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The Pedagogy of Critical Thinking: Object Design Implications for Improving Students' Thoughtful Engagement Within E-learning Environment*

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In this paper, the author described how a model of teaching critical thinking couples with the development of learning objects may help respond to broader calls for critical thinking both as a central goal in education and as a key aspect in the ecology of 21st century e-learning environment. The model developed by the Canadian Critical Thinking Consortium is organized around a framework of four parts and involves embedding five categories of intellectual tools into the teaching of curriculum content. These tools for thought include addressing the need to focus critical inquiry on relevant background knowledge, using criteria for judgment, explicitly addressing thinking concepts, using specific thinking strategies and supporting the development of certain habits of mind. This model is informing a development project focused on designing objects that the author believes advance opportunities to teach critical thinking and better engage students. The project is a part of on-going efforts to design objects that advance "Type II" and generative characterizations and that better engage students in critical inquiry into content, support active learning, provide an extensive range of acceptable responses, involve creative tasks and require extended periods of time to complete. Although the development project is in-progress and yet to be assessed, the author offered a description of four of the objects while discussing implications of the conceptual model in their design. The author also addressed the need to assess the efficacy of using such objects to support instruction by briefly outlining a companion project where we are developing new measures to evaluate use of these objects.

Keywords: CT (critical thinking), learning object design, engaging learners

Introduction

Advancing CT (critical thinking) abilities is a desired general goal in education and a specific focus for science and other core disciplines. As it is the case for the humanities (Case, 2005), teaching CT is supported by many science institutions, such as the National Academy of Science in the US, the American Society for Engineering Education, the National Science Educators Association, Provincial Ministries of Education in Canada, the Queensland Board of Secondary School Studies in Australia, educators in India and China and many others (Balcaen, 2008). Addressing this goal also attends too much of what are deemed 21st Century Learning Skills by many. Despite of these groups' strong statements of intent, little attention is paid to "how" this might be accomplished. As Case (2005) argued, the rhetoric about teaching critical thoughtfulness greatly

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outstrips practice and as Parker (1991) so aptly put it, “For the most part the teaching of thinking remains more wish than practice”. For example, Hiebert (2003) concluded after reviewing the Canadian National Research Council’s analysis of TIMMS (Trends in International Mathematics and Science Study), that successful teaching of what Balcaen and Scarff (2009) characterized as critically thoughtful science teaching requires the design of environments and teaching pedagogies that effectively promote this goal. From the review of the literature and work with hundreds of practitioners, four reasons seem especially influential in marginalizing CT in both conventional and digital environments (Case, 2005).

The Proliferation of Thinking Skills

There is a plethora of so-called thinking skills. For example, science texts and digital curriculum materials identify many “skills”, such as problem-solving, decision-making, researching, inferring, predicting, reasoning, visualizing, adapting and reflecting as thinking skills. The author posited that as long as CT remains but one category or type among so many forms of thinking skills, despite of being a major goal of education, there will never be adequate time devoted to teaching CT.

The Ranking of Thinking Skills

The proliferation deficit identified above is compounded by the designation of CT as a higher order thinking skill, which, in the typical hierarchical approach, requires mastery of lower order thinking skills before it can be introduced to students. Tall (2004) characterized this outdated view as being “in the grips of behaviorism” and not informed by contemporary voices considering effective teaching, learning and thinking. Not only are there many thinking skills vying for attention, but CT appears to be on the top of the hierarchy placing it “at the end of the list” where it is either not addressed or reserved for only top ranked students.

The Separation of Teaching Thinking From Content

In addition, teaching CT is generally separated from the teaching of subject matter. In many science or engineering classrooms, curriculum content is the priority. Thinking skills are typically addressed after knowledge and concepts which have been taught. Because of the heavy course load and the content focus of high stakes tests, many educators found themselves with little time to involve students in such advanced thinking about concepts.

The Lack of a Coherent Pedagogical Model

Willingham (2007) argued that teaching CT is “hard to do”. A review of approaches to teaching CT by Gibson (2007) and the author’s review of those claiming to teach CT, indicates many ‘“limited” approaches. Gibson reports that most approaches to teaching CT leave it up to educators to translate theory into practice. Ennis (1989) lamented the lack of clarity about what constitutes CT within specific disciplines such as science. Most attempts to teach critically thoughtful science focus on individual or small collections of thinking skills and often neglect such essential areas as the explicit use of criteria to inform judgments, the habits of mind attributed to supporting thinking, the formative and summative assessment of CT and the development of a culture of thoughtfulness within groups. A coherent pedagogical model, such as the one outlined below, allows educators to engage in problematizing content, while attending to the teaching and assessing of critical thoughtfulness. Here, rather than being considered merely as a skill, a person is engaged in thinking critically only if he/she is attempting to assess or judge the merits of possible options in light of relevant factors or criteria.

