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Integration of critical and creative thinking skills into an Instructional Technology module of the post-graduate teacher training programme at Singapore's NIE

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Introduction

The purpose of this paper is to introduce a unique pedagogy that helps us to understand the educational links between developing critical and creative thinking skills and the use of Instructional Technology tools to achieve this goal. An overview of the psychological learning theories underpinning critical and creative thinking will be given and these will be linked to the various constructivist pedagogies that explain the educational contribution that Information Technology (IT) can bring the teaching and learning profession. The main thesis of this paper will be an explanation of a new pedagogical perspective that identifies any critical thinking tool as operating within a reflective learning environment. It will be shown that the pedagogic relationship between the learner and the reflective scaffolding tool employed depends on the quality of the system's *reflective learning interface* (RLI). The notion of a RLI will be explored so as to identify the significant principle components that underpin the differing interface qualities of various learning tools - ranging from traditional reading books to software packages. This theory will explain the pedagogical difference between a learner using, say, a pencil and paper, as opposed to a word processor, as an authoring medium for capturing and critically appraising creative thoughts and ideas. Examples of various reflective thinking generic IT tools will be given and discussed in the context of applying them to a post-graduate instructional technology teacher training programme.

What is Critical & Creative Thinking?

Creativity is usually defined as the thinking processes involved in the creation of novel ideas or products. Sternberg and Lubart, for example, defined creative insight as the ability "to entertain unusual, novel, or unpopular ideas for solving a problem at hand" (1995, p. 538). Creative thinking involves critical thinking or reasoning about complex issues in order to make a decision about an original idea, product or service. According to Marzano (1992), critical thinking involves the use of declarative knowledge, procedural knowledge and conditional knowledge to solve a problem. Psychologists believe that most people are capable of critical and creative thinking and that these higher–order processes may be taught to primary school pupils. IT is a particularly powerful teaching tool because it opens up access to a rich variety of resources, it enables flexible thinking to flourish, and because of its infinite patience IT can operate as an inexhaustible learning coach. The goal is to teach pupils useful strategies to locate and select appropriate information from the vast store of potential knowledge available on large databases, such as the Internet's World Wide Web, and to avoid becoming overwhelmed by an overload of information. It is our contention that this can be achieved by providing learners with reflective tools that can stimulate critical and creative thinking skills. The following sections explore this idea of using reflective tools as a teaching scaffold to enable learners with a repertory of critical and creative thinking skills. The concept of a reflective learning interface is introduced as an explanation of how different media attributes can influence the design and quality of reflective tools.

Reflective Learning as a creative thinking process

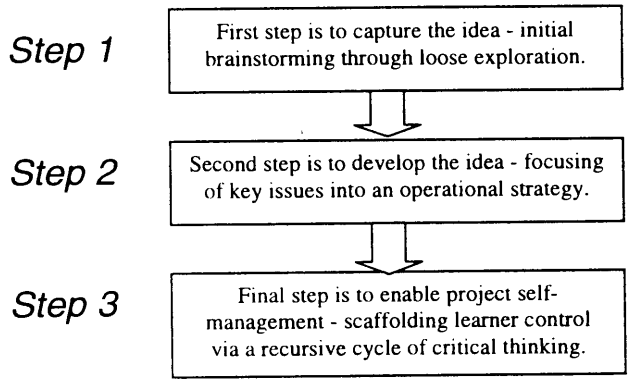
Reflection is generally considered to be an experiential learning activity. Boud (1985) provides an insightful definition of reflective learning that describes the experiential learning process:

> "reflection in the context of learning is a generic term for those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understandings and appreciation" (p. 19).

