THE FACILITATION OF COMPLEX THINKING USING AN INSTRUCTIONAL WEB DESIGN MODEL (IWDM)

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ABSTRACT

The traditional methods for facilitating complex thinking in the Information Technology (IT) learning area, fail to concentrate on an appropriate integration of various modes of learning within the stages of the technological process. The nature of facilitating complex thinking during Information System Design (ISD) is not clearly described in literature.

The aim of this paper is to explore the facilitation of complex thinking through the *Instructional Web Design Model (IWDM)*. This paper provides a description of the IWDM, highlighting its criteria, assumptions, the purpose, the structure and planning for the implementation.

The IWDM is based on the implementation of the Instructional Web Design Programme (IWDP) and corresponding findings in terms of learners' and the teacher's experience of the IWDP. The IWDM offers learners a constructivist vision of multi-method learning in the ISD environment, enlarging and strengthening the insight into the design process and a climate for enhancing intellectual processes and skills**.**

This research was embedded in a qualitative, action-research approach where interviewing, focus group interviewing, observation and document sources were used to gather data. Although the IWDM is based on a case study (located in the computer laboratory at RAU) reflecting conditions in the project-based classroom, the model can be applied to similar project-based classrooms specifically within the ISD context.

1. INTRODUCTION

There is little in the research literature on instructional models that will engage learners in the development of cognitive skills. Eggen and Kauchak [11] state that an instructional model is " … a tool to guide teachers to teach more effectively by making their teaching more systematic and efficient". Reddy [26] mentions several process models for technology, design and problem solving [4][31][17]. Lankard [23] presents an instructional model for problem based learning, based on constructivism. These models do not provide a clear indication of the dynamics of learning/teaching within the stages of the technological process.

According to Ankiewicz, De Swardt and Stark [1] the technological process includes the following ten stages: the problem statement; the design brief; investigation; writing a proposal; initial ideas; research; development; design and planning; making (realisation); evaluation and testing. There is no clear indication of the explicit facilitation of complex thinking and a logical flow of the instructional strategies, which should correspond to the thinking, needs of learners during the stages of the technological process.

Complex thinking includes goal-directed, multi-step strategic processes, such as designing, decision making, and problem solving [15][20]. Higher-order thinking includes critical, creative and complex thinking [20]. For the purpose of this study complex thinking is used as an umbrella term for all sub-processes of higher-order thinking.

The key question addressed in this paper is: *What instructional model for the teaching of web page design can contribute to the development of complex thinking in the IT learning area?*

In considering this question, we argue for more emphasis on in-depth research on the various learning modes within the technological process and their implications for cognitive skills of learners in the Information Technology (IT) learning area.

This paper reports on the description of the IWDM with the purpose to facilitate complex thinking during a Web Design Project (WDP). The IWDM was based on the integration of the teacher's and learners' experience originated from the implementation of the instructional web design programme (IWDP) and the theoretical framework namely: complex thinking, mind tools in web page design, learning theories, instructional models and strategies. Mind tools (for example, semantic networks, programming, computer mediated communication (CMC)) "require learners to think in meaningful ways" (Jonassen, 1996:3). The IWDM is designed for the IT learning area for learners in the Higher Education and Training band (HET), and specifically the ISD context.

As the systematic structure of the IWDM is accommodated within the teacher and learners' experience of the IWDP and the theoretical framework, the basis underlying the design of the IWDM is the topic of the further analysis.

2. BASIS UNDERLYING THE DESIGN OF THE INSTRUCTIONAL WEB DESIGN MODEL (IWDM)

2.1 A summary of the findings based on learners' and the teacher's experience of the IWDP

The basis for the IWDM was derived from the following findings: A variety of instructional strategies, human and technological resources must be applied within the framework for Technology Education if the aim is to facilitate complex thinking. With regard to these, some findings were considered particularly important in creating the IWDM:

- The teacher must more efficiently utilise the tutoring power of learners emphasizing their accountability during collaborative work.

