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Problem-Solving and Web-Based Learning

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Abstract

This article investigates the relationship between Web-based learning and Problem-solving in a web-based course on the fundamentals of Information Technology at a university in Montreal, Canada. We assess for the different learning components of the course, the extent of problem-solving skills acquisition including research, creativity and critical thinking skills. The course entailed two categories of learning, namely resources-based and interactive components. The study aimed at answering the following questions: (1) To what extent is problem-solving skill acquisition explained by the acquisition of the other three skills? (2) To what extent do students understand the definitions of Problem-solving, Research and Creative Idea Generation skills, and Critical Thinking skills? (3) What is the effect of the learning modules in the course on these skills? and, (4) What is the relative contribution of the various learning modules to the acquisition of Problem-Solving, Research, and Creative Idea Generations skills, and Critical Thinking skills?

Keywords: critical thinking skills, information technology, problem-solving, web-based learning

Introduction

Problem-solving, as an outcome or dependent variable, is not to be confused with problem-based learning, which is an input or independent variable. Compared to problem-based learning, the body of knowledge for problem-solving in higher education is significantly less. In Bloom's famous Taxonomy of learning, problem-solving encompasses the three lower levels - analysis, synthesis, evaluation, and in the revised taxonomy - analyzing, evaluating, creating (Anderson & Krathwohl, 2001; Bloom & Krathwohl, 1956). Missing, however, is the requisite need for researching the problem and the potential solutions (Jonassen, 1997; Saade et al., 2012). According to Hennessey, McCormack and Murphy (1993)

and ITS Education Asia (n.d.) problem-solving requires a controlled mixture of analytical and creative thinking.

Problem-solving then, can be viewed as an umbrella term, supported by a tripod of skills encompassing, research, creative idea generation, and critical thinking (Thomas, 2001), but this may not tell the whole story (Figure 1). In this paper, the following definitions are used (Thomas, 2001):

Problem-solving: deriving alternatives and solutions for complex problems/issues with incomplete information, this is built on:

(1) **Research skills**: investigating, finding, and synthesizing information from multiple sources;
(2) **Creative idea generation**: ideas that are novel or unique; and
(3) **Critical thinking**: analysis, inference, reasoning, evaluation, explanation, interpretation**.**

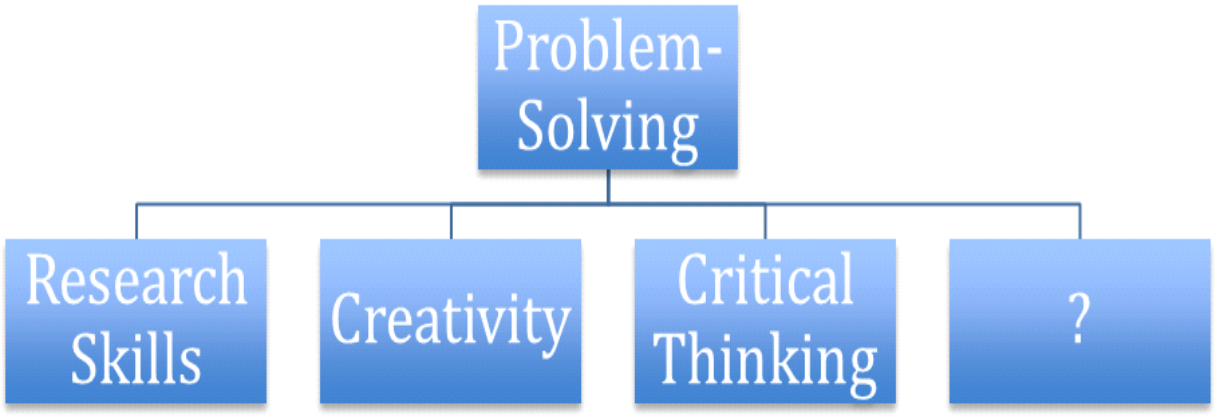

Figure 1. The Problem-Solving Tripod

Considering these definitions and the multi-national context of the university and course student body, a questionnaire was devised and administered to study how these problem-solving skills were perceived in an online information technology course. In specific, students were asked to provide a subjective assessment of the extent to which they felt various activities, resources and technologies supported their acquisition of the above mentioned skills, as defined in an entirely virtual, online course.

