decades (Fleisch, 2008; Christie, Butler & Potterton, 2007; Taylor & Vinjevold, 1999), while the country attained last place in the Third International and Mathematics and Science Study in 1998, and the Trends in Mathematics and Science Study in 2003 in both science and mathematics. These poor results have been attributed to many teachers' inability to stimulate attitudes of curiosity and critical thinking skills and their reliance on rote learning, memorisation and recall (Christie, Butler & Potterton, 2007; Taylor & Vinjevold, 1999). As such the training of teachers (both pre- and in-service) has been identified as a key aspect in implement the modern approaches envisioned in the latest South African national curriculum (Kallaway, 2007). However, there are a number of barriers to successful teacher development, which include teachers' lack of knowledge, skills and self-belief (Christie, Butler & Potterton, 2007).

The critical outcomes of the South African National Curriculum Statement (NCS) specify that learners should be able to (1) identify and solve problems by means of critical and creative thinking, (2) work together in teams, (3) manage themselves responsibly, (4) collect and analyse information, (5) communicate effectively, (6) use science and technology effectively, (7) see the world as set of related contexts, (8) employ effective learning strategies, (9) become responsible citizens, (10) be culturally and aesthetically sensitive, (11) explore education and career opportunities and (12) develop entrepreneurial abilities (Department of Education, 2002). In the Science Learning Area, the curriculum attempts to address issues of developing scientifically literate citizens (Department of Education, 2002). The generative use of ICT via Cyberhunts is seen as one way of attaining these learning outcomes and to address the cognitive development of learners (Du Plessis & Webb, 2008). This paper, which forms part of a larger study on ICT in schools, reports on which aspects should be taken into consideration to develop

teachers for successful ICT implementation of science created cyberhunts as an Internet-based teaching and learning strategy (Du Plessis, 2010).

CYBERHUNTS AND KNOWLEDGE AS DESIGN

A cyberhunt refers to an online activity where learners are using the Internet as a tool to find answers to pre-determined questions (Rechtfertig, 2002) based upon a certain theme or topic. These questions are usually on different cognitive levels, and teachers may use cyberhunts as an introduction to a theme in a pre-activity, as a review for an upcoming test or as another form of authentic assessment (Slayden, 2000). Cyberhunts can also be used as a knowledge generation tool when learners become cyberhunt designers (Du Plessis, 2010). Learners-as-designers of their own cyberhunts on a topic should be the ultimate goal in cyberhunt design for teaching and learning. This relates to the idea of knowledge as design (Perkins, 1986; Harel & Papert, 1990) where learners become designers or users of knowledge instead of passive consumers of knowledge, when they construct, compose, write by typing and investigate (Du Plessis, 2010).

The use of computer technology by learners to design artefacts in order to develop cognitive skills is not, in itself, a novel idea in education as illustrated by the research of Carver, Lehrer, Connell, & Erickson (1992); Lehrer, (1993), Lehrer, Erickson and Connell (1994) and Du Plessis (2004). However, learner created or learner designed cyberhunts is a novel idea, as learners not only become the designers, but they also compose questions on different cognitive levels about the topic(s) that they explore. Composing questions on different cognitive levels requires a significant preparation from the teacher's side as he/she has to introduce the learners to the different cognitive levels and to the different verbs which are associated with each level.

Research has shown that when learners design computer based artefacts by using the computer as a cognitive design tool (e.g. within a knowledge-as-design context), the major thinking skills that learners need to use as designers of these systems, include project management skills, research skills, organisation and representation skills, presentation skills and reflection skills (Lehrer et al., 1992; Lehrer, 1993; Lehrer et al., 1994; Liu, 2003, Du Plessis, 2004; Du Plessis, 2010). Each of these skills include various sub-skills, for example, research skills include reading, note taking, defining or creating keywords, validation of the quality of knowledge, search skills, and so on (Du Plessis, 2010).