- Learners need an expert's help in facilitating system design and programming skills.
- Cognitive apprenticeship through a network of human resources is seen as a useful approach in teaching system design and programming skills.
- The dynamics between individual, collaborative and situated learning must be altered to provide for construction of knowledge and exchange of creative ideas.
- Facilitation of complex thinking was done mainly indirectly through the technological design, assuming implicit development of thinking skills.
- The implementation of IWDP catered for a variety of instructional strategies for the facilitation of cognitive skills with no intention to utilise group discussions and questioning in their full capacity.
- As the nature of mind tools requires that activity-based practice must be balanced by reflective practice further internalization of visual and representational means (technological resources) must be integrated into ISD context.
- The stages of the technological process [16] provide a direction and guidance with a choice of activities for the teacher and a range of tasks and activities for the learner.

These experiences with the IWDP led to the development of *The Instructional Web Design Model* that will cater for appropriate facilitation of complex thinking through individual and group dynamics within the stages of the technological process.

2.2 The theoretical framework as the basis for the instructional web design model (IWDM)

The IWDM is based on the theoretical framework (complex thinking, mind tools in web page design, learning theories, and instructional models and strategies). Some literature findings are considered particularly necessary in the derivation of the IWDM:

- Several principles derived from the behavioural instructional approach to learning: contiguity, repetition, feedback and reinforcement, are necessary for activity-based practice in the project-based classroom for certain types of low-level performance.
- Stage, Muller, Kinzie and Simmons [33] state that social constructivist approach to learning applied through collaborative learning, problem-based learning and peer-based learning create a meaningful leaning experience for learners on higher-educational levels.
- Situated view of learning emphasises learning as social interactions and physical activities [7]. The thinking and learning experience is situated in physical real-world and social contexts [5][28]. Facilitating complex thinking should be based on principles of both behaviorism and constructivism, as knowledge construction depends on learners' experiential foundation supported by direct instruction, inquiry and a situated mode of learning.
- The teacher cannot systematically plan each cycle of experiential learning proposed by Kolb [10], as learners must be guided through their individual experience.
- Arzarello, Chiappini, Lemut, Marara and Pellery [3] point out that learning programming is a practical and cognitive apprenticeship, an interaction between expert and novice aimed at enhancing the cognitive and metacognitive skills of learners. The tasks of scaffolding are an expert-novice or peer tutoring type of cognitive apprenticeship when a higher achieving student assists the lesser able students [29][21].
- Discussions are essential in order to develop skills like synthesis, integration and collaborative learning [6]. Teachers' unrealistic expectations as well as not explicitly conveying their image of good discussions to learners [6] need attention, because learners must be prepared for their learning experience.
- The teacher needs to access learners' work habits, background development, manipulative skills, social skills as well as conceptual levels [21], in order to facilitate individual learning.
- The need for additional help provided by an expert or by peer-based teaching is supported in literature [18][19].
- Reflective skills are essential for problem solving [19] but learners usually don't understand the whole process of reflection [19], which is relevant to the facilitation of critical thinking.
- It is difficult to expect learners to argue a case, if they don't know the theoretical meaning and evaluation of arguments, the process of examining evidence, understanding assertions and conclusions [30].
- The stages of the technological process are cyclical and repetitive [1]. It is also argued in the literature that the technological process is prescribed, systematic and linear [14][17] or in the form of design loops [34].
- In order to guide learners to evaluate the design, learners "need to analyse the components of design, by identifying the attributes, the relationships and patterns, and the main features and then evaluate these components based on previous acquired knowledge related to the characteristics of good design" [32].

The instructional web design model (IWDM) should cater for an appropriate integration of various modes of learning (like individual, collaborative, and situated learning) within the network of human resources. The next section focuses on the description of the instructional web design model (IWDM).

3. DESCRIPTION OF THE INSTRUCTIONAL WEB DESIGN MODEL (IWDM)

This section provides a description of the IWDM highlighting the essential criteria, assumptions, the purpose and the structure of the IWDM. A description of the model is based on the method of theory description of Chinn and Kramer [8]. The model has preparation phases revealing the teacher's responsibilities and learners' activities across the stages of the technological process.

To clarify the facilitation of complex thinking, the IWDM should provide a clear picture of a flow of instruction within the stages, through which the following aspects of the instructional process need to be highlighted: the modes of learning, assessment criteria, performance indicators, and complex thinking outcomes. These influence the creation of essential criteria of an IWDM.