This study provides two significant contributions: (1) At a macro level, obtain some understanding of problem-solving, and its relationship to its subcomponents of research, creative idea generation, and critical thinking skills, in the online learning context (higher education), and (2) At a micro level, identify the kinds of resources and activities that foster / require these problem-solving skills. With this knowledge, practitioners (teachers and online courses designers) can design and implement better online (web-based) courses by integrating learning tools to foster the development of problem-solving, and associated research and creative idea generation skills, and critical thinking skills.

Background

According to Beachboard and Aytes (2013, p. 16):

> *Decision-making is directly associated with selecting one course of action among two or more possible alternatives. Decision-making is driven by a desire to solve problems or exploit opportunities. A problem refers to some type of event that requires a response to avoid a negative consequence. Conversely an opportunity is an event or situation where a response is required to make something desirable happen.*

When it comes to scholastic and professional performance, problem-solving is a key skill that individuals need in order to succeed (Johnson et al., 2010; Pedaste, Pentjärv, &Sarapuu, 2003). The Big Six information problem-solving process proposed in Eisenberg and Berkowitz (1988) suggests that problem-solving requires defining the task and identifying the information needed to solve it, determining sources for the information, locating the sources and the information, extracting the information, synthesizing the information, and evaluating the information. It is regarded as one of the most important skills needed to be able to handle the novel, changing requirements of any job function, and in the current information age, how to bring technology to bear on this problem-solving (Hennessy, Mccormick, & Murphy, 1993). As Eisenberg and Johnson (1996, pp.1-2) noted, this means going beyond the **how** of technology use, to the **when** and **why**, what they refer to as **true computer literacy.** That means "knowing the basic operations, terminology, and maintenance of equipment; knowing how to use computer-assisted instructional programs and other specialized, task-specific applications; having a knowledge of the impact of technology on careers, society, and culture; knowing computer programming". The acquisition, understanding, and use of knowledge require various learning strategies, meta-cognitive skills and the desire to use them. In order to learn in the academic environment, as well as to perform well later in the workplace, students need the skills to acquire, absorb, and transfer knowledge efficiently and effectively (Eisenberg & Berkowitz, 1988). This implies being able to apply problem-solving skills, and associated research and creative idea generation skills, and critical thinking skills, to situations as they arise.

There is a scant body of research work on problem-solving in virtual learning environments, as opposed to problem-based learning for which there is more research. While performance as an outcome variable can be found in studies, it is usually a measure of scores on exams or assignments, rather than specifically a measure of problem-solving, let alone of the associated research and creative idea generation skills. In contrast, the literature on critical thinking skills is extensive (Saadé, Morin, & Thomas, 2012), but not in association with the other skills identified here.

Methodology

Davis (1989) has shown that system use is tied to user's perceptions, while Keengwe (2007) and Koohang and Durante (2003) found that a relationship exists between students' personal computer proficiency and students' perceptions of the effect of computer technology to improve their learning. Song, et al. (2004) focused on students' perceptions as a way to improve online or distance learning. Perceptions are, therefore, important considerations when integrating technology into learning, especially virtual learning. Building on prior research conducted by the authors, the survey used in this study measures the subjective evaluation of the students' use and/or development of problem-solving skills, research skills and creative idea generation skills, as well as critical thinking skills, while interacting with the course resources, activities and technologies (Morin, Thomas, & Saadé, 2012; Thomas & Morin 2010).

The Course

The course used in this study is "Fundamental of Information Technology and Business Productivity" and is offered by the business school. This course is offered to all students entering the business school and do not meet information technology admission requirements. At the same time, many students from other faculties take this course as an elective. Approximately, 50% of the students who take the course are outside of the business school. The course is completely online and virtual with no face to face contact with the teaching assistant or the professor. There are however weekly office hours held by the teaching assistant where only few students take advantage. Approximately 2700 students enroll in this course every year.

