Distance Education: Integrating Technology Into Computer Science Education

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Abstract - This is a limited study of the effectiveness of 3 approaches to teaching one unit of an information technology course. The emphasis is on comparing distance learning with live lecture approaches. In their comparisons, the authors did consider a complete digital video course vs. a complete lecture course vs. a lecture course which included these video interviews. The main result of the paper is that there is no significant difference in the effectiveness of a distance learning approach compared to traditional approaches. However, the distance learning approach has a slight, but insignificant, advantage in its outcomes.

Introduction

Becoming a good information technology professional is a hard task. Various abilities have to be mastered. A professional must master as many technical abilities as those relating to human interaction [1,9]. A professional has to know how to interact with clients or users, how to communicate with them and how to actually understand their information technology needs: “Requirements definition / requirements gathering / requirements elicitation / requirements engineering - all phrases for “figuring out what to build”. If we build a product for sale that meets few customer needs, we will not be competitive in the workplace. If we build an internal system that does not streamline the business process, we will not be competitive in the business world. Designing from deep knowledge of the customer is central to any effective requirements definition process, and companies are introducing customer-centered approaches in an effort to chart a clear path from customer to deliverable” [7, p. 31]. The information technology professional has to understand each business and its own culture. Students are not really aware of this workplace reality. To allow them to learn about this reality, professor Boulet designed thirteen digital video presentations.

The digital video presentation developed for this curriculum are documentaries aimed at showing what is going on in “true life” form, allowing students to make a link with the fundamental (grounded) knowledge. The programs are not considered to be the theoretical foundation of the course. They are instead considered to be an extension. Through the eyes and words of actual information technology practitioners interviewed, daily reality is portrayed. Students can in this way realize the wide range of issues beyond theoretical fundamentals reality [5,8].

This paper first summarizes the result of the needs analysis that allowed the design of the digital video distance course. The second part presents the essential knowledge that must be acquired by students. The third part gives an idea of the content of one digital video program along with their associated instructional objective. The paper will then present results from analysis in regards to the learning vs. the delivery mode for one unit.

Needs Analysis

The various program taught at Université Laval are regularly evaluated. The undergraduate program in Computer Science was evaluated. One-hundred selected employers, three-hundred sixty-three computer professionals (past students) and four-hundred fifty current students answered two different opinion surveys. Brainstorming sessions were organized with employers to portray those capabilities that computer professionals of the future must absolutely master. Among the results obtained from these surveys and brainstorming sessions, it was apparent that there was a need to make links between the fundamental knowledge provided in the course, and the reality of the workplace. Even the training periods within business did not reach that goal. To support this linkage, the professor used the digital video programs along with related, supporting course materials. The written material is a mandatory book [2] especially designed to fulfill the needs of students participating in the digital video distance education course.

In the following part, we describe the knowledge to be acquired by the students of the distance education course Information technology. This is an undergraduate course in computer science from the Department of computer science at Université Laval.

The Information Technology Digital Video Distance Education Course

The Information technology distance course is divided into 13 units. Examples of Information technology units with their main learning objectives are presented below. Note that the instructional objectives are based on the professional tasks the students will have to perform when they will be on the workplace.

1. EVOLUTION OF THE FUNCTION: To explain the roots of the current trends regarding the design and uses of
information technology.
2. EVOLUTION OF THE INVESTMENT: To describe the evolution of information technology investments in business.
3. PROBLEMS AND CHALLENGES: To determine the limits of the current methods and techniques in information technology creation and development.
4. METHODS: To explain the roots of current methods and techniques.
5. STRATEGIC ASPECTS: To prepare a strategic plan pertaining to a business.
6. PROCESS MODELING: To draw process models using data flow diagrams.
7. DATA MODELING: To draw data models using entity-relationship diagrams.