3.1 Essential criteria of an instructional web design model (IWDM)

When developing an instructional model it is necessary to describe the essential criteria, which provide guidelines during the derivation of its structure related to the subject area. The following essential criteria must reflect the teaching and learning in a project-based classroom particularly relevant to the ISD context:

- A model should be designed to meet the learning outcomes.
- A model should be drawn from constructivist and behaviorism theoretical paradigm.
- The teacher's responsibilities during the planning and implementation stages of the model must be clearly

specified.
- The learners' activities must be clearly defined.
- Advantages and disadvantages of the model must be determined [26][8][11].

Additional criteria for theory generation (clarity, simplicity, generality, accessibility and importance) suggested by Chinn and Kramer [8] are considered relevant in providing guidelines for the derivation of the structure of an instructional model. As assumptions underlying the IWDM are a necessary part of a model structure [8] the next section will specify these.

3.2 Some assumptions relevant for the design of the instructional web design model (IWDM)

The design of the IWDM is based on certain assumptions, which are specific to the IT learning area. These assumptions are described below in order to communicate the model's limitations and advantages:

- The model is applicable for learners in the Higher Education and Training band.
- The instructional model focuses on the two strands 'technological process' and 'communication' [12], located in the Higher Education and Training band in the IT learning area.
- The instructional model may serve as an orientation for teachers in the project-based classroom in which the principles of Outcomes-Based Education (OBE) are applied.
- The teacher possesses essential instructional skills (for example, organization, instructional alignment, focus, feedback, monitoring, communication, questioning) and positive affective characteristics (for example, enthusiasm, modeling, warmth and empathy, positive frame of mind). The teacher also possesses a number of competences and roles relevant to technological problem solving.
- The teacher is trained in Technology Education.
- A senior tutor possesses essential system design and programming skills.
- Peer-tutors are trained and allocated within groups.
- An assistant/expert is present to assist learners.
- Learners' and teacher's activities are not prescribed and may serve as an orientation for learners and the teacher to guide them through the technological process.
- Learners' activities are arranged for both individual and group work. The choice in terms of order and the inclusion of all stages should not be prescribed. The model should allow the teacher and learners to experience the complete cycle of learning/teaching during each technological stage.
- The technological learning environment is organized in terms of the following: the physical setting is determined; human and technological resources are prepared (material, aids, software and hardware equipment, evaluation aids and self-assessment tools); collaborative groups are formed.

It is assumed that an IWDM with its provision for different learning modes within the stages of the technological process will extend learners' cognitive capabilities and technological skills. The purpose for the IWDM needs to be clarified before the structure of the IWDM can be discussed.

3.3 The purpose of the IWDM

The IWDM is designed to accomplish two interrelated purposes. The first is to help learners develop a deep understanding of ISD with specific application to web page design. The second is to promote complex thinking, knowledge, skills and values of learners through a variety of instructional strategies and resources.

In traditional teaching the goal is to attain content as well as thinking goals. These two aspects coexist in teaching technological design, and this is particularly visible in the structure of the IWDM.

3.4 The structure of the IWDM

A definition of the structure of a model provided by Chinn and Kramer [8] as consisting of the assumptions, components (concepts), the relation statements and the nature of the structure, is considered relevant for the IWDM.
To describe the structure of the model the following aspects are considered: the components (concepts) of the IWDM and the nature of the structure.

The model reflects the dynamics of learning/teaching (dynamics between human resources, dynamics between learners, and dynamics between learners and human resources), a variety of learning modes and teacher and learners' tasks with regard to the explicit teaching of complex thinking spread across the stages of the technological process Also, assessment criteria and performance indicators are incorporated into the structure of the model.

The instructional model includes different components (concepts). Each component (concept) of the IWDM will be briefly described in the following section.

3.4.1 Components (concepts) of the IWDM

Components (concepts) relating to different instructional aspects, which constitute the structure of the model are listed below:
- *Instructional strategies/Different modes of learning*: (individual learning, collaborative learning, inquiry learning, apprenticeship learning, peer tutoring within and across the groups, situated learning, observational and experiential learning).
- *The stages of the technological process* [1].
- *Human resources:* The teacher, peer-tutors, a senior tutor, an assistant, an expert are involved in different interactions in facilitating technological design.
- *Assessment criteria:* They provide the teacher with clear indicators of what learning aspects should be assessed across the stages.
- *Performance indicators:* They provide the teacher with detailed indicators of how learners should perform during the stages of the technological process.
- *The teacher's tasks (TT) and learners' tasks (LT) on complex thinking:* The set of tasks should correspond to the needs of learners with different capabilities, and should be of individual and group type. It should correspond to different thinking skills required during the stages of the technological process.

