Learning Programming Online: Student Perceptions and Performance

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Abstract

Student perceptions and performance are examined and compared for both traditional face-to-face and Web-based online delivery in the teaching of an object-oriented programming unit. Material of identical content was taught using both delivery modes; student perceptions were obtained using a self-administered Likert scale questionnaire and performance was monitored via assignment and examination results. It was found that a majority of students (58%) preferred face-to-face lectures to online ones and that they considered such lectures as having better educational values; in addition, 70% of high-achievers and a majority of all students (56%) felt that the least advantageous aspect of online lectures was the ability to assimilate difficult concepts. High-achievers were found to perform equally well irrespective of delivery mode.

Keywords

Online learning, Internet teaching, Web-based tuition, Programming languages

Introduction

Teaching a programming language has long been a challenge in the classroom. The learning curve is a step function for many students; such students struggle to assimilate the concepts involved in the early stages, making little progress and becoming more and more confused, until, all of a sudden, the "penny drops". Overcoming this step is crucial; sadly, some students never make it, either failing or withdrawing. This paper attempts to compare student performance and perceptions in a programming unit

between traditional face-to-face (FTF) and online (OL) Web-based delivery methods. The academic benefits (or otherwise) of going online are, as yet, unclear. Although some studies have shown that students perform better using OL delivery (e.g. Shutte, 1998; Martin & Rainey, 1993; Souder, 1993), there are many more studies that indicate student performance is independent of FTF or OL delivery modes (e.g. Clarke, 1999; Dobrin, 1999; Goldberg, 1997; Barry & Runyan, 1995; Lin & Davidson, 1994). Two Internet databases which feature comparative studies between courses delivered by traditional (FTF) methods and those delivered with new technologies are http://cuda.teleeducation.nb.ca/significantdifference and http://cuda.teleeducation.nb.ca/nosignificantdifference; the former details studies which show a significant difference and the latter studies which do not. However, not all of these studies research learning OL from a Web site. As Bennet et. al. (1999) states, "From a pedagogical perspective, the efficacy of OL learning is still debatable". An issue here is also whether students who have access to FTF delivery will voluntarily forfeit this in favour of OL teaching methods; in other words, will students choose OL delivery for any inherent advantages it may possess over FTF learning?

In order to test the effectiveness in the OL delivery of programming units, a second semester, first year programming language unit (Object-oriented Programming with C++) was chosen to have selected lectures delivered online using the *Blackboard CourseInfo* shell. This subject is well suited to OL delivery, for the following reasons:

- the unit content was a mixture of program syntax and language paradigm and presented the appropriate mixture of surface (rote) learning and deep learning topics
- programming is relatively unique in that it requires the direct and almost immediate application of practice to theory
- the presence of a problem-based learning (PBL) approach in the practical hands-on tutorials allowed linking of lecture content to practical examples of coding
- the program language compiler can be invoked directly from the Web page, allowing automatic compilation and execution of practical examples
- demonstrations of coding can be incorporated into Web pages as "animations" to show how a professional programmer would approach different problem categories.

Subjects and Experimental Method

We have adopted the so-called "quantitative paradigm" in order to collect and analyse student data. This approach has been criticised in the context of "learner control research" by Reeves (1999, 1993). Reeves identifies several research projects of this nature as fundamentally flawed and labels

them, perhaps appropriately, as "pseudoscience". He bases his thesis on the postulates of Kuhn (1970), who sees science as an activity that occurs primarily within the boundaries of a paradigm. Reeves argues that if you do not obey all the rules of the paradigm, the science becomes pseudoscience. But good science does not necessarily have to work within the boundaries of a paradigm, any more than the use of a paradigm ensures that science is good. In this study we are careful to avoid the obvious traps and pitfalls of pseudoscience and claim only that our conclusions are "first approximation"; in particular, we make no generalizations.

Two lectures in the unit, each of which was concerned with a separate well-defined topic, were chosen to be delivered OL at selected campuses, with all other deliveries being given in a traditional FTF manner. Topic A was delivered OL at campus A (Lismore) and FTF at campus B (Coffs Harbour), and topic B was delivered OL at campus B and FTF at campus A. The lectures were delivered FTF using a set of PowerPoint slides, handouts and tutorial instruction sheets, with the narrative of the lecturer (based upon written notes) given as a substitute to the written material on the Web site. Every attempt was made to ensure that the OL and FTF lectures had equivalent content and (where appropriate in the OL case) sequence. The only difference between the two modes was in delivery: slides vs. computer graphics, voice vs. hypertext.
The questionnaires were handed out in the week following each OL lecture. 45 out of the 66 students across the two campuses enrolled in the OOP unit completed the questionnaire in full (31 at campus A and 14 at campus B). Students where then asked to rank five advantages and disadvantages of FTF and OL delivery modes, with no ties. Finally, in four open questions, students were invited to comment on the aspects of FTF and OL lectures that they found the most useful and the most difficult or frustrating.

