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ABSTRACT

Theories of situated learning attempt to overcome the ill-structured nature of some domains of learning, and to use students' tendencies to construct knowledge representation on context and prior experience. Success comes when students apply abstract principles to real life. This study compares the effectiveness of two different lesson structures on helping students make inferences and predictions after studying a computer-based lesson of an interdepartmental information system. The two different lesson structures used were: case-based cognitive flexibility structure and concept-based lesson structure with examples. The two groups were randomly created with 381 sophomore business student volunteers. After the lesson, participants were given a multiple choice test with 10 questions on prediction and 9 questions on inference, randomly mixed. The time the students spent on the program was recorded. After finishing the lesson, students took the first part of the Necessary Arithmetic Operations Test (NAOT), 15 multiple choice questions that measure the general reasoning factor. Time on task and reasoning ability contributed significantly to students' performance making inferences and predictions. The students performed equally well in making predictions in different lesson structures, but in making inferences from given information, the students in case-based lessons performed better than those in concept-based lessons. Multiple perspectives and rich contextual information in case-based lesson structure enabled students to understand the inter-relationships and connect the information into better representations, which helped the inference-making process. (Contains 14 references and 7 tables.) (Author/SWC)

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Introduction

One of the most important goals of instructional design is to help learners to develop capabilities to solve situated real life problems. Students should not only be able to memorize instructional contents, but also be able to make inferences and generate problem solving solutions in novel and complex situations. Traditionally, it is believed that if we can help students to learn abstract rules and principles, they will be able to apply them in a variety of situations. School mathematics, for example, provides abstract principles for different kind of math operations. However, as many researchers have come to realize, the students often cannot apply the rules and principles in real life situations. Rather, they tend to treat them as something to be memorized. When instructional content is taught context independently, students are less likely to be able to see the utilities of information sources in real life situations. (CTGV 1992).

Anderson (1980,1982) proposes that there are two kinds of knowledge representations, declarative knowledge and procedure knowledge. Declarative knowledge consists of network of schema and procedural knowledge consists of network of goal oriented production rules in "If-Then" format. When students encounter novel situation, they rely on existing networks to make inference and generate solutions. Learning is the process of connecting new information to the existing schema and production network and adjusting the existing network to assimilate the new information. When instructional content domain is well structured, the maps of schema network and production system can be clearly defined. Instructional programs based on systematic instructional design models can be very effective in this situation. However in many cases we are facing a more complex world.

The complexity of situation is reflected in at least two aspects.

First, learners construct their meaning and their knowledge representation according to their physical, psychological and social context and prior experience (Duffy and Jonassen, 1992). Each student constructs his/her understanding and knowledge representations in learning experience. While common understanding and communication are made possible by social negotiation of meaning, learning is a process of active seeking of personally owned meaning in context.

Second, many domains of learning are illstructured (Spiro, et al., 1987). This illstructuredness is reflected by the fact that there is no apparent set of concepts or principles that are constantly accurate and applicable to every case in the domain. Each case is different from any other cases, therefore, predefined production rules often fail to address certain situations and rigid schema structure can not describe complexity of the domain. Spiro and associates (Spiro, Coulson et al. 1988) propose that one of the major problems of traditional instruction is reductive bias. Instruction often over-rely on a single or limited number of examples or prototypes, therefore, in many illstructured domains, complex structures are artificially oversimplified. The result is compartmentalized knowledge with rigid structures that are not very useful or usable in real life problem solving situations. Memorization often takes the place of the hoped-for transfer of the abstract knowledge.

Cognitive flexibility theory was proposed (Spiro, et al., 1987, Spiro, et al., 1992) to help students to master the complexity of instructional contents, especially in advance and illstructured domains. Cognitive flexibility theory is based on the idea that learners should be exposed to as many perspectives of the knowledge as possible and they should also experience different cases of the domain. By "Criss-crossing" the domain in different cases and from different perspectives, the students will be able to achieve flexible understanding of the domain and its complexity. With the flexible understanding, they will also be able to assemble their knowledge to solve new problems.

To address the question "how do we help students to acquire knowledge and skills that are usable in real life situation?", anchored instruction (CTGV, 1990; CTGV, 1993), as a prime example of case based situated learning environment, provides an authentic and generative learning environment in which students generate subgoals to meet the challenges afforded by the case. Very rich context information helps students learn and use mathematics in the way that they can see how information can be relevant and useful to solving the problems, rather than just something to memorize. Brown, Collins and Duguid (1989) argue that for learners to be able to obtain usable knowledge, learning should be situated in authentic context and activities. Contextualization of learning, or learning *in situ*, therefore, is believed to be an effective way to help the students achieve meaningful learning. Case based learning environments are suggested to provide rich context for learning and meaning making.

