Int J Technol Des Educ (2016) 26:225–242
DOI 10.1007/s10798-015-9312-5

Project-based pedagogy for the facilitation of webpage design

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Accepted: 22 April 2015 / Published online: 7 May 2015

Abstract Real issues of web design and development include many problem-solving tasks. There are, however, some inadequacies associated with the implementation of appropriate pedagogy for organised and structured instruction that supports the rational problem-solving paradigm. The purpose of this article is to report on a study for the design and implementation of an Instructional Web Design Programme (IWDP) with methodology-specific guidelines in an information systems design context. A second purpose is to discuss the pedagogy developed within the IWDP and its effects on promoting technological problem solving of learners in the project-based classroom. A qualitative, action-research approach was the basis for this study. The sample consisted of 17 learners at an institution of higher education. The researchers used a focus group interview, journals and essays to observe learners' behaviour, to analyse their project designs and to assess their opinions and experiences with regard to the IWDP. An organised and structured instructional environment within the IWDP helped the teacher to promote technological problem solving. The teacher and learners acknowledged the components of the programme (for example, assessment criteria, range statements, performance indicators, pre-defined learner tasks and activities) in the project-based classroom. Practical and cognitive apprenticeship and experiential and situated learning were used to accommodate the problem-solving needs of learners. Learners indicated a need for a variety of tools and expert guidance in a peer-based collaborative learning environment.

Keywords Technological problem solving · Technological process · Project-based classrooms

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Introduction

One of the reasons stated for including technology in the curriculum is the possibility for personal development of higher cognitive skills, including creative thinking and problem solving (Banks and Williams 2013). In this article we are concerned with raising learners' awareness of the importance of reflecting on thinking processes while exploring a variety of design solutions. In earlier literature (Winn 1990; Bednar et al. 1992) there is a remarkable absence of discussions about explicit facilitation of a wide range of thinking skills that learners should develop in an information systems design (ISD) context (Jonassen 1996; Jakovljevic 2002). More recent studies address similar issues and include measuring skills for twentyfirst century learning (Silva 2009; Dede 2010), emerging technologies as cognitive tools for authentic learning (Lautenbach 2010; Herrington and Parker 2013), as well as more theoretical arguments around issues of the mediational perspectives on digital technology and issues of the mind (Kaptelinin 2013) which may all impact on learner's technological problem solving.

Information on the technical aspects of an ISD environment is readily available (Pfleeger 2001; Pressman 2005). There are, however, some inadequacies associated with the implementation of appropriate pedagogy. Such inadequacies add to the frustrated efforts of teachers in their quest to increase learners' problem-solving skills. Real issues of web design and development include multiple tasks (for example, creating hyperlinks, uploading a website and coding). Learners experience the entire process of requirements driven design (RDD) during the systems analysis stage, through a clear definition of basic requirements of the proposed system which they acquire via the fact-finding techniques of interview, questionnaire and diagramming. Requirement specifications serve as an input into the design phase, which then defines how systems operate (Flynn 1992; Avison and Fitzgerald 1996; Griffiths 1998; Castro et al. 2002).

The scope of requirement specifications includes further learner tasks such as functional requirements, user interface layout and output requirements. However, these and other tasks are not sufficiently supported by the present instructional strategies, which neglect the rational problem-solving paradigm (Ankiewicz et al. 2000; Ankiewicz 2003; Van Niekerk et al. 2010). A need exists for organised and structured instruction which reflects the necessary requirements for technological problem solving (Ankiewicz et al. 2000; Ankiewicz 2003, 2015). An organised and structured instruction within an instructional programme may serve as an orientation for teachers in the project-based classroom in which the principles of Outcomes-Based Education (OBE) are applied (DoE 1997).

The outcomes-based curriculum in South Africa is aimed at developing creative problem-solving skills in every learning area (DoE 1997). Learners lack the skills to define the problem clearly and techniques to handle the available data and to understand the methods of problem solving (Cotton 1995). Problem-based learning applies collaborative learning and peer-based learning in a constructivist setting (Stage et al. 1998; Schwartz 2013; Allen et al. 2011).

Design as a particular type of technological problem solving is the backbone of teaching and learning in the technology classroom (Elmer 1998; ITEA 1997; Ankiewicz and De Swardt 2002; Ankiewicz 2003; Jakovljevic et al. 2004). However, achieving an instructional environment that promotes this type of problem solving efficiently needs further investigation (Cotton 1995; Beyer 1991; Eggen and Kauchak 1996). While a variety of instructional strategies exists, this does not mean that they are actually being used in the technology classroom.