Next, the author uses the science context to illustrate an approach to teaching CT that addresses these four concerns. The two distinguishing features are a curriculum embedded approach and an emphasis on teaching the intellectual tools required for CT as a type of thought (Willingham, 2007). The conception is deemed "operational" because it identifies intellectual tools that help educators embed CT into their practice. The approach then informs the author's discussion about objects designed to support teaching aspects of CT.

The Conceptual Framework—A Model of Teaching Thoughtfulness

The approach to critically thoughtful teaching offered here is founded on the belief that people are attempting to think critically when they thoughtfully seek to assess what would be sensible or reasonable to believe or do in a given situation. This need to reach reasoned judgments may arise in countless kinds of problematic situations such as the following examples:

(1) Was Napoleon a hero or a rogue?

(2) Are our current models used to predict weather patterns reliable?

(3) Identify the most effective source for electrical energy generation in your region.

These situations require CT because there is a doubt about which is the most appropriate for several plausible responses and because these situations involve criterion thinking (e.g., best method, most effective, powerful argument, etc.). It is important to note that the focus is on the "quality of thinking" and "not" on a requirement that students must arrive at "the correct answer". The power of the model is that it offers four coherent fronts providing a method for encouraging, teaching and assessing the qualities of good thinkers. They are: (1) providing a specific form of challenging questions; (2) teaching the required intellectual tools; (3) assessing the intellectual; and (4) supporting the development of both virtual and face-to-face communities of critical thinkers.

Asking Challenging Questions

The first front is infusing opportunities to think critically by asking the kinds of complex questions identified above—called critical challenges. These question forms, together with teaching tools for thought outlined below, offer a means to take account of Willingham's (2007) observation from cognitive science that teaching thinking is an "insufficiently met goal". The research indicated that some learning objects are helpful in better addressing this problem when compared with conventional teaching. Such challenging questions are the key invitations for students to engage with the curriculum more enthusiastically through critical inquiry. They also provide the opportunity to teach the use of warranted criteria for making judgments and they form the basis for use of the learning objects.

The Tools for Thought

The second and most crucial front is helping students nurture the use of five categories of intellectual tools used by competent thinkers (Case & Daniells, 2008). Much of what makes this approach unique and powerful is the explicit focus on the development of these tools within learning activities and the complimentary assessment process. Next, the author will define each category with reference to the critical challenge: Which method(s) of generating electricity would best meet a community's needs including increased energy demands.

Background knowledge (Balcaen, 2008). The information about a topic requires for thoughtful reflection. Here, students will purposefully learn about various ways of generating electric energy as well as the benefits and limitations of each including environmental, economic and culturally sensitive aspects.

Criteria for judgment. They are the grounds for deciding between viable alternatives. For example, the criteria of "best" meets your community's needs might include being environmentally responsible, taking account of first nations' concerns, taking account of technological innovations and economic implications.

CT vocabulary. These are the range of concepts and distinctions that are helpful when thinking critically. Within the challenge considered here, it might involve understanding the bias, assumptions or inferences associated with various sources informing students' decisions (The author has identified about 20 such concepts).

Thinking strategies. They are the heuristics, organizing devices, models and algorithms useful in making a decision. Students can organize their information as pros and cons associated with different energy sources. This information will then be used to help make a sound judgment based on justifiable criteria (The author has identified 15 such strategies).

Habits of mind. They are the values and attitudes of a careful and conscientious thinker. Students will have to be consciously open-minded as they consider evidence that might oppose their view and fair-minded as they consider these opposing views about the best source. At the same time, making an argument might include being independent-minded as students establish their positions (The author has identified 19 such habits). Together, these five categories provide a comprehensive list of intellectual tools that support the development of sound thinking abilities. While the author has included only a few examples for each category, The British Columbia-based CT Consortium $(TC)^2$ has identified many others. The e-learning projects described following are focused primarily on offering opportunities to use criteria to make warranted judgments and objects based on proven strategies that support thinking.