While cognitive flexibility theory does not particularly prescribe that the cases for the students to criss-cross should be authentic real life cases, it is not difficult to see that cognitive flexibility theory can go hand in hand with situated learning in case-based environments, especially when the domain of instruction is illstructured and the use of domain knowledge is often expected in real life situations. For example, almost all business students have some exposure of management information system (MIS). One of the most important concept in MIS is that information is shared in enterprises. However, for different people in the organization, an information system provides different kinds of access and different information systems function differently in different business settings. Apparently, this is not a clear-cut topic. The better the students understand the complexity, the more likely they will function effectively in real business operations. What if we design a learning environment that incorporates the assumptions and strategies of both situated learning and cognitive flexibility theory to teach enterprise information system?

Purpose of the Study

The purpose of this study was to compare the effectiveness of two different lesson structures on helping students make inferences and predictions after studying a computer-based lesson of interdepartmental information system. This subject topic was required by undergraduate business majors at most universities.

There were two different implementations based on different lesson structure, which were case based cognitive flexibility structure (case-based structure henceforth) and concept based lesson structure with examples (concept-based structure henceforth).

Case-based lesson was implemented as a cognitive flexibility hypertext. There were four cases in the lesson. Two cases were generic cases in which context information was fairly simple and the other two were very rich cases with heavy contextual information such as where the stories happened, what kind of enterprises they were and so on. Different departments of the enterprises were represented by different on screen figures of the departmental heads with talking balloons. Their perspectives were presented by the words of the department heads with the cases as contextual support. The talking balloons contained refl :tions of these department heads regarding to how information was accessible to the department, how the department co .tributed to the shared information system, and how the information system helped and influenced their business plans and practices. The case scenarios provided a context on which they could reflect.

The implementation of concept-based lesson presented the basic lesson content first. The basic lesson content covered similar information provided by generic cases in case-based lesson implementation. However, the information was presented as concepts and principles in outline and bullets format. After the basic information presentation, two examples were used as support of the concepts and principles. The examples used were similar to the context rich cases in case-based implementation, however, the presentation did not emphasize the contextual information.

The study tests the following hypotheses about lesson structure.

1. Students in case-based lesson make better inferences from given information.
2. Students in case-based lesson predict outcomes of new situation more accurately based on new information.

Method

Participants

Three hundred and eighty-one sophomore business students from a large eastern university comprised the sample. They did not have prior knowledge about the subject matter area covered by the lessons and volunteered to participate this study.

Measurements

At the end of the lesson, the students were given a test with 10 multiple choice questions on prediction, 9 multiple choice questions on inference. These questions were randomly mixed. The time that students spent on the program was recorded. The following are example questions for prediction and inference respectively.

• Predication:

The Profit-Vision program that analyzes all of the stores' sales should produce what operational effect:

a. quicker collection of receivable
b. slower collection of receivable
c. higher in-store inventories
d. lower in-store inventories

• Inference:

The most important advantages of Frito-Lay's information system are centralizing the data collection and:

a. providing regional managers access
b. centralizing data processing
c. expanding the number of collection sites
d. predicting the volume of sales

After finishing the lessons, students also took the first part of Necessary Arithmetic Operations Test (French, Ekstrom et al. 1963), which measured the general reasoning factor. This test consisted of 15 multiple-choice questions that required the test taker to determine what numerical operations were required to solve arithmetic problems without actually having to carry out the calculations.

Treatments and Procedure

Two versions of the lesson were developed. The first version was a concept-based implementation which used examples to help on conveying main concepts and principles to the students. This version of lesson was used in concept-based group. The second version was case-based. It was implemented as a cognitive flexibility hypertext environment with rich cases and contextual information. These two versions were placed on the college LAN server under different names. Each student copied one of the three versions onto his/her own disk. After students' finishing the lesson, the responses were recorded on the disks.

The student volunteers were randomly assigned to one of the two groups using one of these different versions. They were asked to work independently. The students finished the lesson in a period of one week and turned in their answers on floppy disks so that their answers could be retrieved.

Results

There was no significant difference between the average amount of time spent by the two groups (P>.05).

Table 1 presents the average inference and predication scores in case based treatment and concept based treatment respectively.