Yore & Treagust (2006) argue that the focus of science curricula should be the development of learners' cognitive tools and their communication abilities in science. Hokanson and Hooper (2000) argue that when ICT is used in education, it should foster thinking. Hence, when one combines science and ICT in teaching and learning, the main emphasis should therefore be on enhancing cognitive abilities. We are of the opinion that teacher created cyberhunts and especially learner created cyberhunts, have the potential to enhance learners' cognitive and communication abilities in the science curricula when learners create science based cyberhunts. Our argument is based on the fact that when learners become the designers of cyberhunts and not mere users of pre-designed cyberhunts, it is possible for the 'learners-as-designers' to acquire Internet related skills, e.g. searching the Internet by making use of search engines, the identification and evaluation of the level and appropriateness of websites to be included for their cyberhunts and even enabling them to compose questions on different cognitive levels (Slayden, 2000; Rechtfertig, 2002). In addition, it is also important to note that the main focus of the learner-designed cyberhunts is on the design skills (Lehrer et al., 1992; Lehrer, 1993; Lehrer et al., 1994; Liu, 2003, Du Plessis, 2004).

The main difference between learner-created cyberhunts and other web based activities is the fact that in the learner-designed cyberhunt, the learners have to compose questions on different cognitive levels that their peers (or even other teachers) have to answer by exploring the provided hyperlinks. It is important to note that the composition of questions and memoranda by learners is not a key element in webquests and project-

based learning web based activities. We are of the opinion that cyberhunts do have the possibility to generate thought as cyberhunts could become a learning tool for learners and even other teachers, as learners and teachers may utilise the learner-designed cyberhunts to explore a topic. Learners may therefore use the learner-designed cyberhunts to enrich their knowledge, to ameliorate understanding of a topic(s) with which they struggle and/or even to learn and discover at their own pace. Thus, cyberhunts could be used to move learners who struggle with certain aspects within the curriculum, through the Zone of Proximal Development (Du Plessis, 2010). It is therefore argued that the generation of thinking is precisely what could happen when learners answer the composed questions in a cyberhunt or when learners themselves compose questions when they design their own cyberhunts.

The dominant model of computer deployment and computer utilisation in South African schools is the computer room or laboratory where learners work individually and the main focus is computer literacy (Department of Education, 2002). ICT integration seems to be minimal (Department of Education, 2002). It is therefore imperative that other alternatives are explored that will change this situation (Department of Education, 2004). Cyberhunts is totally different from the dominant model, as computer literacy is not the main focus, but the generation of thinking is.

It is important to note that for learners to become designers, their teachers need the design skills required for cyberhunt construction in order that the teachers can empower their learners through a facilitation process to become designers also. This teacher development process would need careful planning, especially pertaining to composing questions on different cognitive levels, as the teacher would have to introduce the learners to the different cognitive levels and to the different verbs which are associated with each level (Du Plessis, 2010).

When learners compose their own questions for their cyberhunts on different cognitive levels about a topic that they explore, they are thus linking this to the identification of a question(s) as required for the development of scientific literacy (Webb, 2009). While the learners design their own cyberhunts either individually or in groups, they acquire new knowledge, they need to explain certain aspects, they have to determine whether the information is truthful and they can be afforded with reflection opportunities regarding their experiences during the design process by means of journal writing (Du Plessis, 2010).

TEACHER DEVELOPMENT

Staff development programs with respect to technology, should be (1) hands-on, (2) on-going, (3) providing staff with the technology equipment, (4) incentive driven, (5) should be reviewed regularly (Picciano, 2006) and should include reflection as a learning tool (Hoban, 2002). Lawless and Pellegrino (2007, p. 597) argue that professional development should have as its focus to assist teachers to change their pedagogies with a view to improve teaching and learning, hence they argue, the question professional developers have to ask is, “What do teachers do differently in their classrooms as a product of professional development?” Therefore, one should ask oneself when deciding on a specific teacher development model, whether this model will result in teachers changing their pedagogies. We are of the opinion that learner-designed cyberhunts have the possibility to add to the pedagogic repertoire of teachers.

