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Deep Learning and Virtual Environment

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***Abstract*—**While computers are known to facilitate lower levels of learning, such as rote memorization of facts, measurable through electronically administered and graded multiple-choice questions, yes/no, and true/false answers, the imparting and measurement of higher-level cognitive skills is more vexing. These require more open-ended delivery and answers, and may be more problematic in an entirely virtual environment, notwithstanding the advances in technologies such as wikis, blogs, discussion boards, etc. As with the integration of all technology, merit is based more on the instructional design of the course than on the technology employed in, and of, itself. With this in mind, this study examined the perceptions of online students in an introductory Computer Information Systems course regarding the fostering of various higher-order thinking and team-building skills as a result of the activities, resources and technologies (ART) used in the course.

***Keywords*—**Critical thinking, deep learning, distance learning, e-learning, online learning, virtual environments.

I. Introduction

THE requirements have changed! "Employers want new personnel to have interpersonal skills and to be able to think. They should have the ability to troubleshoot on an assembly line or other task before having to report to a supervisor." [1]. The need to prepare new students to meet the new requirements of the workplace, means that supervisors and professors have to educate students to improve their analytical skills and instructors will have to develop new ways of enhancing the critical learning process of their courses [2]. Students too consistently consider critical thinking as an important and challenging objective they work hard to master [3]. These skills allow them to plan and conduct research, manage projects, and solve problems. Improving student's thinking skills will give them a better sense of solving problems they face in future situations, moreover, it will liberate their minds and give them the opportunity to think "Outside of the box". Moving students from being passive learners who focus on regular standard tests to students who start using higher-order thinking skills in all aspects of their lives is a big challenge for educators [4].

This higher-order thinking or deep learning can be defined as, "the intention to extract meaning produces active learning processes that involve relating ideas and looking for patterns and principles on the one hand (a holist strategy - [5], [6]), and using evidence and examining the logic of the argument on the other (serialist). The approach also involves monitoring the development of one's own understanding" [7]. [8, p.2]. Reference [9], in addition to analysis, evaluation, inference, and interpretation, which are in conformity with those advocated in [10], added dispositions, metacognitive/ self-regulation, and presenting arguments. These definitions, along with those advocated by [11] in [12], with those of [13] - [15], led to the definition used here, and adopted in other research, which considered deep learning to include higher-order thinking skills such as: critical thinking, problem-solving, research, and creative idea generation, and team-building skills, such as: communication skills, work coordination, and team cooperation. [16]. These are the skills that students are expected to acquire through their tenure in university, and ultimately to take with them into their careers and which [17] identified as extremely pertinent for the information systems (IS) professional.

In a continually changing world, and with the availability of information on the Internet, teaching strategies to develop deep thinking need to be updated continuously to be able to meet the needs of students and educational institutions [18]. How best to do that is still an open question. Online courses make a unique demand on students and instructors. The research literature on learning investigating these issues has spanned the gamut from courses delivered in a traditional classroom setting, using traditional delivery methods versus courses delivered with some technology integration, usually in the form of PowerPoint presentations within the classroom and, in some cases, Internet access, to courses at the far end of the spectrum taught via distance education technologies, or in specialized computer labs known as smart e-classrooms ([19]-[26]).

In a survey that aimed to measure the importance of online learning for the students, the majority of the students believed that the learning process can be highly affected by the Internet and online learning. They noted the role of the Internet in improving academic performance, enhancing research skills and critical thinking, encouraging independent or collaborative learning, and improving teaching methods [27]. In a study comparing traditional computer lab, smart e-classroom, mixed traditional lab plus e-classroom, and online course settings, [28], [29], found that those in the electronic classroom setting perceived significantly less support from online resources for various higher-order learning skills than did those in other sections, while those in all sections perceived strong and equal support from the offline resources. Distance students perceived less support for these skills from the text and material in Blackboard than the onsite students. A brief survey of research into the factors influencing online effectiveness

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indicates that the bulk of research either finds no difference from traditional delivery, or a mixed bag [30], [31]. Fewer studies support the notion of online instruction outstripping traditional methods of instruction. As society gravitates more and more to mobile technology, instruction is likewise adapting to this mode of delivery. Research continues to be needed to understand how to use these media to effectively enhance learning.

II. The Study

A. The Course

The study presented here involved four hundred and ninety (490) students from Concordia University, John Molson School of Business, enrolled in an introductory undergraduate course, "Fundamentals of Information Technology and Business Productivity". Most students are asked to take this computer and information literacy course as part of the Bachelor's program.