The study guide [3] presents what has to be done, unit by unit. For each learning unit, the students can find the instructional objectives related to the learning material and to the corresponding activities (exercises). The following example reproduces a part of the Information technology seventh unit: "At the end of this unit, you will be able to draw data models using entity-relationship diagram notations and symbols. To do so, you have to master the following objectives:
• To perceive hidden things.
• To interview users.
• To distinguish an entity from a relationship.
• To separate entities from attributes.
• To discover the proper cardinalities of relationships.
• To verify a data model.
• To validate a data model".

As mentioned before, the book Technologies de l’information: Applications et évolution [2] was specially written to fulfill the need of the distance-learning course. It details the fundamental key concepts pertaining to each instructional objective. At the beginning of each of the 13 chapters, the list of unit objectives appearing in the study guide is reproduced. When writing the content of each section appearing in a chapter, the professor frequently recalled within the text what the instructional objectives are. In regard to the data modeling, students must first master the fundamental concepts presented in the book. They become familiar with the vocabulary: Entity, attribute, relationships, and so on. Then, they master the entity-relationship diagram notations and symbols.

There are 13 digital video programs related to the objectives. Each digital video presentation is a documentary showing how the knowledge detailed in the book is used in the real workplace. The content of one digital video presentation [4] relevant to the seventh unit instructional objectives (listed above) is summarized in the following section:

In the introduction of this unit, a business is described. The aim of this presentation is to give a broader grasp of the business functions that the data model will represent. The professor Boulet makes this same comment upon introducing the course. The professor also describes that the analyst has to do this kind of task in the real workplace. In order to provide this description, the crew taped scenes of current life within the business. A background narrator comments these scenes in the voice over.

A discussion between an analyst and a client, called a "user interviewing session" by information technology practitioners, is then presented. It is a discussion with the President of Centre Jardin Hamel. For the purpose of the digital video presentation, the discussion was separated into parts that fit the learning objectives. Each part is introduced with a recall of the related instructional objective and the part of the pertinent written material. The first portion is presented as a kind of an open-ended brainstorming process (Figure 1). It aims at producing a list of things and nouns that apply to the Centre Jardin Hamel’s business environment.

Figure 1. An open-ended brainstorming session

There is a close link with current life scenes and comments presented at the beginning of the digital video presentation. This allows students to become familiar with the business as analyst must do in a real work setting. When the discussion ends, students’ attention is attracted to the drawing of the preliminary list of things that will be used when elaborating the entity-relationship diagrams. To do so, the President is frequently quoted and several scenes of current life within the business are shown again as reinforcement.

In the next section, students observe the President and the professor walking around the Centre Jardin Hamel pursuing the discussion further. This section provides reinforcement of importance of perceiving hidden attributes. For example, while walking around, several signs are seen, such as one with the name of a particular tree, another with the category of this tree, another with the advises for putting it into soil, etc. As he is talking about his business, the President does not pay attention to these signs, yet what is appearing on each sign is very important for the analyst. There is information provided on the signs that must be included as part of data model. This notion of “hidden attributes” is explained in the next part of the presentation. Here is an extract of the sound track with related image (Figure 2): “During the visit, we saw that many signs appear on the Centre Jardin site. Moreover, on those signs, there are notices pertaining to each category of tree and flower. For a professional analyst, that means the
existence of an entity Product (Produit végétal at Figure 3) being in relationship Concern (Concerne-2) with another entity Advice (Conseil) [...]."

Figure 2. The professor making the link with the theoretical knowledge.

Figure 3. Part of an entity-relationship diagram.

Each digital video sequence was designed to teach capabilities that cannot be explained in a written form. For example, it is hard to explain the perception of things not mentioned by the client, yet this information is essential to model in the process of understanding information needs.

Written instructional materials

The content of the written material, i.e., the book, the study guide and the exercises, is available electronically. They allow a direct access to the different parts of the digital video presentations. A student can click on one objective, and see on computer the part of the presentation pertaining to the objective. The quality and the speed of the digital video images are obviously less good than those on cable TV. On the other hand, the student can make the links between the learning objectives and the digital video presentations easily. Moreover, a student can click on one objective, then have an access to the relevant content of the book; click on some hotwords directly situated within the text allowing him or her to see a part of a digital video. In fact, even if the multimedia gives an access to the same learning and teaching material presented on cable TV, it does not teach the same knowledge. It allows the student to emphasize the links between different parts and types of knowledge. It allows the students to reorganize the knowledge as he or she wants and needs.