Shaffer (2005, 2006) points out the option of including epistemic games as one way to improve cognitive skills in the classroom. Through a variety of tasks and activities in the technology classroom, learners are free to use epistemic games such as video games, computer games and other interactive online tools as mechanisms of learning. Learners of web design usually have to develop a prototype website as a technological solution using online design tools. Owing to their complex nature, projects in a technology classroom need a well-planned and structured instructional environment. Using only epistemic games in the technology classroom could be insufficient for improving problem solving if applied without explicit guidance in a real technological context. It would, furthermore, be difficult to measure learners' performance in terms of technological problem solving if they do not have to develop a model, prototype or product in the course of the game.

Based on the above discussion, the purpose of this study was to:

1. Identify criteria for the development of the instructional programme—the IWDP;
2. Set a structure and related components for the instructional programme that will positively influence the problem-solving environment; and
3. Identify and discuss key instructional strategies and learning modes that can support technological problem solving.

To do this, the following research questions were set:

1. What criteria for the IWDP development can be derived from learning theories, instructional models and strategies in order to create an appropriate instructional environment for addressing technological problem solving?
2. What should the structure and relevant components of the IWDP entail?
3. What instructional strategies and modes of learning have supported technological problem solving?

To identify pedagogy for the facilitation of technological problem solving in OBE, the researchers of this study developed the IWDP, which was implemented at a higher education institution (HEI). The IWDP provides an innovative technological learning environment in terms of the physical setting; human resources; technological resources; and forming of collaborative groups.

The theoretical framework for the development of the IWDP

A theoretical framework based on learning theories, instructional models and strategies; programmes, models and conceptions of higher-order thinking; and mind tools were essential pillars in the development of the IWDP. Policy related to technology education and OBE in South Africa as well as these essential pillars served as a point of departure for the development of the IWDP. These pillars provided a wide range of interdisciplinary issues together with the conceptions of the Illustrative Learning Programme (ILP) and the roles and competencies of the teacher in the technology classroom (Jakovljevic et al. 2004).

The role of learning theories, instructional models and strategies

The development of the IWDP was based on both behaviourist and constructivist instructional approaches (Clark and Lampert 1986; Smallwood 1995; Johnson 1997). Several principles derived from the behavioural instructional approach are necessary for certain types of low-level performance in the project-based classroom: contiguity, repetition, feedback and reinforcement (Jakovljevic 2002). Constructivists emphasise the need for active learner involvement and the development of reflective awareness during learning processes (Winn 1990; McCormick 1997; Lautenbach 2014), realising the idea of 'knowledge as design' (Perkins 1994).

Learner activities in a project-based classroom (see Table 2) require different modes of learning (the situated view of learning, experiential underpinning supported by cognitive apprenticeship, inquiry learning and peer-based learning) (Rogoff and Lave 1984; Johnson and Johnson 1991; Bednar et al. 1992; Johnson 1997). Cognitive apprenticeship is an interaction between an expert and a novice aimed at enhancing the cognitive and metacognitive skills of learners (Arzarello et al. 1993). The situated view of learning emphasises the learning experience that is situated in physical real-world and social contexts (Rogoff and Lave 1984; Bednar et al. 1992). Participating in small problem-solving groups can stimulate cognitive disequilibria to such an extent that there is a measurable change over time in the structure of thinking (Wheatley 1991). Peer coaching provides an opportunity for analytical observations and thoughtful dialogue in a classroom atmosphere (Fogarty and McTighe 1993).

Learners need to perform programming tasks of relatively *high tech* solutions to sufficiently challenge the development of their problem-solving competencies. Arzarello et al. (1993) point out that learning programming should be taught through a practical and cognitive apprenticeship (Bransford et al. 2000; Kuo et al. 2012) to ensure an interaction between an expert and a novice aimed at enhancing the cognitive and metacognitive skills of learners. Learners should, however, be guided through the whole process of reflection (Johnson 1997). When developing an instructional programme of this nature it is necessary to identify and describe the essential criteria that reflect the teaching and learning in a project-based classroom.

Essential criteria for the IWDP derived from learning theories, instructional models and strategies

The researchers derived the criteria from the theoretical framework that served as a basis for the development of the IWDP (Jakovljevic 2002). For purposes of this article, the most prominent criteria derived from learning theories, instructional models and strategies are presented in Table 1.

Learners' and teacher's activities guide learners and the teacher through the technological process. Design and development activities in the technological problem-solving context (see Table 2) should be facilitated with a variety of instructional strategies based on behaviourist and constructivist theories of learning (Magadla 1996; Duffy and Cunnigham 1997; Johnson 1997; McCormick 1997). Any problems with the activities tend to come to light only once actually implemented in the project-based classroom and put to the test.