This online course uses a web-based *learning management system (WBLMS)* that includes both learning elements and learning processes [32]. The WBLMS includes tools that fall under three categories: (1) *learning, (2) assessment and (3) support. (1) Learning tools* include a set of learning objects (with measurable learning outcomes), such as an educational information system for enhanced learning (EISEL). *(2) Assessment* in the WBLMS includes tools for *formative assessment, summative assessment, and self-assessment. (3) Support* to students is done through an innovative centralized question center with private and public zones that may also be configured to operate in synchronous and asynchronous modes.

B. Methodology and Definitions

All Students were asked to identify the extent to which they felt various activities, resources and technologies, (fondly referred to as the ART of Instruction and Learning, [16], were perceived to support their acquisition of various higher-order thinking and team-building skills, in an entirely virtual, online course. Prior research has indicated that these do have an impact on students' perceptions of their acquisition of these skills ([28], [29], [33]- [35]). This was then corroborated with their performance scores on assignments designed to elicit these skills.

Students were asked to indicate the level of support perceived for these skills from the various activities and resources of the course either, providing no support, moderate support, or a lot of support. Also, in addition to students' perceptions of their acquisition of these various thinking- and team-building skills, this study was also interested in how these perceptions might be moderated by other factors, such as demographics, age, gender, computer experience, GPA, etc.

The following definitions were used:

TABLE I
Definitions

Higher-Order Thinking Skills	*Definitions*
Critical Thinking	analysis, inference, reasoning, evaluation, explanation, interpretation
Problem Solving	deriving alternatives and solutions for complex problems/ issues with incomplete information
Research	investigating, finding, and synthesizing information from multiple sources
Creative Idea Generation	Ideas that are novel or unique
Team-Building Skills	*Definitions*
Communication	conveying ideas effectively, both orally and written
Work Coordination	bringing together work from multiple sources and team members
Team Cooperation	interpersonal skills, resolution of differences

III. Results

Looking at Tables II to V, below, there can be no doubt that the majority of students perceived strong support for the acquisition of both the thinking skills and the team-building skills, with the exception of team cooperation under the team-building skills in Tables IV and V.

The Activities of the course – Assignments, Excel mini-case, Access mini-case project, and Quiz were all seen as contributing positively (Moderate support + A lot of support) to the thinking skills ranging from 77.1 to 91.7% of students. (see Table II, below). Only 8.3 to 22.9% perceived no support by the Activities. The outlier was the perceived support for Creative Idea Generation from the Quiz where close to 60% perceived support and 40%, no support. As can be observed in Table III, the same is true of the Resources of the course – Textbook, Online book chapters, Overall online system, Material on the Web, EISEL, wherein 65-87% perceived support for the learning skills, while 15-34% did not. Again the outlier was the support perceived for Creative Idea Generation, this time by EISEL, wherein 57% perceived positive support and about 43% none.

Not quite as markedly, but sufficiently significant, was the perceived support of team-building skills from the Activities of the course. (see Tables IV and V, below). Communication Skills and Work Coordination were deemed to be positively supported by 61-79% of students, and not at all by 21-39% of students. The Resources of the course likewise were perceived to contribute to these skills positively by from 52-77% of students, the exception being the Online book chapters that was perceived by only 38% as contributing to Work Coordination. Team Cooperation, not surprisingly, did not fare as well, being equally split between those perceiving support and those perceiving none.

TABLE II
STUDENT PERCEPTION DISTRIBUTIONS
% SUPPORT FOR HIGH-ORDER THINKING SKILLS FROM ACTIVITIES

Activities	N	Mean	S.D.	Not at all[1] (%)	Moderate[2] (%)	A lot[3] (%)	Positive Impact %
Critical Thinking Skills							
Assignments	483	2.20	0.69	15.7	48.0	36.3	84.3
Excel mini case	488	2.21	0.72	17.8	43.5	38.7	82.2
Access mini case (project)	483	2.18	0.70	18.6	45.1	36.3	81.4
Quiz	488	2.18	0.73	19.3	43.6	37.1	80.7
Problem Solving Skills:							
Assignments	484	2.37	0.63	8.3	46.3	45.4	91.7
Excel mini case	487	2.37	0.66	9.9	43.1	47.0	90.1
Access mini case (project)	483	2.31	0.69	12.6	43.3	44.1	87.4
Quiz	487	2.16	0.68	16.4	51.3	32.2	83.5
Research Skills:							
Assignments	484	2.24	0.70	15.1	45.5	39.5	85.0
Excel mini case	488	2.23	0.72	16.6	43.4	40.0	83.4
Access mini case (project)	484	2.18	0.74	20.2	41.9	37.8	79.7
Quiz	487	2.11	0.71	20.5	48.3	31.2	79.5
Creative Idea Generation:							
Assignments	480	2.11	0.72	21.2	46.5	32.3	78.8
Excel mini case	488	2.17	0.72	18.9	45.2	35.9	81.1
Access mini case (project)	485	2.14	0.76	22.9	40.0	37.1	77.1
Quiz	487	1.81	0.76	40.5	38.4	21.1	59.5