From an instructional design perspective, the course includes practice quizzes, readings, proctored exams, video and audio, business problem solving cases, Excel and Access simulations and assignments. In essence the course entails many activities that require students to not only learn the content but also establish interconnections between them to specific context.

The purpose of this research was to investigate what observations could be made about students' acquisition of an important aspect of higher-order learning, namely problem-solving, with supporting research, critical thinking and creative idea generation skills. In such a course, students are required to demonstrate acquisition of lower level skills, such as remembering concepts as well as keystrokes in software, and additionally, how to solve problems with the software being learnt. Learning in the course is supported by various activities and resources, as well as by technology. The activities are assignments, an Excel project, an Access project, and quizzes, in addition to an educational information system for enhanced learning (EISEL). The resources are the textbook, the online book chapters, the overall online system and the material on the web.

The Survey

A survey methodology was used for data collection. At the end of the semester, students were asked to respond to the survey as candidly as possible. The survey used in this study is based on an instrument developed by the second author (Thomas, 2001). Students were instructed that there were no right or wrong answers and that the interest was primarily in their beliefs and perceptions about the course components and their experiences with the different tools for learning. The survey was divided into three major parts. The first part contained demographic questions, such as gender, age, level of computer experience and mother tongue. The second part was about the students' level of understanding of definitions and the third part was about perceptions. For each of the four skills, namely Problem-solving, Research, Creativity and Critical Thinking, students were asked to identify at what level each of the class activity and resources contributed to the development of these skills.

Discussion and Analysis of Results

Demographics and Definition Understanding

There were a total of 985 students enrolled in the course and 490 of them completed the survey online for a response rate of 51.2%. Of those who completed the survey, 44% were female students. Most respondents (73.3%) were in the 20-23 age group, 17.4% in the 24-30 age group and 4% and 5.3% were in the below 20 and above 30 categories, respectively. The average age is 22.7 years, while the median is 22. Figure 2 shows the distribution of the scores representing students' understanding of the definition of the four skills used in the survey. A score of 0 indicates: 'Not at all' and a score of 10 indicates 'Perfect understanding'. The definitions are, as previously stated:

- **Problem-solving:** deriving alternatives and solutions for complex problems/issues with incomplete information
- **Research:** investigating, finding, and synthesizing information from multiple sources
- **Creativity:** ideas that are novel or unique
- **Critical Thinking:** analysis, inference, reasoning, evaluation, explanation, interpretation

The frequency distributions illustrated in Figure 2 using a parallel bar-chart, can be categorized into three groups: 'perfect understanding' (score = 10), 'average understanding' (score from 7 to 9) and 'limited understanding' (score of 6 or below).

From Figure 2 and Table 1, it can be observed that 77.5%, 72.08% and 77.50% of students have at least a moderate or better understanding of the definition of Problem-solving, Creativity and

Critical Thinking skills, respectively. The definition of Research skills is the least understood by students with 31.67% having limited understanding, which could be due to the fact that this is a group of mainly first year undergraduate students. Nonetheless, 68.3% had moderate or better understanding of the definition.