When considering the pedagogy of reflective and critical thinking learning systems the important questions arise: " what are reflective and critical thinking skills?" and " how does reflective competence relate to improved learning performance?" Indeed, the self-pedagogy of reflection in the form of a personal repertory of reflective skills can be explained from conversational learning theory. Self-organized learning is one such theory, in which reflection is considered as an active critical thinking process that constitutes what Harri-Augstein & Thomas (1991) refer to as a Learning Conversation. Self-organized learning is a self-management heuristic applied to one's reflective thoughts. The pedagogy of reflective learning is about developing a learner's reflective management skills. This can be understood as a series of simple *thought-focusing steps* that can be applied to the design of creative thinking tools. A good example of these simple thought-focusing steps to aid creative thinking is the "six thinking hats" procedure promoted by Edward de Bono (1992), where each coloured hat provides a metaphor for thinking about the same issue from different perspectives. This step-by-step procedural approach to thinking is also called systems-based thinking. Cybernetics is the science of systems-based thinking and critical thinkers, such as Peter Checkland (1993), regard reflective practice as a simple common sense strategy that can "initiate and guide actions we take in the world" (p. 4). Coombs & Smith (1998) discuss a learning theory that identifies the nature of **reflection** as a psychological thinking process that relates to active learning experiences. A **reflexive** process, on the other hand, is conceived as being a second-nature prior learned activity that requires no reflective thought. Examples of activities requiring no reflective thought include tying our shoelaces and the picking up of familiar objects such as a mug of tea. Reflexivity can, therefore, be understood as a behaviouristic form of learning requiring little or no thinking skills input.

Reflective skills, on the other hand, are considered by Coombs and Smith to be a form of "conversational constructivism", requiring the person to conversationally deconstruct and reconstruct their learning experiences in order to arrive at a new model of understanding. A good example of this constructive thinking process can be seen in the teaching of mathematics, where the learner needs to understand and "model" difficult concepts. These difficult concepts can be conversationally broken down and reconstructed by the teacher using appropriate visual models and metaphors as a scaffold to describe the mathematical process. This process of deconstructing and reconstructing one's experience is considered to be the hallmark of "the reflective practitioner" by critical thinkers such as Donald Schön (1987) and David Boud (1985). In order to clarify the links between conversation, reflection and learning, Harri-Augstein & Thomas (1985) defined human learning as: "The construction, reconstruction, negotiation and exchange of personally significant, relevant and viable meaning". (p.xxiv). This definition clearly links conversational learning with constructivist methods of reflection. It also links into our understanding of social constructivism where, as teachers, we try to design learning situations that contain socially meaningful, or real-world, authentic tasks. Conversational learning theory also explains reflection as a form of "personal paradigm shift" (Coombs & Smith, 1998), in which our thinking experiences are considered as Kelly (1955) "personal constructs" that underpin our understanding of the world we live in. If our knowledge of the world can be constructed from our personal experiences, then we have a concept that suggests **thinking procedures** from which reflective tools may be designed and used in all active learning situations. One such thinking procedure that has been proposed is George Kelly's three-phase "creativity cycle" (from Bannister, 1981) that builds upon his idea of thinking as a psychological process of "personal constructs". This critical thinking heuristic has been further developed

by Coombs (1995) who suggested that the reflective 'modeling' of ideas could be achieved by designing scaffolding templates that satisfy the following three steps: -



A good example of reflective tools that satisfy the above thinking steps would be to use the Spidergram (see website on p. 675) to perform the brainstorming session in step 1. This could be followed by use of a project management scheduling tool, such as a Gantt chart, to elicit an operational strategy for step 2. This could then be followed with the use of the reflective learning journal, as seen in the website above, for achieving the on-the-job project management objective of step 3. Such a reflective process represents the design criteria of a "content-free" conversational tool. This means that the template operates as a generic guide to shape and focus the user's thinking process, while the "free" content is personally constructed from the user's own experience. The reflective tools presented here can be philosophically explained in terms of Coombs and Smith's (1998) conversational constructivist design criteria, but we may simply understand them as "scaffolding" devices that help us to construct knowledge and ideas drawn from our practical experiences. After repeated uses such scaffolding devices become part of our natural thinking pattern and would become otherwise redundant if it were not for the permanent record produced via the *completed template*. A good example of this completing-the-template process is the use of the reflective learning journal exhibited in the website above to help a student self-manage some curriculum project. The user reflects upon their project tasks experienced and then records information about the nature of the task itself; the sources used to execute the task; and the problems and solutions encountered. The user is also encouraged to reflect upon and jot down their "next step" in the project management cycle. This reflective tool has, therefore, served a number of clear pedagogic purposes and enables the following critical thinking skills benefits:

1. *it provides the user with an on-the-job project management template for both directing and reflecting upon learning experiences, thus encouraging self-organised learning;*
2. *it allows the user to reflect upon what's being learnt as a consequence of doing the activity through providing a focus upon actual problems and solutions experienced - thus applying critical thinking skills to an authentic problem-solving learning environment;*
3. *it empowers the user to reflect upon and anticipate future project steps in the form of new tasks - thus enabling a recursive form of learning experience;*
4. *it provides an authentic record of the learning situation that may be used as assessment evidence, implying that there are additional learner-review benefits if the template is computerised (i.e. it comes in the format of a Word document).*