Assessing for Thinking

The third front is regular assessment of students' competence in using the intellectual tools to think through responses to challenge questions. It requires the careful development and use of appropriate criteria and standards to assess students' demonstrations of the use of background knowledge, criteria for judgment, thinking vocabulary/concepts, thinking strategies and habits of mind. Each challenge includes criteria and standards in rubric form for self-/peer-/educator- assessment of various aspects of the lesson. A fully articulated challenge includes criteria and standards for assessment of the "tools for thought" addressed as outlined in Table 1.

Table 1

Assessing the Tools for Thought: "Determine Best Choice for Generating Electrical Energy in Your Region"

Category of tool	Evidence of CT
Background knowledge	Demonstrated knowledge of the various ways that electricity is generated.
Criteria for judgment	Provided evidence supporting the "economic, environmental, cultural and scientific feasibility" of the options.
CT vocabulary	Showed awareness of the "bias" of those promoting various methods of electrical generation.
Thinking strategies	Identified the pros and cons of each method of electrical generation and uses criteria to justify their argument.
Habits of mind	Exhibited full and fair mindedness in judging each approach to electrical generation.

Building Critically Thoughtful Communities

The fourth and final front is building communities of thinkers where the focus is on developing thoughtful virtual and face-to-face classroom, institutional and broader communities. This involves instructors (Case &

Balcaen, 2008):

(1) Regularly posing questions and designing assignments make concepts and background knowledge problematic;

(2) Creating ongoing opportunities to engage in critical and cooperative dialogue—confer, inquire, debate and critique, that is the key to creating a community of critically thoughtful thinkers;

(3) Employing self- and peer- evaluation as ways of involving students in critical inquiry;

(4) Instructor modeling good CT practices. Together, these four fronts provide a coherent approach to practice supporting both new and experienced educators with a method of modeling and teaching a critical approach to teaching and learning. Implications for e-learning environments, such as discussion forums introduced by Balcaen and Hirtz (2008) are central to the U-shape discussion object described in Figure 1.

Implications for E-learning: Advancing Thinking Through Object Design

In addition to the general critique about approaches to teaching CT in science, proponents of e-learning argue that CT should play a central role in the ecology of 21st century e-learning environment (MacKnight, 2000; Garrison & Anderson, 2003; Drinkwater, Adeline, French, Papamichail, & Richards, 2004). Despite of these and other strong urgings, too little attention has been paid to how this goal might be accomplished (Balcaen, 2008). The literature suggests that rather than improving thoughtfulness, participation in e-learning often leads to confusion and loss of interest unless there are strategies designed to enhance CT opportunities (MacKnight, 2000). Drinkwater et al. (2004) added that one of the challenges for ICT (information and communication technologies) user is to understand how e-learning technologies can “improve thinking”. Finkelstein et al. (2005) concluded that research-based simulations can be “as productive, or more productive, for developing student conceptual understanding as real equipment, reading resources, or chalk-talk lectures” (p. 1). The project addressed here is based on the assumption that well designed LOs (learning objects) based on sound pedagogy will be as productive or more productive than other objects attempting to support teaching CT. The author has a parallel funded development project involving the design of complimentary measures we will use to assess the efficacy of the objects.

Learning Objects

Based on their analysis and 35 years of experience in the area, Maddux and LaMont (2006) cautioned that the pervasive use of what they categorize as Type I (see Table 2) or what some refer to reproductive LO will simply make it more convenient to continue teaching in traditional ways and supporting rote learning over thinking as the goal of education. They proposed greater use of what they characterized as Type II (see Table 2) and that referred to as generative Los, will support the next revolution in post secondary education by advancing teaching and learning. Based on their work in the UK, Cuthell (2006) made a similar claim for the pre-university school system concluding that Type II like LOs may help address the limitations of merely reproductive ones. His work suggests that such objects help provide for a more challenging education where students work on a variety of CT exercises among other things. However, when examining the effectiveness of Type II applications in addressing teaching higher order thinking, Gadanids and Schindler (2006) concluded that while Type II design has some effect, it is the presence of an embedded and effective pedagogical model that provides the predominant outcome with regards to thinking.