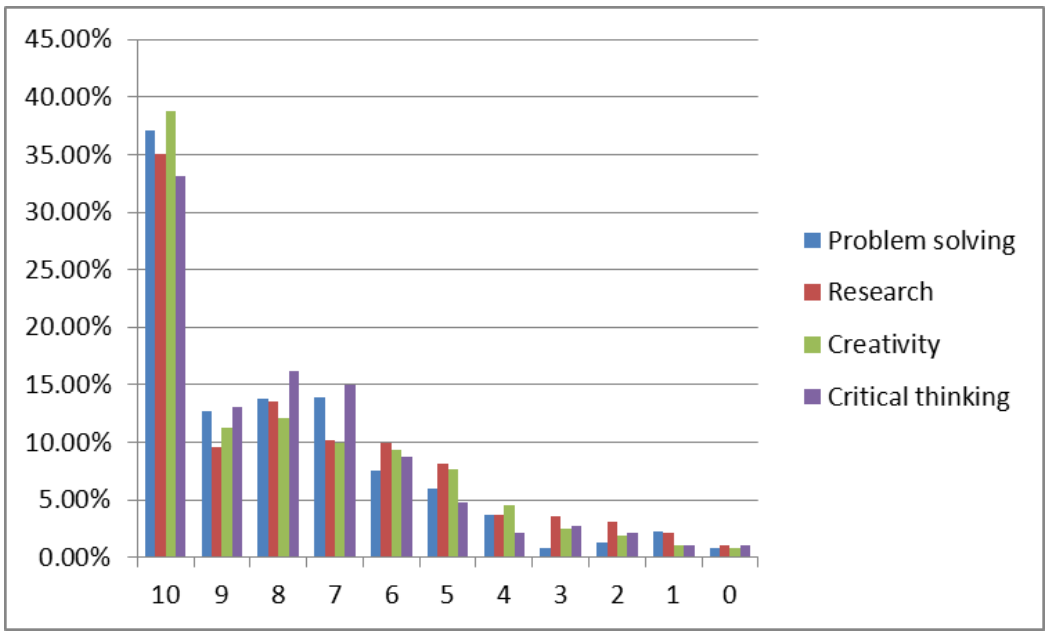

Figure 2. Understanding the Definitions from 0 to 10

Table 1. Distribution of the Scores of Understanding the Definition					
		Problem-solving	**Research**	**Creativity**	**Critical Thinking**
Perfect	10	37.08%	35.00%	38.75%	33.13%
Moderate	7 to 9	40.42%	33.33%	33.33%	44.38%
Limited	0 to 6	22.50%	31.67%	27.92%	22.50%
Average score		7.90	7.51	7.80	7.83

Contribution of Activities and Resources

Students were asked to assess how different activities and resources in the course have assisted them in the development of their Problem-solving skills, Research skills, Creativity and Critical Thinking skills, using the following classification: 'A lot' (3), 'Moderate' (2) and 'Not at all' (1). In tabulating the results, this coding was used and the averages of ranking of students are shown in Table 2.

These means provide a measure of the perceived relative influence of course elements (activities/resources) on the development of skills. The table also presents the Positive impact of each activities / resources defined as the total proportion of answers in the categories 'Moderate' and 'A lot'. The last column gives the average perceived contribution of each activity and resource to the combined set of skills: Research, Creativity and Critical thinking as well as the average positive impact. It is observed that the results in this last column are never as high as those of the Problem-solving skills column which is an indication that although they explain a good portion of Problem-solving skills acquisition, the entire story is not told.

Table 2. Students' Perceived Contribution of Activities and Resources to the Components of Problem-Solving (PS)

	N	Problem-solving (PS)	Research (R)	Creativity (C)	Critical Thinking (CT)	Aggregate contribution (R,C,CT)
		Mean + impact %	Mean + impact %	Mean + impact %	Mean + impact %	Average + impact%
Activities						
Assignments	484	2.37 91.7%	2.24 85.0%	2.11 78.8%	2.20 84.3%	2.18 82.7%
Excel project	487	2.37 90.1%	2.23 83.4%	2.17 81.1%	2.21 82.2%	2.20 82.2%
Access project	483	2.31 87.4%	2.18 79.7%	2.14 77.1%	2.18 81.4%	2.17 79.4%
Quiz	487	2.16 83.5%	2.11 79.5%	1.81 59.5%	2.18 80.7%	2.03 73.2%
EISEL	487	2.19 84.7%	2.07 75.1%	1.76 57.4%	2.13 79.4%	1.99 70.6%
Resources						
Textbook	365	2.05 78.4%	1.95 77.0%	1.88 65.7%	1.95 73.4%	1.93 72.0%
Online book chapters	488	2.00 75.0%	1.95 74.5%	1.83 66.1%	1.90 71.9%	1.89 70.8%
Overall online system	484	2.15 87.7%	2.10 82.9%	1.94 70.2%	2.07 78.7%	2.04 77.3%
Material on the Web	489	2.12 81.8%	2.16 82.7%	1.99 72.9%	2.10 81.4%	2.05 79.0%

Approximately 75%, (365/490 - those who answered the questions about the textbook divided the total sample size) of the students bought the physical textbook and, from the results in Table 2, about 78.4% of them considered that it had a positive impact on the acquisition of Problem-solving skills. Similarly, the perceived contribution of the Online book chapters to Problem-solving was positive, though lower at 75%. Moreover, it seems that students felt that most activities contributed more to skills improvement than did resources. In terms of the strongest positive impact, Assignments, Excel project and Access project generally are perceived as having contributed the most to skills development. On the other hand, and not surprisingly, the Quiz, the Textbook, the Online book chapters, and EISEL, were perceived to contribute the least to the development of creativity skills.