Learning requires both factual knowledge and conceptual understanding. Ramsden (1992) defines it as "… a qualitative change in a person's view of reality …" and maintains that "… vital competencies in academic disciplines consist in understanding." It is not sufficient in Ramsden's view for university students to merely be able to repeat memorised information on demand. As Biggs (1989) has noted, "rote learning scientific formulae may be one of the things scientists do, but it is not the way scientists think". In the final examination for the unit, therefore, questions in both topic A and B where set which required students to operate at different cognitive levels: at the surface level, the students had

to memorise, describe and compare; at the deep level, to analyse and apply. Students were not informed of this particular aspect of the structure of the paper, only that the content of all lectures (FTF and OL) was examinable.

Results and Analysis

Descriptive Statistics

Of the 45 students who completed all aspects of the questionnaire, 69% were enrolled at campus A and 31% at campus B. By coincidence, the gender split on each campus was identical, being 29% female and 71% male. The sample was dominated by students under 20 years of age (49%), with the next largest age group being 20-24 years (18%). Nearly half of the students (47%) with over five years of computer experience were under 20 years of age. The Likert scale section of the questionnaire used is reproduced in *Table 1*. The questions were grouped into three broad categories: social attributes/person characteristics (Q1-6), unit-related issues (Q7-12) and advantages and disadvantages of FTF and OL delivery modes (Q13-19).

The responses to Q1 showed that 76% of students claim that they interact academically with other students and with their tutor. However, only 28% claimed that they preferred to study in a group (Q4) and only 17% claimed that they went to see their tutor in consultation time. This latter figure is supported by the experience of the tutors in the unit, who were rarely consulted. Interestingly, all students claimed that they enjoyed using a computer, with responses of either agree or strongly agree (Q8). Most students also claimed that they enjoyed surfing the web (Q9), with only 5 students (11%) having a neutral response and no students with either disagree or strongly disagree. A massive 82% of students expected to work hard to achieve good results (Q10), with only 9% giving a response of disagree and no students strongly disagreeing. The 9% who felt that they did *not* have to work hard to achieve good results had final aggregate marks ranging from 38% (a fail) to 87% (a high-distinction).

#	Question	SD	D	N	A	SA
1	In tutorials, you interact academically with other students and with your tutor	0	7	18	49	27
2	Usually you adapt easily to changes	2	7	22	53	16
3	You are cautious rather than adventurous in your approach to life	9	33	29	24	4
4	You prefer to study alone rather than in a group	4	24	31	20	20
5	You sit near the front of the class in lectures	4	29	27	22	16
6	In lectures, you sometimes ask questions when given the opportunity	9	38	16	33	4
7	You regularly see your lecturer or tutor in consultation time	7	49	24	13	4
8	In general, you enjoy using a computer	0	0	0	42	58
9	You enjoy surfing the Web with a browser (e.g. Netscape, Internet Explorer)	0	0	11	51	38
10	You need to work hard to achieve good academic Results	0	9	9	44	38
11	You have programming experience prior to studying this course	29	22	9	29	11
12	You find programming units like this one (DP239) easy to do	24	31	33	4	7
13	You prefer traditional (face-to-face) lectures to online lectures	0	4	38	31	27
14	Online lectures better allow you to look up the information you need	2	9	31	42	13
15	Memorising certain types of information is easier with online lectures	9	16	47	22	7
16	Difficult concepts can be better understood with online lectures	13	27	42	16	2
17	Difficult concepts can be more quickly understood with traditional lectures	0	2	42	40	16
18	Learning is more fun with online lectures	9	22	56	11	0
19	Traditional lecturers give you a deeper understanding of the subject matter	0	7	31	49	13

Table 1: Likert scale responses by % of respondents (# = question number, SD = strongly disagree, D = disagree, N = neutral, A = agree, SA = strongly agree)

The responses to Q13 showed that a majority of students (58%) preferred FTF lectures to OL ones, with 38% not caring either-way (this may suggest resignation to future trends as well as indifference). No students who indicated that they had had previous distance education experience (22%) preferred the OL mode. The responses to Q15 through Q19 suggest that, on the whole, students see traditional lectures as having better educational values. OL lectures scored only in Q14, with 55% of students agreeing that OL lectures better allow information to be found.