The superscripts correspond to the weight of the answers, where 1 is for not at all, 2 for moderate and 3 for a lot

We can also note that Textbook was perceived to contribute the most to Problem Solving and the least to Team Cooperation. Assignments were perceived as the activity contributing most to Communication Skills, to Problem Solving, and Research Skills. Assignments and Excel mini-cases were perceived by students as contributing most to Work Coordination. Excel mini-cases were perceived as contributing most to Creative Idea Generation, Critical Thinking, and Problem Solving.

TABLE III
STUDENT PERCEPTION DISTRIBUTIONS
% SUPPORT FOR HIGH-ORDER THINKING SKILLS FROM RESOURCES

Resources	N	Mean	S.D.	Not at all[1] (%)	Moderate[2] (%)	A lot[3] (%)	Positive Impact %
Critical Thinking Skills							
Textbook	361	1.95	0.69	26.6	52.1	21.3	73.4
Online book chapters	485	1.90	0.67	28.0	54.0	17.9	71.9
Overall online system	485	2.07	0.70	21.2	50.9	27.8	78.7
Material on the Web	489	2.10	0.68	18.6	52.6	28.8	81.4
EISEL	486	2.13	0.72	20.6	46.3	33.1	79.4
Problem Solving Skills:							
Textbook	365	2.05	0.69	21.6	52.1	26.3	78.4
Online book chapters	488	2.00	0.71	25.0	49.6	25.4	75.0
Overall online system	484	2.15	.066	15.3	54.3	30.4	87.7
Material on the Web	489	2.12	0.68	18.2	51.9	29.9	81.8
EISEL	487	2.19	0.72	18.3	44.1	37.6	84.7
Research Skills:							
Textbook	370	1.95	0.64	23.0	58.6	18.4	77.0
Online book chapters	486	1.95	0.68	25.5	53.9	20.6	74.5
Overall online system	484	2.10	0.66	17.1	55.4	27.5	82.9
Material on the Web	490	2.16	0.70	17.3	49.0	33.7	82.7
EISEL	487	2.07	0.75	24.8	43.1	32.0	75.1
Creative Idea Generation:							
Textbook	364	1.88	0.74	34.3	43.7	22.0	65.7
Online book chapters	486	1.83	0.70	34.0	48.8	17.3	66.1
Overall online system	483	1.94	0.73	29.8	46.2	24.0	70.2
Material on the Web	488	1.99	0.73	27.0	46.7	26.2	72.9
EISEL	484	1.76	0.75	42.6	38.4	19.0	57.4

The superscripts correspond to the weight of the answers, where 1 is for not at all, 2 for moderate and 3 for a lot

TABLE IV
STUDENT PERCEPTION DISTRIBUTIONS
% SUPPORT FOR TEAM-BUILDING SKILLS FROM ACTIVITIES

Activities	N	Mean	S.D.	Not at all[1] (%)	Moderate[2] (%)	A lot[3] (%)	Positive Impact %
Communication Skills							
Assignments	483	1.89	0.75	33.7	43.5	22.8	66.3
Excel mini case	486	1.87	0.76	35.8	41.2	23.0	64.2
Access mini case (project)	484	1.86	0.78	38.4	37.4	24.2	61.6
Quiz	488	1.73	0.75	45.3	36.3	18.4	54.7
Work Coordination							
Assignments	482	2.14	0.73	20.5	44.8	34.6	79.4
Excel mini case	489	2.14	0.76	22.5	40.9	36.6	77.5
Access mini case (project)	484	2.07	0.77	26.4	39.9	33.7	73.6
Quiz	487	1.95	0.77	32.2	40.5	27.3	67.8
Team Cooperation							
Assignments	481	1.64	0.72	50.5	35.1	14.4	49.5
Excel mini case	487	1.66	0.77	52.5	29.8	18.0	47.8
Access mini case (project)	485	1.62	0.74	53.8	30.5	15.7	46.2
Quiz	486	1.60	0.73	54.7	30.7	14.6	45.3

The superscripts correspond to the weight of the answers, where 1 is for not at all, 2 for moderate and 3 for a lot