Perceptions and Understanding of the Definitions of Components of Problem-Solving

In order to assess whether students' understanding of the definitions is correlated to the perception of the contribution of the activities and resources to the skills development, a correlation analysis is presented in Table 3.

Table 3 shows that most correlations are not significantly different from 0 at the 5% level, except in the cases of problem-solving and creativity. The perceived contributions of the Assignments and Access project to problem-solving seem to increase with the understanding of the definition. The fact that students' perceptions increased with understanding of the constructs, suggests that students don't always know what they are learning, and that, when they do, they appreciate it more. Understanding and learning begets more understanding and learning.

Table 3. Correlations Between Understanding of Skills Definition and Perception of Contribution of Activities/ Resources to that Skill				
	Understanding of definitions of skills			
	Problem-solving	Research	Creativity	Critical Thinking
Activities				
Assignments	0.135*	0.074	-0.037	0.020
Excel project	0.075	0.036	0.005	0.053
Access project	0.094*	0.080	-0.031	0.058
Quiz	0.047	0.050	-0.090*	0.042
EISEL	-0.012	0.003	-0.107*	0.034
Resources				
Textbook	-0.048	0.028	-0.077	-0.088
Online Book Chapters	0.015	0.287	-0.076	0.010
Overall Online System	0.060	0.053	-0.025	0.046
Web Material	0.009	0.090	-0.026	-0.023
* Correlation significantly different from 0 at 5% level				

On the other hand, the perceived contributions of the quizzes and of EISEL to creativity seem to decrease with the understanding of the definition of creativity. As students' understanding of the definition of Creativity increases, their perceptions of the contribution of Quizzes and EISEL decreases. This makes sense since Quizzes, an activity, and EISEL, a resource, are practice tools and not primarily tools for developing Creativity.

Relationship of Research, Creativity and Critical Thinking to Problem-Solving

In this research, it was hypothesized that the Problem-solving skill is partially explained by three other skills, namely Research, Creativity and Critical Thinking. This is supported by Table 4 where multiple regressions show that the variation in the perceived contribution to Problem-solving skills is explained by the regression on the three other perceived contributions.

It can be observed that all multiple regressions are highly significant with p-value of 0.000, which means that perceived contributions of activities and resources to Problem-solving skills are explained by their contribution to Research, Creativity and Critical Thinking. Therefore, Problem-solving stands on three legs: Research, Creativity and Critical Thinking, as had been hypothesized, however, the coefficients of determination indicate that they do not tell the entire story; other factors are also at play and need further research.

Focusing in on the impact of the activities and resources on problem-solving, it is noted that 55.76% of the variation in the perceived contribution of the Excel project to Problem-solving skills is explained by the contribution of the Excel project to Research, Creativity and Critical Thinking, where Research is the most significant predictor. Similarly 54.2% of the variation in the perceived contribution of the ACCESS project to Problem-solving skills is explained by the contribution of the three skills and Critical Thinking and Research are the most equally important predictors. This could be explained by the fact that Access needs deeper understanding of the tools to be utilized. It is likely that critical thinking will be used more in ACCESS than in Excel, because of the nature of those programs. The perceived contributions to Problem-solving skills of the other activities: Assignments and Quiz are also partially explained (40.48% and 50.47%, respectively) by their perceived contributions to the three skills, where Research and Critical thinking are, respectively, the most significant predictors.