Programmes, models and conceptions of higher-order thinking

The development of the IWDP was also based on an in-depth investigation of higher-order thinking processes and their attributes (Jonassen 1996; Jakovljevic et al. 2004). The researchers considered the following range of programmes, models and conceptions of higher-order thinking with clear cognitive outcomes in creating a framework for the IWDP:

Table 1 Criteria for the IWDP drawn from learning theories, instructional models and strategies (Jakovljevic et al. 2004)

Criteria for the IWDP based on learning theories, instructional models and instructional strategies
1. Direct teaching and fostering observational learning during demonstrations are essential for acquiring factual knowledge and basic skills in the project-based classroom
2. Technological design should be taught through a guided discovery approach, where learners are not presented with the subject matter in its final form
3. Cognitive and practical apprenticeship with coaching, scaffolding and prompting in a collaborative learning environment is essential in the project-based classroom
4. In web design, instructional strategies that support reflective practice, activity-based practice, and peer-based learning help learners to develop intellectual skills
5. When applying a constructivist or behavioural instructional approach, a variety of instructional strategies (for example, brainstorming, inquiry/investigation, discussions, case studies, activity-based practice and project work) are essential for technological problem solving

The prominent criteria highlighted in Table 1 served as a basis for developing learner tasks, activities and outcomes (see Table 2) as building blocks of the instructional programme

- De Bono's (1986) *CoRT thinking programme,* which includes six thinking strategies;
- Marzano et al. (1988) *model of core thinking skills* with the primary dimensions of intellectual skills: thinking skills, critical and creative thinking, thinking processes and metacognition;
- Beyer's (1991) *conceptions of teaching thinking skills and their attributes*: each thinking skill consists of attributes, a procedure, a rule or principle, and criteria of other knowledge;
- *Conceptions of design skills developed by* Carver et al. (1992): project management skills, organisation and representation skills, presentation skills, research skills and reflective skills;
- Eggen and Kauchak's (1996) *conceptions of higher-order thinking,* which involves knowledge, basic thinking processes, metacognition, attitudes and dispositions; and
- Ankiewicz et al. (2000) *model of the technological process,* which integrates the following clearly identifiable sub-processes: thinking sub-processes (creative and critical), decision making, problem solving and design (Van Niekerk et al. 2010).

Learners' tasks, activities and outcomes are supported by the use of mind tools. The teacher's tasks (TT) and learners' tasks (LT) correspond to the needs of learners with different capabilities, and should be of individual and group type. The tasks should correspond to different thinking skills required during the stages of the technological process.

Mind tools foster meaningful learning

Mind tools have the potential to foster constructive learning (Simons 1993; Lehrer 1993), and *vision,* the most powerful human sense—having 'evolved to notice spatial relations such as connectedness, juxtaposition and gaps' (Boden 1990: 101). The integration of different mind tools, semantic networks, computer programming, computer-mediated communication (CMC), in a project-based classroom can help to enhance higher-order thinking (Jakovljevic 2002). The following mind tools are considered particularly necessary in the development of the IWDP:

- Computer programming can facilitate the development of abstract thinking, problem solving and logical thinking (Dover 1983).

Table 2 Examples of learner tasks, activities and outcomes (Jakovljevic et al. 2004)

Description of learner tasks (Lt)	Description of learner activities (La)	Description of learning outcomes (Lo)
Lt1: Analyse off-line and online marketing techniques related to car purchasing schemes	La1: Conduct research in a library La2: Organise an interview with a person responsible for marketing tasks and discuss marketing tools, techniques and procedures involved with car purchasing schemes La3: Search the popular websites related to business-to-customer relationships	Lo1: Searching the internet and documents for purchasing policies and schemes Lo2: An interview transcript (with a person responsible for marketing tasks) and a table of findings Lo3: A chart of resources and a summary of marketing off-line and online tools, techniques and procedures
Lt2: Reflect on the purpose of developing online solutions for an effective purchasing scheme yourself Lt3: How can this task contribute to your personal development?	La4: List the advantages and disadvantages of the existing car purchasing schemes La5: Write down your opinions and perceptions about the proposed website La6: Reflect on your past experiences through self-direction and other metacognitive skills La7: Observe the teacher while she performs reflective strategies through modelling	Lo4: A short essay containing: Experts' opinions and perceptions about the proposed website Reflections on the pre-construction process with constructive suggestions
Lt4: Set the envisioning phase of the development (modelling) process	La8: Visualise a sequence of design steps La9: Present a design in the form of a computer-generated map La10: Brainstorm ideas with regard to the plan and strategies, information style and multimedia design features La11: Indicate the steps to be taken on a planning list La12: Do interactivity planning, interface and navigational map design according to the checklists and guidelines La13: Decide on the segmentation of information La14: Draw detailed designs (screen design, scripting, multimedia assets)	Lo5: A chart containing: Project goals Tasks to reach project goals A plan to accomplish the tasks Steps to implement the plan Criteria to evaluate the plan Lo6: A list which contains: The plan and strategies Information style Interactivity design Multimedia design: Lo7: A computer-generated map that contains detailed design features