The benefits of teaching thinking with IT tools

Encouraging a learner to follow-through a defined pattern of thinking steps represents a reflective process that may also be explained as a *creativity heuristic*. The thinking steps underpinning a reflective tool can be designed as content-free "empty" templates. The learner can use these generic reflective tools as a self-coaching device, developing an ability to focus thoughts and ideas and turn them into useful concepts and knowledge. Information Technology (IT) can be employed as a catalyst to both assist and accelerate this kind of reflecting process and represents a user-friendly thinking tool (Coombs, 1998). Generic IT tools such as Word© and Excel© may be developed to produce content-free reflective templates that encourage the user to perform focused reflections relative to some learning task. Thus, reflective tools are employed in the context of "task-managing" a purposeful learning activity that provides the learner with meaningful feedback of his/her actions. This means that knowledge and understanding of authentic learning events can only be gained through reflective activities that encourage the learner to make sense of the experience. Harri-Augstein and Thomas (1991) believe that reflective tools achieve this learning process through the recursive and cyclical nature of critical reflection relative to some active learning task. It will be later shown that many IT instructional systems contain task-based recursive learning features and, therefore, provide an educational *value-add* that aids reflection and improves critical thinking skills. Harri-Augstein and Thomas also consider that reflective tools should be used to "record behavior directly (so as to) support the reconstruction of experience, which generates feedback about the quality of performance." (p.263)

This type of knowledge building process through reflective elicitation of one's learning experiences is referred to as a knowledge elicitation system (KES) (Coombs, 1995). Coombs considers that knowledge is a psychological phenomenon contained in persons, not machines, and therefore supposes that the traditionally held concept of a computer operating as a knowledge-based system (KBS) is potentially flawed. Instead, Coombs considers that the learner interface is based upon the reflective capability of the learning system to allow the user to meaningfully elicit knowledge - hence, the notion of a knowledge elicitation system (KES). Thus, the ability of the user to elicit knowledge meaningfully from an IT system is considered to be a function of the system's reflective learning interface (RLI) capability as well as the user's prior learning. All the reflective tools presented in this paper are designed as Knowledge Elicitation Systems and have been operationally considered from that design principle. Several important questions arise regarding the nature of an RLI that we would like to focus upon:

1. What are the core human factors and medium attributes affecting the design criteria of different RLIs?

2. How does the concept of an RLI explain the quality differences between using distinct media resources to achieve a similar learning task, e.g. the reflective learning difference in writing an essay manually on paper compared to using a wordprocessing software package on a computer?

The first question suggests that the quality and nature of the learning environment medium being used can affect one's reflective ability. Critical theorists coming from diverse academic fields, including media communications, instructional technology, behavioral and educational psychology, have addressed this important issue in terms of a learner's cognitive ability. In Clark & Salomon's (1986) definitive work on the subject (in conjunction with many others, such as Anderson & Lorch, 1983; Goodman, 1968; Bruner, 1964; Bandura, 1978; Gardner et al., 1974; Olsen, 1976; Salomon, 1979), they have considered the question of what media attributes affect instructional learning environments. In particular, they identify the learning attributes that influence the learner's interactability with a chosen in-

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structional medium. The pedagogic and reflective rationale of these medium learning attributes is summarised in Table 1 and provides a reasonable, but not perfect, answer to question 1. The implication of Table 1 is that we can now consider a whole range of instructional media in terms of their medium learning attributes and how these might affect the quality of the system's reflective learning capability for learners. Table 2 attempts to plot these medium-based reflective learning characteristics against various instructional media types, ranging from paper books to virtual reality learning environments. The important caution is that these attributes are characteristics influenced by the learner's prior learning, so that the nature of any tick-chart table presented is that it will represent a specific profile for every learner. The reflective learning interface is a function of both the learner's unique prior learning experience and the system's medium learning attributes relative to the task.