The relationships between components indicate a systematic form. In order to understand the structure of the IWDM in its entirety, the nature of the model is described in the next section.

3.4.2 The nature of the instructional web design model (IWDM)

Apart from the importance of considering why the components of the IWDM come together, the nature of the structure refers to how the components are linked in terms of the dynamics of relationships. The following is a brief description:

(1) Individual and group dynamics between learners

Four learners with the different expert roles of business analyst (BA), content designer (CD), graphic designer (GD) and programmer (PR) form a collaborative group. The role of a project leader (PL) is rotated between learners. Another group (G) has a similar configuration.

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. Multiple interactions are possible through peer tutoring during the stages, reflecting individual and group dynamics, constructivist and behaviorist modes of learning.

(2) Dynamics between human resources

An assistant (A), a senior tutor (S) and an external expert (E) are actively involved in tutoring, particularly during the stages in which system design skills and programming skills should be developed. Human resources perform different interactions under the coordination of the teacher during the WDP. The responsibilities of each member of the human resource team change during the stages. Each member takes a dominant role during the particular stage leading to a chain of interactions. The inclusion of a human resource and role depend on the functionality of the stages and different needs of learners and learning modes in terms of developing thinking skills. For example, an expert is a necessary human resource during situated learning.

(3) Dynamics between learners and human resources

Individual and group dynamics are particularly evident through interactions between learners and human resources. The teacher is always present or in the background, facilitating complex thinking and coordinating the interactions between learners and human resources.

Recommended modes of learning lead to a variation of learning during ISD. Although some modes of learning such as inquiry and collaborative learning are happening throughout the technological process, it is necessary to place them into the most relevant stage to provide an educator with control over the flow of learning and instruction.

The development of complex thinking is seen as progressive and cumulative. It is considered necessary to develop the set of teacher's and learners' tasks in order to control explicit teaching of complex thinking based on the needs of the learners during the WDP. Each sub-process of thinking is placed into an appropriate stage of the technological process.
The individual and group dynamics during the WDP reveal the following:

- A variety of learning modes consisting of individual, collaborative, situated learning, inquiry learning, apprenticeship learning, peer tutoring, observational learning and experiential learning.
- A variety of individual interactions within the collaborative group and between groups including individual interactions with available human resources.
- An exchange of roles and expertise.
- The exchange of classroom experience and real world experience in relevant businesses.
- Enabling skills through peer tutoring within ones' own group and tutoring in another's group.
- The teacher's and learners' tasks on complex thinking skills vary across stages and are placed into the relevant stage according to their needs.

The facilitation of complex thinking takes place during the stages of the technological process. The following paragraphs offer a brief description of the stages of the technological process, which represents the core of the IWDM.

(4) Description of the stages of the technological process

STAGE 1: The statement of the problem: The teacher who provides the technological problem based on learners' experience triggers this stage. Learners share experience within the group based on their expert roles and knowledge base with the participation of the teacher.

STAGE 2: Design brief: Learners are involved in individual learning. They write the design brief from their perspective taking into the consideration their expert role and experience. The teacher provides an explanation of the general steps in the creative process.

STAGE 3: Investigation: Learners investigate a business case, establishing interactions with experts outside the project-based classroom. During this stage learners' critical skills and research skills should be facilitated.

STAGE 4: Initial ideas: Learners generate and record ideas through brainstorming within the group, and communicate ideas to the teacher, an assistant and expert. During this stage, learners' creative skills and decision making should be facilitated as they make a choice between ideas.

STAGE 5: Writing proposal: Learners collaboratively write a proposal according to their tasks and expert roles. Practical and cognitive apprenticeship by peers, an assistant, a senior tutor and the teacher provide the opportunity for individual and collaborative learning. Through apprenticeship learning, learners' critical and reflective thinking indicates a departure from traditional thinking.