- Semantic networks are representations of ideas and their interrelationships within the human memory structure (Jonassen et al. 1993; Jonassen 1996).
- CMC acts as a vehicle for delivery and sharing the product of any mind tool (Jonassen 1996). CMC enhances collaborative learning and thinking through negotiating meaning and sharing of ideas (Hiltz 1986; Mabrito 1992; Jonassen 1996).

The researchers derived criteria from programmes, models and conceptions of higher-order thinking as well as from research on mind tools and existing educational policy in South Africa (DoE 1997; SAQA 1997; GDE and GICD 1999).

The IWDP will be discussed in this the next section by referring to its purpose, structure and components, the stages of the technological process as an explicit organisational framework for the teacher and learner, and knowledge sharing.

The Instructional Web Design Programme (IWDP)

The purpose of the IWDP

The IWDP provides an organised instructional framework that aids the facilitation of learners' problem-solving skills, and recognises instruction, technological and human resources as essential in the project-based classroom. It is designed to accomplish two interrelated purposes. The first purpose is to help learners develop a deep understanding of technological design with specific application to web page design. The second purpose is to promote problem-solving skills and values of learners through a variety of instructional strategies and resources.

The IWDP has technological problem solving as point of departure which is further contextualised within a web page design. Based on the paradigm of rational problem-solving a stage model, which serves as explicit organisational framework for the teacher and learners (De Swardt et al. 2010; Ankiewicz 2015) is used to provide an innovative approach to learning and teaching in the technological context. The programme includes a novel integration of various components with the stages of the technological process. The IWDP creates a learning environment that facilitates online modules, project-based learning and problem-solving learning. The IWDP relates to various instructional strategies and modes of learning, including a network of human resources:

- *Instructional strategies and modes of learning*: individual learning, collaborative learning, inquiry learning, apprenticeship learning, peer tutoring within and across the groups, situated learning, observational and experiential learning; and
- *Human resources:* the teacher, peer-tutors, a senior tutor, an assistant and an expert are involved in different interactions in facilitating technological design.

Cavan (2007) reports on projects at a HEI where students are guided by a network of advisors, subject associations and mentors. Such wide human networks or communities of practice may support the application of a variety of instructional strategies and modes of learning.

The structure and components of the IWDP

In addition to structuring the IWDP according to the framework for the national school curriculum in South Africa, the following *components* were identified:

1. *A theme* relates to an authentic, real-world problem for the learners.
2. *Critical outcomes (COs)* are generic cross-curriculum outcomes, which ensure that learners gain the skills, knowledge and values that contribute to a wider community (Jakovljevic 2002).
3. *Specific outcomes (SOs)* include technological knowledge, skills, attitudes and values that help learners to understand and demonstrate achievements in technological contexts (Jakovljevic 2002).

4. *Assessment criteria* (AC) form the standards against which performance is assessed.
5. *Range statements (RS)* include the critical areas of content, processes and context that the learner should engage into reach an acceptable level of achievement (DoE 1997).
6. *Performance indicators (PI)* provide details about the content and processes that learners should master, as well as details about stages learners need to achieve in the learning context.
7. *Case study tasks* help learners to link the problem to the community outside the classroom, build a knowledge base and set the base for resource and capability tasks (Jakovljevic 2002).
8. *Resource tasks* are short, practical activities that engage learners' thinking processes and help them to develop knowledge and skills (Givens and Barlex 2001).
9. *Capability tasks* help learners to demonstrate cognitive, psychomotor and technology-related skills, content (subject matter) knowledge, values and attitudes and to utilise technological problem solving (Jakovljevic et al. 2004).
10. *Online and off-line activities* are allocated to each task within the technological stages.
11. *Teacher activities (instructional strategies*) are developed to facilitate learner activities.
12. *Notional time* represents contact time, learners' efforts and time, preparation time and other issues (DoE 1997).

In summary, the components of the IWDP are as follows: theme; outcomes (critical and specific); content, formulated as RS and PI, conceptual and procedural knowledge (the ten stages of the technological process); learner tasks (case study, resource and capability tasks); learner online and off-line activities; teacher activities (instructional strategies); AC and notional time (Ankiewicz et al. 2000; Jakovljevic 2002; Reddy et al. 2003).