METHODOLOGY AND METHODS

The research formed part of a larger study that used quantitative and qualitative data gathering tools. The project was conducted within the post-positivist paradigm (Niglas, 2001; Mertens, 2005) underpinned ontologically by a critical realist position (Sayer 2000; Benton & Craib, 2001) and epistemologically by a socio-cultural perspective (Vygotsky, 1978; Engeström & Miettinen; Roth & Lee, 2007). Qualitative and quantitative data gathering methods (mixed research) were used (Kelle & Erzberger, 2004; Johnson &

Christensen, 2008) within an interpretative case study (Yin, 2003). Several different quantitative and qualitative data collection tools were used. Quantitative data gathering tools that had been used; comprised of Likert scale questionnaires, a computer skills questionnaire, as well as certain quantitative sections within the semi-closed-open-ended questionnaires. The qualitative data gathering tools that had been used in the cyberhunt aspect of the larger study were semi-closed-open-ended questionnaires, journal-reflection sheets, observation and interviews.

THE INTERVENTION, ITS THEORETICAL BASIS AND ITS PHASES

Thirty-six teachers from six poorly resourced (both human and material) schools (four primary schools and two high schools) formed the convenience sample used in this study, as each of these six schools received 20 computers for free from the Dell Foundation. The project ran from March 2008 to the end of September 2008 with an average attendance of 27 participants per session.

This intervention that took place was informed by a community of practice framework embedded by cognitive apprenticeship (Brown, Collins & Duguid, 1989). It is acknowledged that teachers' prior beliefs and knowledge related to classroom practice influence their interpretation of new pedagogical ideas (Putman & Borko, 1997) and new practices. However, teachers also learn a great deal from their social interaction(s) in discourse communities when they share experiences from the classroom contexts in which they experiment with new or alternative practices (Putman & Borko, 1997). During the teacher development process pertaining to cyberhunts, participants received regular opportunities for reflection through the completion of journal sheets at the beginning and end of the various cyberhunt teacher development sessions. This is in line with Hoban (2002) and Turbill (2002) who state that reflection and communities of practice are two important keys to assist with teacher development.

As a result of the value of social interaction as a learning tool through language, the knowledge creation model of Nonaka and Takeuchi (1995) was seen as a useful model for learning. Nonaka and Takeuchi (1995) identified two kinds of knowledge that play an important role in knowledge creation, namely tacit and explicit knowledge. The four modes of knowledge creation that are represented by Nonaka (1994) and Nonaka and Takeuchi (1995) are the sharing of ideas (socialisation), combining knowledge to test ideas (combination), emergence of new ideas (externalisation) and developing new ideas and learning by doing (internalisation).

In the first phase, the participants explored the Internet in a guided manner by providing them with web addresses type into Internet Explorer's address bar and then to explore these sites. Participants were also introduced to pre-designed cyberhunts in order that they could get a feel of cyberhunts. The Internet search engine, Google, was also introduced as well as Boolean searching. Participants were also introduced to the taxonomy of Bloom.

The second phase consisted of five stages. During the design copy stage, the project leader modelled the cyberhunt design process and the participants followed the instructions, drawing from tacit knowledge (Nonaka, 1995) and by articulating tacit knowledge, the tacit knowledge is converted to explicit knowledge. Being active participants afforded opportunities to learn from the modelling process and to improve self-efficacy through personal mastery, vicarious experience and verbal persuasion (Bandura, 1997). Two tool stages followed which empowered the participants with Word and PowerPoint in order to prepare them for the design of their group cyberhunts. In the design as a group stage, participants could share their tacit knowledge with one another through articulation by means of discussion and peer assistance while they design collaboratively. As a result the tacit knowledge becomes explicit and participants have an opportunity to try to link the new knowledge to their existing knowledge structure.

The presentation stage was the final stage during which participants received an opportunity to showcase their finished cyberhunt products and to obtain feedback from

their peers. The assessment phase was the final phase during which participants were formally assessed.

SUMMARY OF THE FINDINGS

The participants highlighted the importance of the role of the facilitator during teacher development projects and placed a high priority on that person's people skills and competence. Furthermore, it was noted that clear explanations, approachableness and constant feedback were highly valued. This is in line with Havelock and Zlotolow (1995) and George and Camarata (1996) who argue that building relationships and trust, as well as the containment of anxiety, are vital for teacher development.