The exercises are another component of the digital video distance education course. Students are asked to integrate the knowledge presented in the written material and illustrated by the mean of the digital video during their exercises. The example presented here relates to the Information technology seventh unit discussed above: “Using the elements of a transaction that you recently made with a company, produce the corresponding data model using entity-relationship diagram notations and symbols.”

If a student or group of students needs are not fulfilled by the study guide, cable TV programs, book, they can reach the professor by phone (she has a page) or anytime by email. They can have help to perform their exercises.

The Information Technology digital video distance education course has been used by several students. The professor systematically collected data related to their user profiles. In the past, she was responsible for the same course presented in a traditional classroom setting; this means she also possesses data concerning those students. The next section will present results from analysis in regards to the following questions:

- Can a decrease of learning pertaining to the fundamentals for the students enrolled in a fully television distance education be observed?
- Does distance education provide added value in regard to the learning of attitudes?
- Does the delivery mode (fully television distance education, partially television distance education, traditional) have different effects on learning different types of capabilities?

Analysis of the Effects of the Seventh Unit

The purpose was to investigate the relative effects of television distance education versus traditional (classroom) on learning fundamentals and attitudes in regard to the seventh unit objectives listed above. Attitudes is defined as: “An internal state that influences (moderates) the choices of personal action made by the individual” [6, p.44] The analysis was performed for the seventh unit described above.

Data comes from 243 undergraduates from Université Laval. The study was a factorial design. The independent variable treatment groups were in three levels (Learning from fully television distance education course (FTDEC), Learning from partially television distance education course (PTDEC), Learning from traditional course (classroom) (TRADC)) on three continuous dependent variables (Fundamentals test, Attitudes test, and Problem solving test).

The characteristics of the fully television distance education course were detailed in the previous section. A partial television distance education course has the same features as the fully television distance learning experience with the exception that the students cannot see the digital video and reach the professor interactively; they have to wait the moment of each meeting in a classroom. The traditional course is a lecture given by a professor within a classroom. The written material is the same but the content
of the digital video is replaced by the lecture.

Measures consist of scores of the paper-and-pencil test (post-test; split-half reliability = 0.7) being: score on fundamentals, score on attitudes and score on problem solving. The score Fundamentals is the z-score calculated from the number of correct responses to the items involving the learning of fundamentals in data modeling mentioned before (entity, attribute, relationship, etc.). The score Attitude is the z-score of the items included in the test related to behavior of computer professionals performing data modeling tasks. The score Problem solving is the z-score calculated from the number of correct responses to the related items. The means and standard deviation are summarized in Table 1.

Can a decrease of learning pertaining to the fundamentals for the students enrolled in a fully television distance education be observed? There is no decrease of learning in regards to fundamentals. Moreover, the group FTDEC seemed to have outperformed the two others (Figure 4).

Does distance education provide added value in regard to the learning of attitudes? The group FTDEC seemed to have outperformed the two others in regards to the attitudes (Figure 4). As mentioned before, this group can see several times the same digital video presentation in which several attitudes are illustrated.

Does the delivery mode (fully television distance education, partially television distance education, traditional) have different effects on learning different types of capabilities? The effects were demonstrated on students z-scores (Figure 5) of fundamentals, attitudes and problem solving. For the learning of fundamentals, the group TRADC (z score -1.09) performed worse than the FTDEC (z score .08) and the PTDEC (z score -.02). For the learning of attitudes, the group FTDEC (z score .09) performed better than the PTDEC (z score .03) and the TRADC (z score -.09). For the learning of problem solving, the group FTDEC (z score 1.06) performed better than the PTDEC (z score -.15) and the TRADC (z score -.09).