The stages of the technological process

The *technological process* relates to '…identifying needs and opportunities, exploring problems and constraints, gathering information from a variety of sources, modelling and testing production and evaluation' (Jones 1997: 90). It is common in technology education to present the procedural knowledge of technology in a stage-oriented format in models. Most models of the technological process indicate a linear progress, assuming that the process is completed in a particular sequence. One does, however, also find models with iterative design activities in the form of a loop (De Swardt et al. 2010; Ankiewicz 2015). The IWDP adopted the following ten stages of the technological process: Statement of the Problem; Design Brief; Investigation; Proposal; Initial Ideas; Research; Development; Planning; Realisation/Making; Testing, Evaluation and Improvement. These stages of the technological process are cyclical and repetitive (Ankiewicz et al. 2000; Van Niekerk et al. 2010).

For the IWDP each stage of the technological process included a variety of learner tasks and activities, as well as reasonable time limits that allowed learners to achieve an outcome (Ankiewicz et al. 2000; Van Niekerk et al. 2010). Furthermore, for the each stage of the technological process, appropriate AC, RS and PI were derived as well as a reasonable time for allowing learners to attain an outcome. The teacher also followed the set of AC, RS and PI; performed the pre-defined teacher activities that guided learner activities; and adjusted learner activities and instructional strategies as situational factors came into play. The teacher monitored the outcomes of each stage of the technological process (Jakovljevic 2002).

Knowledge sharing and transfer in the IWDP through innovative pedagogy

By building an information system as a solution to a business problem using web technology, learners applied their problem-solving skills by linking the technology classroom to the real-world environment. Learners were involved in knowledge sharing guided by a network of human resources and an expert-mentor relationship (Jakovljevic 2002). The teacher's activities were set to control the basic aspects of technological problem solving starting with demonstrations of technological skills and providing a frequent modelling of problem solving through a repetitive, cyclic mode of teaching. The teacher helped learners in constructing and implementing interviews, writing reflective notes and analysing documents and statistics relevant to the technological problem.

Apart from the importance of considering why the components of the IWDP come together, it is also important that the nature of the structure refers to how the components are linked in terms of the dynamics of relationships. Individual and group dynamics are particularly evident in the IWDP through knowledge sharing between learners and human resources. An assistant, a senior tutor and an external expert are actively involved in tutoring, particularly during the technological stages in which system design skills and programming skills should be developed. Learners interact within their collaborative group and across the groups through sharing of expert roles, and exchanging the teaching role in the form of peer tutoring.

The research design will be discussed in this section by referring to the research approach, the intervention and the way it was implemented, the data collection and data analysis, and trustworthiness.

Research design

Research approach

This study can be described as a qualitative, single case study as the learning experience of learners relates to a specific event in a bounded context (Creswell 1994; Merriam 1988; Yin 1994; Leedy and Ormrod 2005). 'Case studies have proven particularly useful for studying educational innovations for evaluating programs' (Merriam 1988: 41). The researchers applied action research to create and investigate changes simultaneously using new instructional strategies and tools. To improve the facilitation of technological problem solving it was necessary to adapt instructional strategies through the application of the following stages of action research: diagnosing, action planning, action taking, evaluating and specifying learning (Baskerville and Wood-Harper 1996).

The learner profile and setting and the way the IWDP was implemented

In this study, two distinct mixed cultural groups of learners were identified. The two groups respectively consisted of five second-year learners (2 females and 3 males—average age of 20) enrolled for the Information Systems Diploma at a university of technology and 12 first-year learners (5 females and 7 males—average age of 19) enrolled for the International Diploma in Computer Studies at a HEI. The majority of the learners were from a middle socio-economic environment. Participants from the two groups presented a purposive convenient sample because they were available and their participation was cost-effective to this particular study (Patton 1980).

In planning for the implementation of the IWDP, different aspects were considered; for example: learning outcomes, instructional approaches and strategies, formation of collaborative teams, technological environment, technological resources and human resources. One of the researchers, who also played the role of the teacher, organised extra-curricular sessions in a well-equipped computer centre at a HEI and presented the IWDP to teach learners web-design skills and to facilitate problem-solving skills (Jakovljevic 2002). The teacher presented the IWDP once a week for 13 weeks. Each session lasted 4 h. Learners were given a set of small pre-defined tasks and on-line and off-line activities (embedded within the IWDP), which catered for web-page design.

Participants were divided into five groups of three to four learners per group. During this period the teacher followed the IWDP's pedagogy in the project-based classroom. Learners received instructions to submit deliverables when they designed and developed a website (for example, the project plan, analysis package, design specification, prototype, documentation and the final website). During the web design, action research allowed for the application of different instructional strategies; for example, scaffolding and modelling through cognitive apprenticeship.