Table 4. Perceived Contribution of Research, Creativity and Critical Thinking as Predictors of Perceived Contribution to Problem-Solving Skill for each Activity and Resource				
	Coefficient of Determination	Significance	N	Most significant predictor
Activities				
Assignments	40.48%	0.000	469	Research
Excel case (project)	55.76%	0.000	474	Research
ACCESS case (project)	54.20%	0.000	468	Critical Thinking/ Research
QUIZ	50.47%	0.000	472	Critical thinking
EISEL	44.36%	0.000	470	Critical thinking
Resources				
Textbook	43.34%	0.000	353	Creativity
Online Book Chapters	43.24%	0.000	473	Research
Overall Online System	54.57%	0.000	468	Creativity
Web Material	63.67%	0.000	477	Research

As for the resources in the course, Table 4 indicates that the perceived contribution of the Web material to Problem-solving is explained more (63.67%) by its perceived contributions to the other three skills than by the perceived contribution of any other resources (43.34%, 43.24% 54.57% and 44.36%) and even activities. The most significant predictor is Research, which could be explained by the fact that students have to search the course content and distinguish between important and less important elements of the course. Similar results are found for the Online book chapters but to a lesser extent, with a coefficient of determination of 43.24%. For the Textbook and the Overall online system, Creativity is the most significant predictor, while for EISEL, Critical thinking is most significant.

Conclusions

The regression analyses supported the hypothesis that research, creative idea generation and critical thinking are strong supporting legs of problem-solving, but did not tell the full story. Other factors are involved and need further investigation and elaboration.

Level of understanding varies across the skills and in general among students but about three-quarters of students had at least a moderate understanding. As the understanding of the definition of Problem-solving increases, the perceived contribution to this skill, of the Assignment and Access project also increase. On the other hand, as the definition of Creativity increases, the perceived contribution to the Quiz and EISEL decreases.

Students clearly had an average to better than average understanding of the definitions given of the constructs, as well as perceived contribution of the activities and resources of the course to their development. Certain activities and resources were perceived to contribute more than others, which were the Assignments and the Excel and Access projects. The Quiz, the Textbook, the Online book chapters, and EISEL, were perceived to contribute the least to the development of creativity skills. It also seems from the regression analysis that the perceived contribution of the Activities to problem-solving skills is largely explained by research and critical thinking skills, while for Resources it is research and creativity.

These results have implications for the design of web-based delivery of learning content. Understanding those aspects of a course that can contribute to developing problem-solving skills, and the other supporting skills, research, creativity and critical thinking, can assist in this process and

needs further study. The authors are not aware of other studies which have looked at these elements in quite the way presented in this study and the results found suggest the need for further study and elaboration of these ideas. Possible expansions of this study include looking at the effect of team-building skills on the elements of problem solution, which is the topic of a subsequent paper, as well as expanding the types and number of questions used in the survey.

In a recent study (Chia-Wen & Yi-Chum, 2013) where a review of research in problem-based learning in online education environment was performed, the authors report on the number of publications per target student groups. What is interesting is that over the 8 year period, 63 articles were published, giving an average of 8 articles per year. If only higher education students are considered, the number of publications falls by around 25%. Needless to say, research in online education and problem-based learning is scarce, even more so if one considers problem-solving skills acquisition in particular. Conducting a small research on Google Scholar on higher order thinking and eLearning resulted in less than 10 articles over the past 5 years.

It is clear that the study of various higher order thinking skills in eLearning environments (online education) is scarce and therefore any insights that can be used to further the understanding via comparative synthesis are rare and therefore making the task the more difficult. However, in a study performed by Fox & Mackeogh (2003) on eLearning's ability to promote higher-order learning via different pedagogical methods, it was suggested that given the appropriate pedagogical design, students can develop effective ways of engaging with the online course activities showing evidence of engaging in higher-order learning. This is in-line with the present study findings and supports the results that pedagogically sound online activities can engage students in higher order learning.

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Biographies

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Dr. Raafat George Saadé has been teaching in the Business faculty at Concordia University since 1998. He obtained his Ph.D. in 1995 (Concordia University) after which he received the Canadian National Research Council postdoctoral scholarship, which he completed at McGill University in Montreal. Dr. Saadé has published in journals such as Information & Management, Decisions Sciences, and Expert Systems with Applications. His research interests include information-systems-driven organizational change, supply chain of digital information products and change management.