Table 2

Characterizing and Comparing Objects

Criteria	Type I (Reproductive)	Type II (Generative)	Type III (CT embedded)
Level of engagement	Passive user involvement	Active intellectual involvement on the part of the user	Active intellectual involvement of the user through inquiry oriented activity
Learners capacity to act	The software developer pre-determines almost everything that happens on the screen	The user, rather than the developer, is in charge of most of what happens	The user, rather than the developer, is in charge of most of what happens, often involves collaboration with others
Nature of input	Limited repertoire of acceptable responses, predetermined by the developer of the software	The repertoire of acceptable user input is extensive	The repertoire of acceptable user input is extensive and generally involves critical reflection on content
Cognitive activity	Usually aimed at the acquisition of facts by rote memory	Usually aimed at accomplishing generative tasks	Usually aimed at doing generative tasks and involves advancing development of the "tools for thought"
Time required	Student involved for a short time	Substantial time is generally necessary for learning and participation	Substantial time is generally necessary for learning and participation—often involves critically thoughtful interaction with others

While understanding the limitations of such an assumption, the author also believed that Type II like LOs informed by a sound pedagogical approach can help meet the important goal of teaching CT while effectively addressing content knowledge. Next, the author will take up the challenge of informing object design by addressing McKnight's (2000) insistence that designers use strategies developed specifically to enhance CT opportunities. The author did this by building from the broadly endorsed $(TC)^2$ pedagogical model described in previous parts and attending to what the literature on Type II like objects suggests provides for more effective learning experiences. Finally, the author discussed how the development team for these two projects adapt Type II design criteria to better support teaching CT and then offer several concluding comments.

Comparing Type I and Type II

The author's comparison of LO types is based on Gadanids and Schindler's (2006) characterization of Type I and II categories. Like Gadanids and Schindler (2006), the author saw the categories as helpful by identifying extremes of a spectrum extending from objects that are primarily about rote learning—sometimes referred to reproductive learning and those that are primarily supporting students to better understand and use content in some thoughtful way; sometimes, referred to generative learning. The author also appreciates their focus on aspects of pedagogy as opposed to comparing and characterizing objects primarily on technical merits. However, as Gadanids and Schindler (2006) pointed out, merely identifying the polar opposites of LO design is also limited because this polarized approach infers an either/or construction rather than recognizing the many possible hybrid LO designs or instructor applications that do not conform to either/or Types I and II characterizations. Indeed, aspects of the Type II like hereafter referred to a Type III objects may involve Type I characteristics at times.

The author used the following five criteria to assess learners' "likely use" of the two types of objects originally described by Maddux, Johnson, and Willis (2001). Their characterization allows one to assess or assess objects based on the intended: (1) level of learner engagement; (2) capacity to act; (3) nature of learner input; (4) level of cognitive activity; and (5) time needed to complete the tasks. Ideal Type I or II LOs may be characterized using these criteria as outlined in Table 2. The author had the Type III category to illustrate his conception of CT embedded design.

Advancing Type II Design by Embedding CT Pedagogy (Type III)

The proposed Type III design addresses the need to embed CT pedagogy as a means of meeting the goal of teaching CT. The author is doing this by adapting the Type II characterizations as Type III objects (see Table 2). The "Tools for Thought Development Projects I & II" involves a group of developers addressing the Type III criteria by designing objects intended for use within distance learning environments or within live K-12 classrooms and lecture hall practice. Below, the author briefly describes four of the 14 objects currently under development as well as provides a link to a pilot video illustrating the sort of CT embedded support material accompanying the use of the objects.

Figure 1. The U-shape discussion.

The U-shape discussion LO. The U-shaped discussion strategy offers an alternative to the traditional two-sided debate where instead of an adversarial format; this strategy encourages students to consider the merits of all sides of an issue, such as weather science and to recast binary options as positions along a continuum. The goal with this object is to encourage students to initially endorse positions provisionally then listen to others' present background knowledge and arguments in an attempt to decide on the most defensible stance along a continuum of possibilities. The goal is "not" about trying to convince others, but merely explaining the reason why the position students are sitting in is the most defensible one for them at the time. The strategy emphasizes that there is no need to reach consensus on the issue, but rather to present and defend a variety of positions. During the U-shape discussion, participants were invited, at several predetermined times, to re-evaluate their positions and justify remaining where they are or explain a move to a new position on the virtual U-shape.

The object currently being piloted, is our first attempt at meeting our goal of "providing strategies for embedding CT pedagogy within a LO". This object was designed for delivery within a learning management system, such as Moodle is based on our consultations with various institutions interested in using the CT objects. The U-shape discussion object is facilitated through a discussion forum and supported by linked activities, an interactive progress chart, as well as self- and peer- assessment materials based on the identified criteria for making an informed judgment.

The object provides for tracking and displaying positions of the group and individuals as well as documenting evidence and arguments made as the discussion proceeds.