Data-collection methods

In her role of participant-as-observer, the teacher implemented the IWDP in the project-based classroom, conducted classroom observations through an observation schedule and field notes, and evaluated the impact of the programme on learning outcomes. In addition, an independent researcher conducted the retrospective interview with the teacher, as well as a focus group interview with the learners. Learners expressed their experience of the IWDP in journals they wrote during and after each class. They wrote an essay to express their expectations of the course and the adaptation of instruction during action research.

The assessment of problem-solving skills through observations depends on the extent to which a project-based classroom could emulate a design community (Carver et al. 1992). To imitate the design community, the teacher planned the following aspects and corresponding questions during classroom observations:

- Activities and interactions: Is there a definable sequence of activities? How do learners respond to the activity and interact with one another? What norms or rules structure activities and interactions? When did the activity begin? How long did it last?
- Conversations: What is the content of conversations in the setting?
- Subtle factors: What informal and unplanned activities, symbolic or connotative meanings of words, nonverbal communication and physical clues occur? (Merriam 1988)

Analysis of data and assessment of trustworthiness

According to Merriam (1988), a constant comparative method within and between interviews is appropriate for qualitative data analysis. Multiple data-gathering methods (observations, interviews, journals, essays) and the use of two different data sources (teacher and learners) satisfied the criteria for triangulation (Creswell 1994; Merriam 1988; Yin 1994).

The data were consolidated and analysed through constant comparison of the data of the teacher's and learners' experience of the IWDP. The researchers identified major themes and sub-themes both within each interview transcription and across the observational notes (as suggested by Merriam 1988). A 'map' of themes and a colour coding and reference number system were used to identify such themes.

The following measures were used for judging the validity of the research design: reliability, construct validity and internal validity (Creswell 1994; Yin 1994; Merriam 1988). Merriam (1988) strategies, namely peer/colleague examination and the statement of the researcher's biases, and Yin's (1994) conceptions about internal validity (making inferences, analytical pattern matching) were followed in this study. The former enhanced the internal validity of the findings.

In addition, a rich, thick description of the researched phenomenon, which was embedded in a theoretical framework of learning theories, instructional models and strategies, contributed to the external validity of this study (Merriam 1988). The transferability and generalisation of the findings are restricted to similar contexts. Instead of the limited generalisability of the findings, the intention was rather to interpret the events (Merriam 1988), based on the uniqueness of the instructional setting.

The teacher in her role as the participant-observer (Merriam 1988), performed the necessary preparations to improve her essential competence in the field. This included the clarification of biases (specifying the researcher's assumptions, worldview and theoretical orientation at the beginning of the study), and submerging the researcher in the study (LeCompte et al. 1993). The researcher addressed biases by carefully planning observational sessions (Merriam 1988), critically reviewing her own comments and writing observational comments immediately after the classroom sessions.

An independent researcher conducted the retrospective interview with the teacher and a focus group interview with the learners. Strategies such as peer/colleague checks, the statement of the researcher's biases, submerging the researcher in the study, making inferences and analytical pattern matching enhanced the internal validity of the findings in this study (Merriam 1988; Yin 1994). The teacher as a qualitative researcher provided a rich, thick description of the researched phenomenon, embedded in a theoretical framework, which contributed to the external validity of this study (Merriam 1988).

Findings

The findings show how both teacher and learners experienced the pedagogy of the IWDP (refer to Table 3). Table 3 indicates the findings (categories), a brief description of the categories, and evidence/examples from the data.

Discussion

The findings (refer to Table 3) indicate the criteria that were derived from the theoretical framework, as an answer to the *first research question (What criteria for the IWDP development can be derived from the learning theories, instructional models and strategies in order to create an appropriate instructional environment for addressing technological*