It is revealing to compare responses from both high-achievers and low-achievers. *Table 2* summarises percentage responses for both of these groups for questions where the difference in both of the "agree" responses was greater than 20%. The high-achiever group consisted of the top 10 students, chosen by final assessment (with marks ranging from 59% to 92%) and the low-achiever group consisted of the bottom 10 students by final assessment (with marks ranging from 3% to 40%). It is seen that, compared to low-achievers, high-achievers tend to study alone (40% more), sit near the front of the class (70% more) and ask questions of the lecturer (50% more). They have had prior programming experience (40% more) and some are "natural" programmers (30%). High-achievers also tend to believe that FTF teaching methods provide a deeper understanding of the subject matter than do OL lectures (40% more). However, compared to low-achievers, fewer high-achievers surf the web (30% less) and fewer adapt easily to change (40% less).

Data was collected on student perceptions of workload and attendance. Students worked a range of hours, with almost half (45%) working less than five hours per week and 16% putting in more than 10 hours per week. The majority of students claimed relatively high attendance rates, averaging 91% for lecture and tutorial attendance. There were no significant differences in lecture and tutorial attendance between the high-achiever and low-achiever groups. The average workload for the high- and low-achiever groups was also similar (5.7 and 5.6 hours per week respectively). However, the hours per week worked by the high-achiever group ranged from 1 to over 10 (median 7, mode 8), whereas the hours per week worked by the low-achiever group ranged from 4 to over 9 (median 5, mode 4). This suggests a mix of abilities in the high-achiever group, with some students achieving good results because they work hard and others achieving similar results because of a natural talent in programming.

Percentage of Students		
QUESTION	**HIGH**	**LOW**
Q2 Adapt easily to changes	30	70
Q4 Prefer to study alone	50	10
Q5 Sit near front of class	80	10
Q6 Ask questions in lecture	80	30
Q9 Enjoy surfing Web	70	100
Q11 Prior programming experience	80	40
Q12 Find programming easy	30	0
Q19 FTF give deeper understanding	90	50

Table 2: Comparison of high- and low-achievers for questions with response differences of greater than 20%

Students were also asked to rank five aspects of FTF delivery and five aspects of OL delivery, with no ties. *Table 3* shows the percentage of students who considered each aspect to be the most advantageous and the least advantageous. Where percentages differ between groups by more than 30%, they are marked with an asterisk. As far as high-achievers were concerned, the most advantageous aspect of the FTF mode was the ability to ask questions of the lecturer (50%). In the low-achiever group, this aspect was rated as second most advantageous by 40% of the group, as third most advantageous by 20% and as least advantageous by the remaining 40%.

For the OL mode, 60% of low-achievers felt that setting your own pace was the most advantageous aspect. In the high-achievers, this aspect was rated as most advantageous by 10% of the group, as second most advantageous by 30%, third most advantageous by 40% and as fourth most advantageous by the remaining 20%. It seems that high-achievers saw FTF as being a good thing in that they could interact in person with the lecturer and OL as being a good thing in that they could choose when to do the lecture. In contrast, there was no aspect of FTF that was seen as advantageous by a majority of the low-achiever group. However, they saw OL as being a good thing in that they could set their own pace (high-achievers may have realised that setting their own pace is only possible within narrow limits, because the unit has a 12 week schedule with three deadlines: two assignments and an examination). 70% of high-achievers and a majority of all students (56%) felt that the least advantageous aspect of OL lectures was the ability to assimilate difficult concepts. However, there was no corresponding majority for the companion question in FTF mode. This view may be a result of poor Web page design and the absence of any multimedia artefacts to get difficult points across.

DELIVERY MODE ASPECTS	**MOST Advantageous Aspect**			**LEAST Advantageous Aspect**		
	ALL	**HIGH**	**LOW**	**ALL**	**HIGH**	**LOW**
FACE-TO-FACE MODE						
You can ask questions in or just after the lecture	22	50*	0*	24	10*	40*
A verbal explanation is better than a written one	24	30	20	11	10	0
You can discuss issues after	13	20	20	20	0	20

the lecture with other students						
Difficult concepts are easier to assimilate from a lecture	22	40	20	13	0	20
A traditional lecture forces you to concentrate for a set period of time	38	30	40	24	60*	20*
ONLINE MODE						
You can set your own pace	36	10*	60*	4	0	10
You can review the lecture material at any time	13	10	10	7	30*	0*
You can easily reference any section of the lecture	18	0	20	16	10	30
Difficult concepts are easier to assimilate when studied online	0	0	0	56	70*	40*
You can choose when to do the lecture	36	60*	10*	18	20	20

Table 3: Advantages of lecture modes (percentage of students)

Analysis of Written Statements

In the questionnaire, students were given the following open questions: (a) What aspects of the online lecture did you find most useful? (b) If you found certain aspects of the online lecture useful, please explain in what way; and the complement: (c) What aspects of the online lecture did you find most difficult or frustrating? (d) If you found certain aspects of the online lecture difficult or frustrating, please explain in what way.