TABLE V
STUDENT PERCEPTION DISTRIBUTIONS
% SUPPORT FOR TEAM-BUILDING SKILLS FROM RESOURCES

Resources	N	Mean	S.D.	Not at all[1] (%)	Moderate[2] (%)	A lot[3] (%)	Positive Impact %
Communication Skills							
Textbook	366	1.71	0.71	43.7	41.5	14.8	56.3
Online book chapters	485	1.68	0.70	45.4	41.2	13.4	54.6
Overall online system	484	1.80	0.72	37.6	44.8	17.6	62.4
Material on the Web	486	1.80	0.74	38.9	42.0	19.1	60.1
EISEL	486	1.71	0.76	47.5	34.2	18.3	52.5
Work Coordination							
Textbook	364	1.91	0.74	31.9	45.1	23.0	68.1
Online book chapters	482	1.93	0.75	31.3	44.0	24.7	38.7
Overall online system	485	2.06	0.71	22.1	49.9	28.0	77.9
Material on the Web	487	1.99	0.74	27.9	44.8	27.3	72.1
EISEL	485	2.02	0.80	30.7	36.9	32.4	69.3
Team Cooperation							
Textbook	362	1.60	0.71	52.8	34.0	13.2	48.2
Online book chapters	485	1.58	0.70	54.0	33.6	12.4	46.0
Overall online system	483	1.64	0.71	50.1	36.2	13.7	49.9
Material on the Web	485	1.67	0.72	48.2	36.9	14.8	51.7
EISEL	483	1.58	0.73	55.7	30.2	14.1	44.3

The superscripts correspond to the weight of the answers, where 1 is for not at all, 2 for moderate and 3 for a lot

As can be seen from the analysis of the above tables, activities and resources are perceived to contribute differently to each skill. An Analysis of variance was performed for each high order thinking and team building skill and we obtained highly significant differences between the contributions of activities and resources except for Team Cooperation where the result indicates a lack of significance.

Table VI below, identifies to what skill, each activity seems to contribute the most by assigning 'X'. As we can see, students consider that all the activities except the Quiz and all the resources except Material on the Web contribute to the development of Problem Solving skills.

TABLE VI
STUDENT PERCEPTION OF MAXIMUM CONTRIBUTION TO HIGH-ORDER AND TEAM-BUILDING SKILLS

	High-order thinking				**Team-building**		
	CT	PS	R	CIG	C	WC	TC
Activities							
Assignments		X	S		S	S	
Excel mini case	S	XS				S	
Access mini case (project)		XS		S			
Quiz	X						
Resources							
Textbook		X					
Online book chapters		X					
Overall online system		X					
Material on the Web			X				S
EISEL		X					

*where X identifies where the activity has contributed the most and S identifies which activity or resource has contributed the most to a specific skill.
CT:Critical Thinking, PS Problem Solving, R: Research, CIG: Creative Idea Generation, C: Communication, WC: Work Cooperation, TC: Team Cooperation.

Similarly, when considering each skill, an 'S' identifies which activity or resource contributes the most to its enhancement. We see that Critical Thinking skills are perceived to be developed the most with the Excel mini-case, while Problem Solving is developed the most by the Excel and Access mini-cases. Research, Communication and Work Cooperation are most enhanced by the Assignments. Creative Idea Generation is most developed by the Access Mini-case project.

IV. DISCUSSION

Evidently, even in an entirely online course, most students perceive that the activities and resources of the course can assist in their development of important thinking and team building skills. There were nonetheless some surprising findings. Half of the students perceived support for team cooperation even though there was no teamwork prescribed in the course. It is curious that any support was perceived at all, and that by half of the students. This seems to point to the fact that some students are finding opportunities on their own, outside of the online class, to work together, evidently on their assignments and the Excel mini-cases. Interestingly, this did not seem to happen with the Access mini-case project. Secondly, Assignments were perceived as contributing most to Communication Skills, again a curiosity, given that it is an online course without any specific attempt to develop this skill. Again, this might be an indication that students seek opportunities to interact with fellow students and the professor to solve the assignment problems, thereby forcing communication beyond the mandate of the course. Thirdly, as was to be expected, the Excel mini-cases were viewed as contributing most to the main thinking skills, creative idea generation, critical thinking and problem solving, but surprisingly, not the Access mini-case project, the Assignments, nor the Textbook, though the latter two were found to be most supportive of Problem Solving. Additionally, the Assignments were perceived as supporting the acquisition of Research Skills, the only activity or resource to do so. The other resources of the course showed no differences in their contribution to the thinking and team-building skills. These findings indicate the importance of the Excel mini-cases and Assignments in developing the learning skills and the Assignments in developing the team-building skills.

V. CONCLUSION

From this study, it would seem that deep learning can be achieved in the virtual environment from most students' perspectives. On the other hand, there are some who may still need support outside of this environment, or may need additional or different support within the environment. These are important issues to understand in the ongoing attempt to improve the development of deep learning in our students as they prepare to meet life's challenges personally and professionally. Future studies are needed to tackle these issues and to advance research in the area.

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