STAGE 6: Research: Learners are involved in peer tutoring with an aim at improving group members' research skills and web design skills. Learners are introduced to basic concepts and examples of decision making. They develop knowledge and techniques in critical, creative and reflective thinking accumulated through previous stages.

STAGE 7: Planning and designing: At this stage learners are exposed to observational and individual learning through which they observe expert strategies in the ISD context. Reflecting on the meaning of design skills influences learners' thinking skills.

STAGE 8: Development (Modeling): At this stage learners perform peer tutoring across different groups. They organize expert meetings across the groups sharing ideas in terms of their field of expertise. Relevant problem solving techniques and design skills are modeled and discussed with learners.

STAGE 9: Making: Learners are involved in activity-based practice following conceptual learning. Learners proceed to the application of knowledge and skills within collaborative groups through apprenticeship learning. Learners should be able to recognise and apply design skills and utilise problem solving techniques.

STAGE 10: Evaluation and Testing: At this stage learners communicate their learning experience, evaluate and perform different levels of testing. Learners should reach a point of internalization and integration of thinking skills and individual independence in terms of ISD.

4. PLANNING FOR THE FACILITATION OF COMPLEX THINKING

In planning for the implementation of the IWDM, general specifications for instructional models are considered [8]. Different aspects of planning are considered in ISD context. These aspects are briefly examined below:

- *Learning outcomes:* Learning outcomes must be communicated to learners before the implementation of the IWDM. Clear communication of the expectations could improve intrinsic motivation and individual responsibilities and subsequently individual accountability.
- *Planning instructional approaches and strategies*: A balance between behavioural and constructivist instructional strategies must take place within collaborative groups highlighting explicit teaching of thinking skills within the technological context.
- *Planning, formation and facilitation of collaborative teams*: The complete cycle of small group formation, coordination, development and adaptation should be mastered [2].
- *Planning of a technological problem*: The problem that learners must solve, should be based on learners' experience [20]. Also learners' initiative in searching for a technological problem should be supported.
- *Preparing content structure and visual means*: Some graphic organizers that the teacher can use in preparing the content structure are: a hierarchy chart, synthesisers, agendas, a 'snowball method for teaching' [22] [27] [35], advanced organisers, historic and emerging organizers [34] and the visual aid on the board [13].
- *Planning of the technological environment*: The nature of web page design reflects situated learning as learners extend their experience, enriched through experiential learning, beyond the actual project-based classroom.
- *Planning of technological resources:* Mind tools (for example, semantic networks, programming, CMC) present essential technological resources in facilitating thinking skills [20].
- *Organizing/planning of human resources for the facilitation complex thinking*: By delegating practical responsibilities to an assistant, expert and peer-tutors, the teacher is provided with more time in facilitating cognitive skills.

5. CONCLUSIONS

The following conclusions in terms of the IWDM can be drawn:

- Activity-based practice [19], and the interactions with multiple human resources lead to individual learning and teaching, thus promoting active learning and thinking applicable for learners in the HET band.
- The learning process is embedded in the classroom environment and real-world environment thus fulfilling the enabling factors of informal education [18].
- Explicit teaching of the sub-processes of complex thinking which correspond to the needs of learners during the stages influence learners' responsibility and understanding of the thinking processes in the ISD context. Specifically, learners deal with the conceptual meaning and attributes of thinking skills.
- A balance between constuctivist and behaviorist instructional strategies contribute to a dynamic individual and collaborative activities, which stimulate the attainment of system design skills and creativity during ISD. This provides a rich array of social interactions through a network of human resources and different modes of learning. Learners develop their thinking [33] particularly outside a project-based classroom.
- Utilising peer tutoring stimulates a wide range of skills, including social and thinking skills [3]. The teacher becomes a coordinator of the learning process and human resources concentrating on the cognitive aspects of the facilitation.
- Exchange of expert roles, the rotating role of the project leader and the opportunity to teach within one's own group and across the groups will lead to the development of multiple skills, knowledge and thinking.

An attempt was made to build an IWDM, through which learners will be involved in multi method learning, providing opportunities for the teacher to be involved in individual teaching [24].

An IWDM provides a general instructional framework that will aid the facilitation of learners' cognitive skills, and recognize the aspects of instruction, technological and human resources mentioned above as valuable and essential in the project-based classroom.

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