For this analysis, four additional responses were used from questionnaires that were complete with the sole exception of the student identity number, bringing the sample total to 49. From this sample it was possible to identify 10 areas of favourable comment and 11 areas of unfavourable comment. The percentage of students who commented in each area is given in Table 4. It is seen that the aspects of OL lectures that most students identified as useful are that they can be self-paced (45%), easily referenced (27%) and provide direct access (27%). The aspects of OL lectures that most students found difficult or frustrating are that it was not possible to ask questions of the lecturer (35%) and that there were network connection and user problems (29%). Interestingly, both of these problems can be addressed with improved or more efficient technology.24% of students felt that the additional notes provided with the lecture slides were useful. It is unclear how many students appreciated that the notes directly substituted for the usual aural narrative in a lecture. One student commented that "[it was useful] not having to take notes", whilst others observed "It is a lot easier to understand topics and new concepts when being verbally addressed", "I prefer to listen to a lecturer, it forces me to learn", "It doesn’t sink in as well as listening" and "I like the traditional

way the lecturer talks and explains". There is an implication here that some students take few or no notes in FTF lectures, expecting instead to learn from the slide handouts and from the act of listening. Such students might be expected to be unhappy about the additional effort required to undertake an OL lecture. One interesting aspect of the OL mode was that some students (10%) found it difficult to motivate themselves to commence the OL lecture. One student commented that "It was hard to just start because I knew I could do it at anytime". However, some of the unfavourable comments must be seen in the context of students who lack familiarity with an OL learning environment.

% who found OL lectures useful		% who found OL lectures frustrating	
Self-paced	45	Cannot ask questions	35
Easy referencing	27	Connection/network problems	29
Direct access	27	None	10
Additional notes beneficial	24	Reading from the screen	10
Flexible study times	22	Setting aside the time	10
Can work at home	8	Motivation to start	8
Can print out notes	8	Does not convey full understanding	6
Programming issues	6	Cannot easily or cheaply print out notes	6
Easy to repeat	6	Listening is better than reading	6
Access to electronic copy of slides	4	I just prefer FTF	4
		Dislike the navigation	4

Table 4: Percentage of selected student comments

It is disappointing to note that only 6% of students identified advantages of OL delivery which were unique to the teaching of a programming language: namely, the ability to copy code (1 response) and to multitask the language compiler alongside the lecture (2 responses). It seems that the majority of students need to be educated in how to utilise these important advantages in the OL delivery of programming units.

Further Statistical Analysis

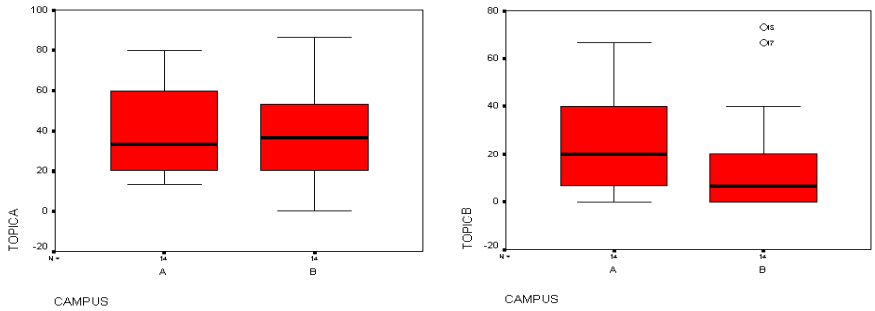
The student rankings obtained for the aspects in Table 3 were subjected to a Kendall's W test for both achiever groups. Some agreement was found between students in the high-achiever group (W = 0.225, sig. 0.06) for the FTF aspects, but not for the OL ones (W = 0.054, sig. 0.71). Stronger agreement was obtained between students in both groups for the OL issues (high-achievers W = 0.325, sig. 0.01, low-achievers W = 0.342, sig. 0.08). It seems that students as a whole have more fixed ideas about the advantages and disadvantages of OL lectures than they do about FTF ones.