Figure 2. Course manager framework for setting up debate within Moodle.

The generic nature of the activity supported by the object allows for its use by students considering problematic issues (challenges) from any discipline, while teaching students several intellectual "tools for thought" required for participation in critical inquiry. These include using warranted criteria to make judgments, identifying and critiquing thinking concepts, such as evidence, bias or inference, using particular thinking strategies, such as a Web of effects or values time lines (both objects under development) and practicing habits of mind, such as open-, fair-, full- or independent- mindedness.

Image challenger. The image challenger object allows for the selection, display and manipulation of images uploaded by an instructor, such as photographs, graphs and electron microscope imagery, and then provides supports for critical inquiry about the selected image or images.

Within the viewer, an image can be considered by selecting one of 13 different CT strategies by using a generator function to provide outlines for instructors or guides for students' inquiry. These include assessing the given explanation, identifying the feature, and interpreting the situation presented by the graphic. The challenger also allows for the generation of graphic organizers where students can record, organize and save information used to take a position in repose to a challenging question. Our pilot video production of the type we are developing to provide strategies and support the challengers may be viewed at the Website http://www.youtube.com/watch?v=lz_Tqu1UUpI.

Other objects under development. Other objects under development include a line of values time where events are placed along a timeline but then ranked with reference to the criteria for judgment being used. This object helps students evaluate the impact of events, studies, emerging ideas or hypothesis in a scale from -3 to +3 as they study the development of such phenomena as a nation state or a theory, such as evolution. Another objects, rating arguments, support students to evaluate the quality of arguments by rating a collection of evidence and then evaluating the strength of various arguments made. Both of these objects are designed for use across the disciplines.

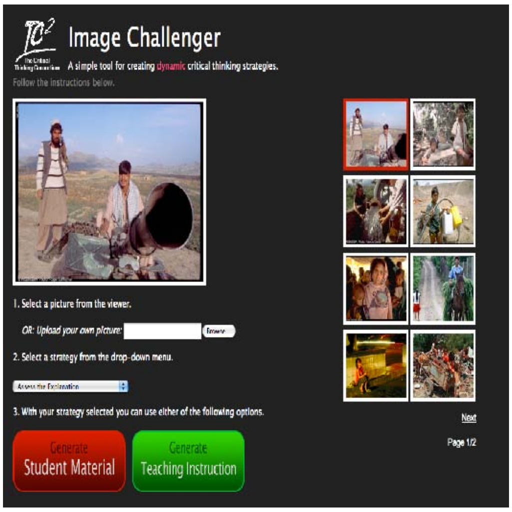

Figure 3. The image challenger.

Concluding Statement and Further Research

In this article, the author addressed two key issues arising from the literature—the "how to" of effectively embedding CT pedagogy in LO design and the "likely characteristics" of such objects. The author first addressed the "how to" by offering the four-front model, developed by the CT consortium, as a means of addressing the four reasons that seem to marginalize teaching CT. The author then posited that designing objects based on the proven $(TC)^2$ strategies, such as the U-shape discussion, offer a specific approach. However, the development team is not naïve about the limitations involved in transferring practices from the conventional face-to-face classroom into e-learning environments.

"The likely characteristics" are extensions of the Type II category originally introduced by Maddux and Lamont (2001). They offer standards as a framework for distinguishing between Type I and II objects that are supported by others, although the labels change at times. The author used these standard organized around four design criteria to guide our attempts to embed CT—resulting in or "working" Type III category (see Table 2), which was designed by borrowing proven strategies from the $(TC)^2$ model and adapting them to support critical inquiry. They did this through exposure to challenge questions, require use of criteria to make judgments, encourage students to learn aspects of the "the tools for thought", including engaging more effectively with content knowledge and involvement in self- and peer- assessment of their thoughtfulness. In addition, the U-shape discussion in particular and our other LOs in general provide opportunities to develop more critically thoughtful communities of inquiry.

This work naturally leads to areas of further inquiry and development. Consequently, we are currently involved in a parallel project focused on developing a series of assessment measures that will help evaluate the efficacy of the Type III LOs. The measures differ from the many existing ones that tend to focus on varying narrow aspects of what constitutes CT making them poor choices for assessing use of the model described above. The more comprehensive measures we are working on are constructed around narratives about complex issues confronting contemporary student experiences, while attending to assessment of the tools for thought. These assessments as well as feedback from the field will be reported in future papers.

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