It is recommended that more educational research should be conducted in this field, so as to establish general profile patterns for common groups of learners sharing a similar background of prior learning experiences. Despite this caution, Table 2 clearly demonstrates the pedagogic differences for the author between using a word processor and paper and pen for the same authoring task. Clearly, the use of a wordprocessing tool encompasses some of the learning attributes of using a pen and paper, namely, reflective skills involving text literacy, user control of the system, specific content knowledge being authored, and coding knowledge of the English language. The pen and paper method had the additional benefit of touch, as the medium represents a more tactile interface than that of the word processor's keyboard. However, in answer to question 2 above the authors identified four additional medium learning attributes: namely, a recursive reflective learning feature in using the word processor as both an editor and reviewer of authored content; a text format and design feature aiding better quality manipulation and organisation of the material; additional thinking steps for when using language utilities such as the thesaurus, grammar and spell checker; and finally, the benefits of using an icon-supported graphical user interface.

All of these additional features attributed to the wordprocessing medium represent the improved reflective learning capability and quality of this system compared to the use of paper and pen. In a similar vein, arguments could be made comparing all the other instructional media types listed in Table 2. The central thesis here is that the integration of appropriately designed IT tools into teaching and learning can vastly improve the quality of critical and creative thinking skills.

How IT reflective tools have been integrated into a teacher training module

Because of these additional reflective learning benefits that IT tools can offer learners, we decided that the critical and creative thinking templates discussed earlier in this paper would benefit from having an IT interface. It was for these *deep* pedagogic reasons that the conversational tools of Figures 1 and 2, the Spidergram and Reflective Learning Log, were provided as downloadable Word file templates on the School of Education (SOE) Website at Singapore's National Institute of Education (NIE). Our aim was to test the effectiveness of these IT reflective templates by using them meaningfully in the curriculum to support learners on a teacher training module. Over one thousand teacher-trainee students were then able to download these reflective tools from the SOE's Website and use them to support the pedagogical thinking components of their IT practical project work. A total of four downloadable reflective thinking templates were provided to NIE's post-graduate diploma in education (PGDE) students from July 1998. In addition to the Spidergram and Reflective Learning Log two new templates were designed: a Reading Table and an IT Pedagogic Table. All four reflective templates were designed as generic templates to support the student's project management of various IT assessment tasks. The use of these templates to support IT project-based tasks is explained in Table 3. More details of the PGDE IT project

work supported by the use of these templates, including working copies of these templates and exemplars, can be obtained by visiting the PGDE IT Website, which is currently located at: http://www.soe.ntu.edu.sg:8000/programme/pgdes/ned513/index.htm

Conclusion

This paper has outlined how students undertaking an Instructional Technology module at NIE may develop critical and creative thinking skills. Students have been encouraged to use reflective scaffolding tools, such as the Spidergram and the Reflective Learning Journal, to support their project management of various IT assessment tasks. These tools have provided them with a rich resource that is a significant advance over previous critical and creative thinking tools, such as brainstorming and concept maps because of the advantages of using computer software over the use of paper and pencil. The benefits of teaching thinking with IT tools promise to make student thinking even more effective and efficient in the future.

Table 1: Medium learning attributes underpinning a reflective learning interface

Medium Learning Attribute	Pedagogic and reflective rationale
Use of novel and new medium formats	Affects the attitude and motivation of the learner. This can lead to improved interaction via greater attentiveness and involvement with the system. This quality relates to the affective self-concept domain and to a user's perception of the media being used. For some users, a new medium is positively embraced. However, if the system generates feelings of low esteem, then this will have the reverse effect and alienate the user's personal ability to interact meaningfully with it.
Nature of text organization	Physical shape, size, layout and style of text can influence the quality of learner interaction.
Written text systems within a medium	Develops a culture of "text" with a "literacy bias".
Programmed instructional steps and their "size"	This affects the nature of any in-built heuristics (i.e. problem-solving procedures should have suitable thinking steps that match the prior learning capability and assumptions of the user).
Visualisation and imagery-evoking properties	Considered in terms of acting as a learner stimulus. Eye-catching graphics stimulates reflective attentiveness upon the image focus (e.g. advertising billboards).
Comprehensibility of the medium	Comprehensibility determines attention rather than just 'looks'. Media systems should be primarily designed to be fully comprehensible to the user. Salomon argues that personal comprehension of media systems is improved when the symbolic modes employed match the person's prior learned map of cognitive representations (e.g. a simple symbolic logo can be more effective than a "busy" picture). Thus, a balance between comprehensibility and visualisation needs to be struck for maximising reflective attention and comprehension.