Table 3 The teacher's and learners' experience of the pedagogy within the IWDP

Findings (categories)	Description of the categories	Evidence/examples from the data
The teacher's experience		
T1: A pre-defined set of AC, RS and PI, learner activities and a variety of the teacher's actions relieved the teacher of the organisational burden of promoting a problem-solving atmosphere in the project-based classroom	The innovative structure and components of the IWDP provided a positive climate for technological problem solving. Rather than concentrating on organisational aspects, the teacher spent time on the facilitation of technological problem solving	'The IWDP with its AC, RS and PI components and a variety of teacher strategies to choose from (for example, explanation, demonstration, modelling, questioning, discussions, dialogues, inquiry/investigation, lecture and whole-class instruction) relieved the organisational burden… rather than concentrating on organisational aspects (for example, setting learner tasks and activities for different stages of the technological process), the teacher spent time focusing on the facilitation of technological problem solving'
T2: The technological stages provided an environment for explicit teaching of thinking skills and metacognitive strategies	Problem-solving skills were modelled and discussed with learners. The explicit teaching of thinking skills and metacognitive strategies within the stages of the technological process provides an opportunity for the teacher to promote technological problem solving	'I had to adapt teaching methods … thinking skills and reflective strategies were taught explicitly… It was useful to have technological stages … it was easier to address technological problem solving during technological stages'
T3: Practical and cognitive apprenticeship created a conducive environment for technological problem solving	The learners responded positively to the teacher expert demonstrations, knowledge transfer and modelling design activities through practical and cognitive apprenticeship. The teacher acted as an expert, supporting their design activities rather than concentrating on classroom preparation	'Expert-novice types of interactions were noted; for example, a higher achieving learner was assisting a less able learner through practical and cognitive apprenticeship [knowledge sharing]. I was acting as an expert demonstrating and modelling design activities through cognitive apprenticeship'
Learners' experience		
L1: Experiential and situated learning supported problem solving but some guidance was necessary	Learners felt that the teacher actively supported experiential and situated learning modes through a variety of technological tools and techniques by, for example, setting agendas for meetings with managers and preparing an observational protocol	'They conducted interviews and observations in a real-world environment under the supervision of the teacher, who supported their experiential and situated learning…' 'Only in class there was somebody, right [the teacher] there, but when we met up on our own … we need more guidance …'

Table 3 continued

Findings (categories)	Description of the categories	Evidence/examples from the data
L2: Step-by-step instruction in a peer-based collaborative learning environment supported problem solving	Learners' comments indicated a positive inclination to knowledge exchange within collaborative groups and peer tutoring. The teacher's observations revealed that learners actively discussed and researched web-design issues with their peers and project leaders within collaborative groups	'the developing software, it's a step-by-step process… you can't just start at one point and finish at a certain point… You have to keep things going in a certain order… you have to see the whole process of design…' 'You find that if we were working as individuals the stress would have been a whole lot more, but we were working as a group. We could divide what should be done in a certain step … It's taking less time to complete the step and then we can have less stress on everybody else … Everyone in the group gives ideas and you build on the ideas together … George helped me with my design'
L3: Knowledge sharing within a network of experts and practical apprenticeship promoted technological design	Knowledge sharing through practical apprenticeship and an active involvement in learning design provided a basis for technological problem solving. Learners enjoyed the individual help they received from the teacher and their peers as they were being exposed to expert strategies and practical apprenticeship in the collaborative context. This created a positive atmosphere for technological problem solving	'You find that if we were working as individuals the stress would have been a whole lot more, but we were working as a group, we could divide what should be done in a certain step … the teacher helped us…'

problem solving?), laid a solid foundation for the facilitation of technological problem solving and provided a basis for a variety of learning modes and instructional strategies in the project-based classroom. Criteria for the IWDP indirectly guided the teacher's activities and influenced the nature of learner tasks and activities (Jakovljevic 2002).

Regarding the *second research question (What should the structure and relevant components of the IWDP entail?),* the focus in terms of pedagogy was on the following components of the IWDP: the stages of the technological process, AC, RS, PI, learner tasks and a variety of teacher activities. From the findings it would seem that an organised and structured instructional environment aligns with a project-based classroom with a growing need for problem-solving skills. The findings indicate that both the innovative structure and the components of the IWDP were regarded as vital for assisting the teacher in promoting technological problem solving. Through a set of pre-defined learner tasks and activities (see Table 2), which supported project planning, design, quality assurance and problem solving, learners developed implicit knowledge (procedural knowledge) (McCormick

1997). Through provisioning of a fully organised and structured learning and teaching environment via the innovative structure of the IWDP, learners could integrate conceptual and procedural knowledge more effectively (McCormick 1997). Conclusions drawn from an analysis of the data in response to the second research question were that provisions for technological problem solving *have* occurred in a few instances. For example, the teacher observed that AC, RS and PI and a variety of teacher strategies to choose from relieved the teacher's organisational burden. Rather than concentrating on organisation, the teacher spent time focusing on the facilitation of problem solving. The teacher's activities were set to control the basic aspects of technological problem solving, from demonstrations of technological skills to providing a frequent modelling of thinking. However, the application of the pedagogy in a different environment might depend on the competences and attitudes of the specific teacher. It is clear that there is a vast range of available instructional strategies and again this knowledge needs to be passed on to other ISD contexts.