In addition, participants indicated that they would highly value that the project facilitator visit them at school to assist them with classroom implementation. This was indeed a very positive stance, as teachers are the champions of change and classroom support could probably assist them to experiment with alternative approaches (Fullan & Smith, 1999; Mouza, 2005), for example by using the cyberhunt strategy.

Participants also highlighted the importance of a paper based guide and notes during training as this gave them some form of security. This seems to concur with Leach and Moon (2000) and (Hodgkinson-Williams, 2005) who highlight the importance of clear guidelines for implementation. Participants also said that they had experienced the training as totally different from any other training they had been involved with before. Data analysis suggests that the positive attitude, patience and good listening skills were valued by the teachers. They also highlighted the fact that the atmosphere was relaxed and that this was appreciated, which is in agreement with George and Camarata (1996) who emphasise the importance to contain anxiety when technology is introduced to people.

The teachers also explained that the training was different, because it was ongoing, not like the normal one day sessions. This emphasis of the importance of training that is spread over some time concurs with Royer's (2002) thoughts. Overall, the majority of the participants stated that the pace of training was important. An aspect that made the use of capable peer facilitators very different and attractive, was the fact that the peer-facilitators could assist their fellow peers in their home language, isiXhosa. This enabled them to often render greater assistance to their peers than could be done in English. Consideration of the language ability of participants during teacher training is thus very important, as this could influence the successfulness of the training. In sum, the following aspects are vital for teacher development, namely (1) establishing a relaxed atmosphere, (2) containing anxiety, (3) the pacing of the training by taking the progress of the participants into consideration, as well as their individual needs, (4) using peer-facilitators, (5) modelling/coaching and mentor when appropriate and when required, (6) Be patient, approachable, and listen to the their learners' needs, motivate them constantly, assist them and compromise when necessary (people skills), (7) Ensuring that the training is ongoing and progress feedback should be provided on a regular basis, (8) Ensuring that the training is hands-on, practical and explanations are clear, (9) encouraging the use of the participants' home language to explain to one another, (10) providing ongoing support keeping the school context in mind, (11) developing competence, and (12) providing opportunities for personal goal setting, reflection and the sharing of experiences.

The data generated via the teacher development process that was implemented in this study; which is underpinned by the collaborative, motivational, knowledge generative and situated cognition approach corroborated by cognitive apprenticeship principles; suggests that the intervention was effective. These data also informed the design of the framework discussed below for teacher development of this nature.

A PROPOSED FRAMEWORK FOR TEACHER DEVELOPMENT

This data suggest that the following aspects encompassed by the acronym $CRAR^3FS^2$, as indicated in Figure 1, can enhance teacher development and classroom implementation of this type of Internet-based teaching and learning strategy. The $CRAR^3FS^2$ acronym represents the verbs or actions that the participating teachers highly valued during implementation and what they have indicated as being important. The verbs or actions of the C R A R^3 F S^2 framework are (1) Care, (2) Relate, (3) Assess, (4) Reflect, (5) Read, (6) Re-Plan (7) Feedback, (8) Share and (9) Support. The diagram also provides an overview of the proposed process for teacher development aimed at empowering them to use cyberhunts as a means to introduce the Internet to teachers. The same elements that were valued by the teacher participants during the teacher development training process should also form part of the implementation process of ICT related learning in their classrooms. Within the $CRAR^3FS^2$ framework, reflection through journal writing or by means of the completion of reflection sheets plays a vital role.

Care refers to establishing a learning context in which learners can experience and see that they are cared for and believe that the will be able to succeed with the new approach. Relate refers to building a relationship between the facilitator and the learners. Assess implies that the teachers should assess and identify the positive and negative aspects that have occurred during implementation.

Reflection refers to the completion of reflective journals consisting of several questions to which participants can reflect upon. The rationale behind the reflective journals is that they are a tool that enables both the designer and the teacher to obtain a snapshot of his/her progress for future planning. Hence, journal writing is strongly advocated as a tool to assist both the teacher and the learners in their planning, to determine their progress and to identify areas in which assistance is required.