In order to allow t-test comparisons to be made, normally distributed data was required. Normal and detrended P-P and Q-Q plots showed that the final aggregate marks (obtained from a 40% assignment weighting and a 60% examination weighting) and the examination results of all students in the unit followed a normal distribution. A series of correlations were then undertaken with examination performance as the dependent variable. No correlation was found between examination performance and:

(i.) lecture attendance ($R^2 = 0.014$)
(ii.) tutorial attendance ($R^2 = 0.002$)
(iii.) effort ($R^2 = 0.009$)
(iv.) interaction with students and staff ($R^2 = 0.071$)
(v.) previous programming experience ($R^2 = 0.047$)
(vi.) computer experience ($R^2 = 0.001$)
(vii.) computer enjoyment ($R^2 = .029$)

To compare the effectiveness of FTF delivery with OL delivery, distributions of student marks were compared for topics A and B across campuses A and B. 41 students completed the unit on campus A (mean final mark = 46%, std dev. = 21%) and 25 on campus B (mean final mark = 39%, std dev. = 28%). However, because all students did not complete and/or return the questionnaire, the campus A group consisted of 45 students (mean final mark = 46%, std dev. = 21%) and the campus B group of 14 students (mean final mark = 56%, std dev. = 21%). The significantly higher marks in the campus B group arise because the 13 of the 14 students who returned the questionnaire were in the top 19 (55%) of the class; only one student in the group had a mark less than 40%. In comparison, the marks in the campus A group ranged from 87% to 3%. To ensure a fairer comparison between groups, the top 14 students from the campus A group were selected to represent that campus. A t-test was then undertaken to compare FTF and OL performance as determined from the

examination marks for topics A and B. The results are represented by the box plots of *Figure 1*.



(a) Topic A. (b) Topic B.

Figure 1: Independent samples t-test comparing student performance for FTF and OL delivery modes

Levene's test for equality of variances was applied to both group comparisons (topic A:
F = 0.014, sig. = 0.91; topic B: F = 0.59, sig. = 0.45); as can be seen, the agreement between variances is less marked in the case of topic B. In addition, the mean marks for topic B were in general considered too low (campus A: 22.4%; campus B: 17.6%) to allow a meaningful comparison between groups; students clearly found this topic difficult, irrespective of delivery mode. For these reasons, the results for topic B were discarded. The results for topic A show that the mean mark for each group (campus A: 40.0%; campus B: 40.5%) were not significantly different (sig. = 0.96). This indicates equal performance across groups, suggesting that good students perform equally well irrespective of delivery mode.

Conclusions

This study has shown that the OL delivery of lecture material in a programming unit is both feasible and practical. However, it was found that a majority of students (58%) preferred traditional face-to-face lectures to online ones, with a significant minority (38%) not caring either-way. On the whole, the students saw traditional lectures as having better educational values: 70% of high-achievers and a majority of all students (56%) felt that the least advantageous aspect of OL lectures was the ability to assimilate difficult concepts. However, this perception was not reflected in the students' performance: in line with many other studies, it is

concluded from the evidence so far that students who are high-achievers perform at least as well using OL delivery as they do using FTF. At this stage, it is less clear whether or not low-achievers are disadvantaged by the absence of FTF tuition.

It has also been shown that student performance in this C++ object-oriented programming unit is independent of lecture and tutorial attendance, effort, the amount of interaction with staff and other students, previous programming experience and previous computer experience: not unexpectedly, some students achieve good results because they work hard and others achieve similar results because of a natural talent in programming. In the context of OL learning environments, it is of interest to note that interaction with staff and other students is not by itself important in determining grade outcomes. This is despite the students' own perception that FTF contact is important in terms of being able to ask questions. It should not therefore be expected that OL environments are inherently disadvantageous to student performance because of the absence of FTF interaction. One researcher (Schutte, 1997), whose students were frustrated with the OL mode but who nevertheless performed better online, has commented that "[The students' frustration with OL learning] stemmed from the inability to ask questions of the professor in a face-to-face environment". Schutte further postulated that, paradoxically, this led to more student-student interaction, with ultimately beneficial results.

In terms of teaching a computer programming language, many potential advantages of OL delivery have still to be realised. These include the use of cut-and-paste techniques to reuse existing code and the ability to compile and execute code examples whilst studying lecture material. Further development of Web-based teaching methods is needed to maximise this potential. In addition, further research is required to ascertain more clearly the advantages and disadvantages in the OL delivery of programming units to both high-achievers and low-achievers.

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