Table 1, Average of Inference Scores and Predications Scores in Two Treatments

	Case Based Structure	Concept Based Structure
Inference	4.11	3.80
Predication	5.09	5.01

A regression of Predication Scores on Time Spent on Task and scores of Necessary Arithmetic Operations Test (NAOT) is present in the table below:

Table 2. Regression of prediction on time spent on task and NAOT

Predictor	Coefficient	St. Dev.	t-ratio	p
Constant	2.78	0.27	10.29	0.000
Time	$2.98\ E^{-4}$	$6.75\ E^{-5}$	4.40	0.000
NAOT	0.20	0.03	7.27	0.000

s = 2.032 R-sq = 18.1% R-sq(adj) = 17.7%

A regression of Inference Scores on Time Spent on Task and scores of Necessary Arithmetic Operations Test is present in the table below:

Table 3. Regression of inference on time spent on task and NAOT

Predictor	Coefficient	St. Dev.	t-ratio	p
Constant	2.07	0.23	9.05	0.000
Time	$2.16\ E^{-4}$	$5.71\ E^{-5}$	3.79	0.000
NAOT	0.18	0.02	7.45	0.000

s = 1.721 R-sq = 17.5% R-sq(adj) = 17.0%

Table 2 and Table 3 show that both time and NAOT contribute significantly to the variances in distributions of Predication Scores and Inference Scores.

Using scores of Necessary Arithmetic Operations Test (NAOT scores) as covariate for Predication and Inference scores, two different treatments as independent variables, Table 3 and Table 4 present the results of Analysis of Covariance:

Table 4. Analysis of covariance for prediction with NAOT scores as covariate

Source	DF	ADJ SS	MS	F	P
Covariate (NAOT)	1	265.49	265.49	61.15	0.000
Treatment	1	0.19	0.19	0.04	0.835
Error	378	1641.13	4.34		
Total	380	1907.15			

Table 5. Analysis of covariance for inference with NAOT scores as covariate

Source	DF	ADJ SS	MS	F	P
Covariate (NAOT)	1	192.62	192.62	63.07	0.000
Treatment	1	7.61	7.61	2.49	0.115
Error	378	1154.37	3.05		
Total	380	1356.05			

Using scores of Time spent on task as covariate for Predication and Inference scores, two different treatments as independent variables, Table 5 and Table 6 present the results of Analysis of Covariance:

Table 6. Analysis of covariance for predication with time as covariate

Source	DF	ADJ SS	MS	F	P
Covariate (NAOT)	1	130.07	130.07	27.67	0.000
Treatment	1	3.11	3.11	0.66	0.416
Error	378	1776.55	4.70		
Total	380	1907.15			

Table 7. Analysis of covariance for inference with time as covariate

Source	DF	ADJ SS	MS	F	P
Covariate (NAOT)	1	78.31	78.31	23.33	0.000
Treatment	1	14.46	14.46	4.31	0.039
Error	378	1268.68	3.36		
Total	380	1356.05			

With either NAOT or Time scores as covariate, these results indicate that there were no significant different between students' scores on predication in the two treatments ($P<0.835$ and $P<0.416$ respectively).

With NAOT scores as covariate, ANCOVA for Inference scores did not yield significant results ($p<0.115$). However, it is worth noticing that when the time on task is use as covariate, ANCOVA for Inference scores yielded significant results ($P<0.039$). This indicates that if we partition out the variance brought about by how much time the students spent on task, the different treatments then demonstrate significant impacts on the students' capability to make inference. The students in case based treatment performed better on making inference than those in concept based treatment.

Discussion

The results indicate that both the time on task and NAOT scores contribute positively to inference and predication scores. The more time the students spent on task, the higher their inference and predication scores tend to be. While NAOT is a measure of flow of reasoning(French, Ekstrom et al. 1963), it is reasonable to believe that time on task is an indicator of how much mental efforts that the students made in the lessons. It is therefore not surprising at all that they both help the students to perform better in make predications and inferences.

By using ANCOVA as a means of statistical control, we were able to isolate the effect of instructional treatments, lesson structures in this case, by separating the contribution of time and NAOT scores. As table 4 to table 7 indicate, different lesson structures did not contribute to the variance in predication score. In other words, the difference in the students' performance of making predication is statistically insignificant.

However, if we take the contribution of time on task into account by using it as a covariate, it became clear that students in case-based treatment perform better in making inferences. This provided some empirical data that support both cognitive flexibility theory (Spiro et. al. 1987, 1992) and situated learning theory (Collins, 1991). In case-based lesson, the different perspectives served as different themes that helped the students criss-cross the knowledge landscape in different cases. These flexible knowledge representations helped them in making inferences from given information. The rich contextual information also helped students to make rich connections in their schema and production network (Anderson, 1980). These relatively more complete networks also helped the students to infer.

Conclusions

The time that the students spent on tasks and the reasoning ability, measured by Necessary Arithmetic Operation Test, contributed significantly to the students' performance of make inferences and predications. The students performed equally well in making predications in different lesson structures (cased based and concept based). In making inference from given information, the students in case based lesson performed better than those in concept based lesson did. It is suggested that the multiple perspectives and rich contextual information in case based lesson structure afforded students to understand the inter-relationship and connect the information into better representations, which helped the inference making process.

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