Read refers to the teacher who has to read what the learners have written in their journals with a view to identifying aspects that would need attention the next time they continue with their cyberhunts. Re-plan and read is interlinked, as the teacher reads the journals to plan or re-plan for the next session in such a way that he/she addresses the issues at hand. It is also important to note that learners could also read one another's personal reflections in their journals, in order to assist them to understand that they are not the only ones who struggle with certain cyberhunt design aspects. Alternatively, the journals sheets could become an identifier of the 'capable peers' in their class whom they might approach when they need assistance.

Feedback is another important element, as constructive feedback during the lesson, at the end of the lesson, after personal observation, or feedback given after scrutinising the participants' (learners') journals, should assist the teacher to provide adequate feedback and help with preparation and planning for the next session. Share refers to the teacher creating opportunities for the learners to share their experiences of the learning process with their peers either in their groups or with the whole class in order to articulate their tacit knowledge, experiences, successes and needs. Lastly, support refers to both the project facilitator's and participants' role of rendering on-going support when the school based implementation process commences.

Support implies support that is on-going. This implies support from the project facilitator (or from the teacher when the teacher is involved with his/her learners) and from fellow expert participants (the peer-facilitators or from fellow learners within the school context) during classroom implementation. Thus, just as the project facilitator supported the participants during the training process, the participating teacher supports his/her learners in the classroom and the peers support one another too in a similar manner.

Support also implies classroom visits by either the project facilitator and/or other capable peers in order to render assistance and/or to discuss the successes, the areas where assistance is required and to plan how to address the identified issues at hand. The support aspect goes beyond classroom visits, as it also requires the establishment of an

internal school based support group which will have to meet regularly to establish caring support. Furthermore, support implies that the principal and the senior management team (SMT) create the necessary learning space for the participants from their school, and support them on emotional, motivational and resource levels.