A MANOVA was conducted with SPSS to examine the effects. Tests from Pillais, Hotellings and Wilks were performed. Results are summarized in Table 2. The results indicate that there is no significant mean vectors difference in the learning in regards to groups (Wilks’ $\lambda = .97, F_{6,476}= 1.38, p > .05$). There is no decrease or increase of learning pertaining to the fundamentals or problem solving for the students enrolled in a fully television distance education course. There is no added value in regards to the learning of attitudes.

A one-way ANOVA was conducted on the score TOTAL. Table 3 reports the summary of the ANOVA. Results indicated that no significant means difference ($F_{2,240}= 2.34, p>.05$) found between different delivery modes.

<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>FTDEC (n=93)</th>
<th>PTDEC (n=67)</th>
<th>TRADC (n=83)</th>
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<tr>
<td>FUNDAMENTALS (/15)</td>
<td>M(z score) 11.89 (.08)</td>
<td>11.64 (.02)</td>
<td>11.12 (-1.09)</td>
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<tr>
<td></td>
<td>SD 2.37</td>
<td>2.72</td>
<td>2.25</td>
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<tr>
<td>ATTITUDES (/10)</td>
<td>M(z score) 7.61 (.09)</td>
<td>7.31 (.03)</td>
<td>6.97 (-1.01)</td>
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<td></td>
<td>SD 1.83</td>
<td>2.03</td>
<td>1.55</td>
</tr>
<tr>
<td>PROBLEM SOLVING (/20)</td>
<td>M(z score) 15.32 (1.06)</td>
<td>14.64 (-.15)</td>
<td>14.21 (-.09)</td>
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<td></td>
<td>SD 3.92</td>
<td>4.00</td>
<td>2.90</td>
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<tr>
<td>TOTAL (/45)</td>
<td>M(% correct) 34.82 (77%)</td>
<td>33.59 (74%)</td>
<td>32.31 (71%)</td>
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</table>
on overall learning. The mean scores were 77%, 74% and 71% for Groups FTDEC, PTDEC and TRADC, respectively (Table 1).

Figure 5. Fundamentals, Attitudes and Problem solving scores for treatment groups.

Conclusion

The results of the study of the effects of one learning unit show that no significant difference of learning is due to the change of the delivery mode. More analysis are needed to determine the actual effects of different delivery mode on learning different types of capabilities required by computer professionals. In the future, we will perform the analysis of other learning and teaching units in regards to the Information Technology digital video distance education course. Other issues such as the learners’ preference of delivery mode must also be addressed. Therefore, the results issued from it can help to determine the teaching and learning environments pertaining to the computer science domain.

Acknowledgments

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References


Table 2
Summary Table for the MANOVA (FTDEC, PTDEC & TRADC) x (Fundamentals, Attitudes, Problem solving) (with S =2, M = 0, N = 118) (Note: F statistic for Wilks’ Lambda is exact)

<table>
<thead>
<tr>
<th>Test name</th>
<th>Value</th>
<th>Approx. F</th>
<th>Hypoth. DF</th>
<th>Error DF</th>
<th>Sig. of F</th>
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<td>Pillais</td>
<td>.03</td>
<td>1.38</td>
<td>6.00</td>
<td>478</td>
<td>.22</td>
</tr>
<tr>
<td>Hotellings</td>
<td>.03</td>
<td>1.37</td>
<td>6.00</td>
<td>474</td>
<td>.22</td>
</tr>
<tr>
<td>Wilks</td>
<td>.97</td>
<td>1.38</td>
<td>6.00</td>
<td>476</td>
<td>.22</td>
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Table 3
Summary Table for the ANOVA (Score TOTAL)

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<tr>
<th></th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>F Prob.</th>
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<tr>
<td>Between Groups</td>
<td>2</td>
<td>277.44</td>
<td>138.72</td>
<td>2.34</td>
<td>.09</td>
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<tr>
<td>Within Groups</td>
<td>240</td>
<td>14221.22</td>
<td>59.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>242</td>
<td>14498.66</td>
<td></td>
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