Regarding the *third research question (What instructional strategies and modes of learning have supported technological problem solving?)* the findings show that various learning modes and instructional strategies were used to support learning (for example, experiential and situated learning), which indicates that learners had opportunities to develop different web-design and problem-solving skills. The fact that frequent use of practical and cognitive apprenticeship (Arzarello et al. 1993) was widely accepted by learners indicates that various basic and advanced web-design skills were supported. The assumption is that the latter will eventually contribute to problem solving as this skill demands frequent interaction and knowledge sharing between expert and novice learners. Programming and design tasks were performed through hands-on activities that were linked to the real-world nature of the problem, which related to a car purchasing scheme. Knowing 'how' (McCormick 1997) was efficiently achieved through experiential and apprenticeship learning, as learners enjoyed expert–novice interactions. More guidance was, however, necessary. The interaction among the expert, novice and peers is aimed at enhancing the cognitive and metacognitive skills of learners (Arzarello et al. 1993). Cognitive apprenticeship promoted situated learning by giving learners the opportunity to 'observe, engage in and invent or discover expert strategies in context' (Johnson and Thomas 1992: 7).

The findings also indicate that learners appreciated structured guidelines in a collaborative environment, which is suggested in the literature (Johnson 1997). This finding supports varying knowledge demands in the technology classroom (McCormick et al. 1994). The incorporation of structured guidelines makes it easier to select and sequence learning experiences as one of the procedures relevant to cognitive apprenticeship (Johnson 1997). Findings indicate that structured and sequential guidance can serve as an explicit instructional framework for both teacher and learner (McCormick et al. 1994; McCormick 1997). The teacher and learners preferred a structured approach, which helped them to concentrate on the content and processes of the project design (McCormick 1997).

A need for explicit identification and a clear conception of thinking skills in a technology-based learning environment was identified by the researchers (Beyer 1991; Johnson 1997). This was established through the explicit teaching of thinking skills and their attributes as set in the form of learner tasks and activities that promoted technological problem solving. Furthermore, small problem-solving groups and peer coaching through questioning, thoughtful dialogue, role play and reflection stimulated change in the structure of thinking (Wheatley 1991; Fogarty and McTighe 1993).

Learners understood the idea of 'knowledge as design' through reflective activities (McCormick 1997; Winn 1990) as the findings indicate. Learners wanted to solve the problem; it was real and relevant to them. It is thus likely that learners might be able to transfer these skills to other areas (McCormick et al. 1994). Based on the findings, it is reasonable to conclude that the innovative pedagogy was based on constructivist and behaviourist instructional approaches that channelled learners' technological problem-solving skills during web-design activities.

Conclusions

This research was conducted to add value to the body of accumulated knowledge about pedagogy and its application in the project-based classroom. In terms of the purpose of this study (to identify criteria for the development of the IWDP, to set a structure and related components for the instructional programme that will positively influence the problem-solving environment, and to identify and discuss key instructional strategies and learning modes that can support technological problem solving), the following conclusions have been drawn:

1. Criteria from learning theories, instructional models and strategies were used as a point of the departure for the development of the IWDP.
2. The structure and related components for the IWDP were identified and described. The components that positively influenced the problem-solving environment were as follows: a pre-defined set of AC, RS and PI, instructional strategies and learner tasks and activities. This relieved the teacher of organisational aspects and provided the opportunity for the teacher to concentrate on facilitating technological problem solving. Technological stages provided an environment for problem solving and metacognitive strategies.
3. Key instructional strategies and learning modes were identified and discussed.

The pedagogy that both teacher and learners perceived as adequate for technological problem solving had the following benefits:

- The use of peer-based learning and practical and cognitive apprenticeship stimulated the attainment of various basic and advanced web-design skills and thinking.
- Experiential and situated learning (a real-world problem with task-orientated teams) suited the dynamics and complex nature of learning and teaching in the ISD context.
- The step-by-step instruction with explicit teaching of thinking skills and reflective strategies catered for both conceptual and procedural knowledge.
- Knowledge sharing within a network of experts created a link between the technology classroom and the real-world environment and contributed to a problem-solving learning environment.

The complex structure and a variety of relevant components of the IWDP provided the teacher and learners with an organised and structured instructional and learning environment. This had some benefits for the teacher in that it relieved the teacher of organisational aspects and increased her energy and time for the facilitation of problem-solving activities. This suggests that the IWDP provides an organised and structured instructional environment which could be applicable in a project-based classroom.

Future research needs to be carried out into the application of the IWDP in different learning contexts. This would include testing of different instructional strategies, as well as investigations into the successes and problems of their actual influence on technological problem solving. The implementation of an innovative pedagogy within the IWDP revealed new paths in the facilitation of technological problem solving that could serve as a foundation for constructing an instructional web-design model.

Acknowledgments The authors would like to express their sincere gratitude to Prof. Estelle de Swardt, for her assistance with the research.

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