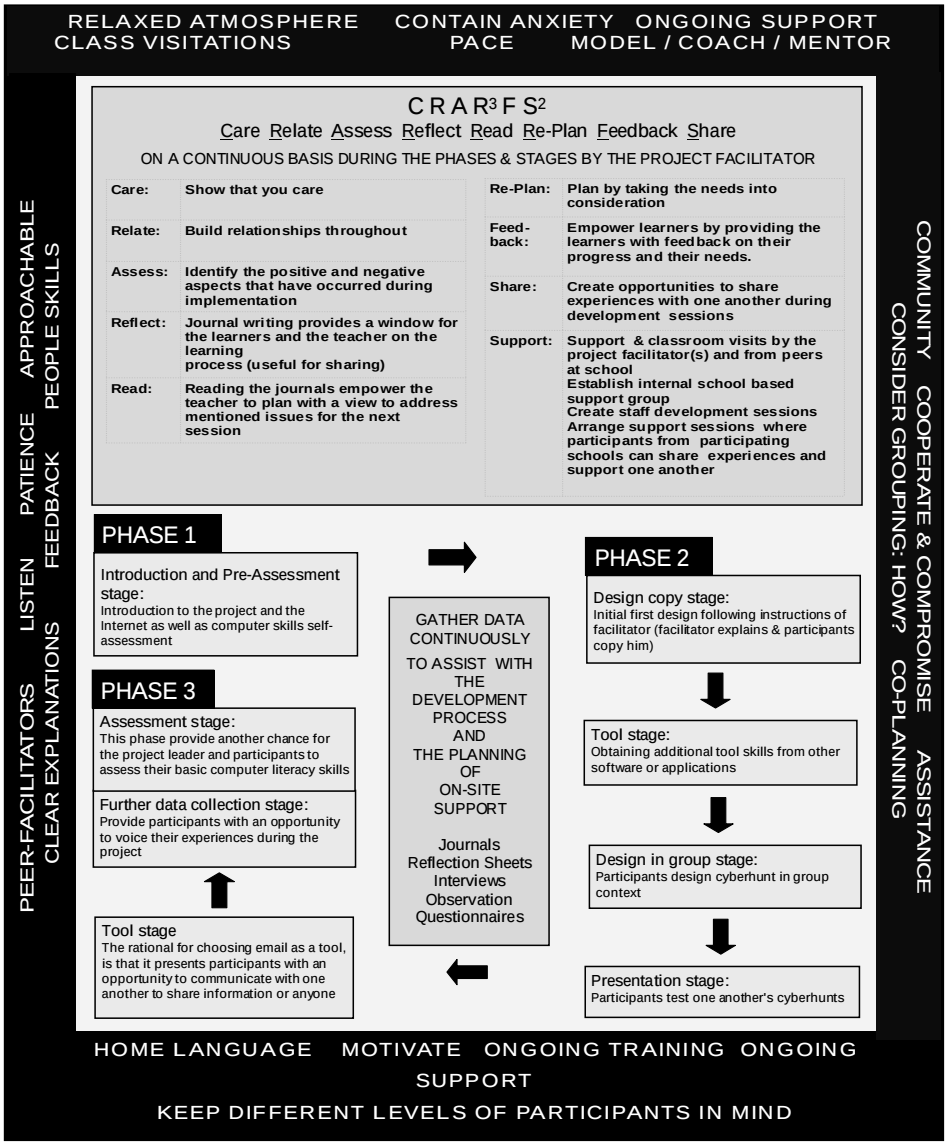

Figure 1: Proposed phases and stages for teacher training and development related to cyberhunts

In addition, support requires the institution of staff development sessions in order that the participants, who have received training, can share with other staff members who did not attend the training sessions what they had learned. Equally important, the staff development sessions can then also serve as training sessions for other staff members who want to be trained. Support also implies that the project facilitator and the participants decide upon specific times when all the participants from the different schools can meet in order for the participants to share their school-based experiences with participants from other schools.

The support session for teacher development thus become forums and during these sessions a platform is created to identify the areas in need for further training. These

platforms enable the project facilitator to plan for future on-going support training sessions, as the facilitator plans by taking the identified need of the participants into consideration. The project facilitator can then decide whether the future training sessions will be planned by either the project facilitator alone, with the assistance and input of expert participants or by the expert participants on their own. Without the necessary ongoing support, it is highly likely that the implementation process at schools and the staff development at the participating schools could grind to a halt.

It is important that the facilitator (or the teacher who implements the ICT related activity at school) should also take note of the following aspects and responsibilities, during the teacher development process. These aspects and responsibilities forms part of the $CRAR^3FS^2$ framework and have to be planned for and kept in mind for the teacher development process to be successful, namely: (1) Establish a relaxed atmosphere, (2) Contain anxiety, (3) Pace the training by taking the progress of the participants into consideration, as well as their individual needs, (4) Use peer-facilitators, (5) Model/coach and mentor when appropriate and when required, (6) Be patient, approachable, and listen to the their learners' needs, motivate them constantly, assist them and compromise when necessary (people skills), (7) Ensure that the training is on-going and progress feedback should be provided on a regular basis, (8) Ensure that the training is hands-on, practical and explanations are clear, (9) Encourage the use of the participants' home language to explain to one another, (10) Provide on-going support keeping the school context in mind, (11) Develop competence, and (12) Provide opportunities for personal goal setting, reflection and the sharing of experiences. All the elements of the $CRAR^3FS^2$ model should be addressed at any point in time within the teacher development-training process. However, the care, relate and support components should receive attention from the start and should be on-going, as these components contribute to the creation of a positive learning context from the start.

CONCLUSION

The purpose of this paper was to present a framework for teacher preparation and teacher development regarding science education by means of cyberhunts as an Internet strategy for teaching and learning. It is proposed that the C R A R^3 F S^2 framework for teacher development and classroom implementation can assist teachers embrace ICT implementation and integration. It is hoped that this paper, coupled with further research, might provide a starting point in unravelling a range of complex questions that might assist learners and their teachers to perceive school, especially science education, as being different to what they usually experience. We suggest that in this way ICT implementation in schools could become a tipping point by helping teachers transform their practice through seeing the fruitfulness of the approach and the possibilities that exist. However, the literature suggests that on-going support is the key in this quest. Although cyberhunts are used as the vehicle for teacher preparation in this case, we do not mean to give the impression that cyberhunts are the only, or the best way, of assisting teachers to embrace ICT implementation and integration. However, the use of cyberhunts does provide a clear example to illustrate the C R A F3 F S2 model and against which to judge other means of attaining this aim.

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