Use of Goodman's symbol systems to communicate instructional messages – verbal & pictorial symbols with notational qualities	Goodman argues that symbols act cognitively as referential personal constructs and have semantic and syntactic qualities differentiating structure and field mapping relative to a frame of reference. The use of icons within an IT graphical user interface (GUI) as part of a Windows-Icons-Mouse-Pointers (WIMPs) environment underpins the value of these symbol types as a scaffold for reflective learning
Olsen's transfer of learning elements - content-knowledge and decoding user skills	Medium content component relates to knowledge acquisition and message decoding cognitive skills (e.g. reading Egyptian hieroglyphics requires a user to have prior knowledge of hieroglyphic decoding skills before content knowledge can be reflected upon).
Media with new symbol systems	To cultivate in the user new skills and concepts for exploration and internal representation - implying a new reflective capability. For example, compared to 20 years ago many people now take for granted the use of an IT GUI and WIMPS working environment. We have cultivated new skills and concepts as aids to support higher-order critical reflection (e.g. word processors allow us to reflect better while authoring, as the built-in editing and review capability of the system encourages cycles of recursive learning that are difficult to emulate on, say, a manual typewriter).
Oral language media systems	Develops a culture of "utterance" - social discourse qualities (e.g. Internet chat-rooms).

Medium Learning Attributes relative to reflective learning tasks and relative to user's prior learning																		
Instructional media type	Reflective Learning Task	Novelty of media	Recursive	Text-literacy	Text-format	Thinking steps	User control	Verbal skills	Visual-still	Visual-real	Icon-symbols	Content knowledge	Coding knowledge	Spatial	Touch	Taste	Smell
Computer games	Decision-making	✓	✓			✓	✓		✓	✓	✓	✓		✓	✓		
Wordprocessor	Authoring		✓	✓	✓	✓	✓				✓	✓	✓				
Paper and pen	Authoring			✓			✓					✓	✓		✓		
Electronic book	Research	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓				
Paper book	Research		✓	✓	✓		✓		✓			✓	✓				
Internet	Research	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
Video-conferencing	Presentation	✓					✓	✓		✓	✓	✓		✓			
Television	Presentation							✓		✓		✓		✓			
Cdi – interactive	Presentation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			
Whiteboard	Presentation			✓		✓			✓			✓					
OHP	Presentation			✓	✓	✓			✓			✓					
PowerPoint	Presentation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓			
Written letter	Correspondence			✓			✓					✓	✓				
Email	Correspondence		✓	✓		✓	✓				✓	✓	✓				
Virtual Reality	Field trip	✓	✓			✓	✓	✓		✓		✓		✓	✓		
BASIC programming	Code language		✓			✓	✓				✓	✓	✓				
HTML programming	Code language		✓		✓	✓	✓		✓	✓	✓	✓	✓				

Table 2: A profile of the author's medium learning attributes for various instructional media

Table 3: How IT-based reflective tools have supported project work for NIE's PGDE teacher trainees

Instructional Technology Project Task/Activity	*How, where and what reflective tool to use*
Complete the journal as tracking evidence of all your specific project activities over the module's period of continuous assessment. Completion of these journals will be part of the project assessment process.	Use the reflective learning journal template to record all the task activities participated in. Do this as you go along, i.e. in real-time close to finishing each discrete task activity. You can simply open up the template as a word file and enter your reflective self-observations onto the computer as and when necessary.
You will need to report back evidence of completing all the required module readings (i.e. the downloadable texts from the course Website etc).	Once again, record all your reading activities into your reflective learning journal as evidence of participation. As evidence of understanding the issues you've read, you are now asked to complete the downloadable Reading Table, recording your source references and a short abstract feeding back your thoughts, ideas and issues that each reading has impacted upon your view of teaching.
One task will involve each project team to identify a unique area of new technology to investigate. This is to be researched and reported back via a tutorial group presentation.	Use the Spidergram with your project partner to explore and identify a range of new technology themes that you're both interested in. Once you've identified a particular new technology theme (e.g. virtual reality), complete another Spidergram to identify both your common experiences and knowledge of the subject as a basis for further research and investigation. After you've decided on which area to investigate, record this event and all your subsequent activities onto a reflective learning journal template. Complete the downloadable IT Pedagogic Table as evidence of your understanding of the educational issues underpinning your practical IT investigation.

Note: Table 3 is an exhibit taken from the student's IT project brief and is written in the first person.

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