The Impact of Virtual Classroom Laboratories in CSE

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ABSTRACT

In order to gauge the pedagogical implications of conducting Computer Science practical sessions remotely, the Division of ICS at Macquarie University conducted a formal experiment using a virtual classroom environment called Macromedia Breeze Live. Research results indicated that students who completed their practical in the virtual classroom: i) felt they performed significantly more collaboration, ii) expressed a preference for this mode of practical session over regular laboratory sessions, iii) felt that they learnt significantly more from their classmates and iv) felt that they learnt significantly more from the practical supervisor than students in the standard classroom. Reasons for these results are proposed in the pedagogical context of offering Computer Science practical sessions online.

Categories and Subject Descriptors

K.3 [**Computers and Education**]: Computer Uses in Education – *Computer-assisted instruction (CAI)*, *Computer-managed instruction (CMI)*, *Distance learning,* Computer and Information Science Education.

General Terms

Measurement, Performance, Design, Experimentation.

Keywords

Virtual Classroom, Survey, Online Learning, Pedagogy

1. INTRODUCTION

There has been much debate in educational circles regarding whether the media of delivery affects learning outcomes [3, 4]. Coinciding with this debate the need for a more scientific approach to research in Computer Science education has been identified [10]. In order to ascertain the educational efficacy of conducting Computer Science practical (or "laboratory") sessions using a virtual classroom environment, Macquarie University conducted a formal experiment involving eight lab classes.

2. BACKGROUND

There has been reported success in using online collaboration tools in a wide range of educational settings [6, 7, 9]. However these accounts consistently advise of the need to carefully consider the learning context and domain in order to provide an effective educational experience.

Computer Science education is unique because it requires the learner to simultaneously develop a logical understanding of the learning domain and the procedural capacity to implement it on a machine. Expert modeling has been proposed as an outstanding means to purvey proficiency in areas involving complex cognitive schema [5]. However to offer students such a "cognitive apprenticeship" in Computer Science means that students need to be able to hear the thoughts of their instructor at the same time as they see programming being performed. There is less research into whether or not virtual classrooms can effectively deliver this style of instruction to facilitate the learning of programming.

On a separate but related front the efficacy of collaborative approaches to learning has been supported by several Computer Science educators [8, 11, 12]. However there are potential obstacles, for instance a defensive classroom climate, that can stand in the way of effective implementation of collaborative approaches [2]. Given the increasing prevalence of online learning it is important to ascertain the degree to which collaborative processes can be successfully executed in virtual classroom environments and whether or not practical impediments to implementation can be overcome.

The purpose of this experiment was to formally determine the extent to which a virtual classroom environment could be used to offer students a valid learning experience in computer science and to measure the student utility of this approach compared to their standard laboratory sessions.

In the next section we briefly describe the experimental design used to conduct the research. This is followed by a section summarizing student feedback collected using a ten-point survey instrument. Finally a discussion of the findings and their resulting implications for Computer Science education is provided.

3. METHOD

The Division of ICS Breeze Trial was conducted during week 10 practical sessions for the second year Computer Science subject "Object Oriented Programming Practices" in Semester 1, 2004. Four out of 8 practical classes completed their week 10 practical in the "Breeze" virtual classroom environment and 4 in the "Standard" practical laboratory environment. Both groups

covered content from the same practical exercises, which related to installation and use of the CVS version control system.

The "Breeze Live" [1] software package allows students to collaborate in a virtual classroom environment, either from home or from the on-campus computing laboratories. The environment provides text chat capabilities between all students and the practical supervisor as well as VoIP and webcam broadcast features (the later two facilities were only used by the practical supervisor). The software also provides desktop broadcasting capabilities (that were used extensively by the practical supervisor) and desktop sharing (which was used on occasion by the lecturer to take control of a student's desktop and show the class how to correctly execute a set of instructions).

After completing their week 10 practical students from both the "Breeze" and "Standard" groups were asked to complete the same questionnaire regarding how they felt the mode of delivery for the practical affected their learning. A summary of the responses to the survey is provided below.

4. RESULTS

Fifty-five responses to the feedback survey were received. The questions and results are presented in sequential order.

Question 1: "For this practical I (H) attended a virtual classroom practical from home, (L) attended a virtual classroom practical in the labs, (N) attended a regular classroom practical in the labs"

Table 1: Distribution of participants

	H	L	N	Grand Total
Breeze	8	24	3	35
Standard	0	2	18	20
Grand Total	8	26	21	55

Note that two students were allocated to the Standard practical group but completed the virtual classroom practical from the labs. Also note that three students were allocated to the Breeze practical but attended the normal classroom practical from the labs. Because these five students self selected their treatment they have been excluded from data analysis for all further questions. This leaves a total of 32 students in the Breeze treatment group and 18 students in the Standard treatment group.

Question 2: "How much collaboration did you perform in this practical (with either your peers or the prac supervisor)?"

Table 2. Amount of collaboration performed

	None (0)	Very Little (1)	Some (2)	A lot (3)	Entirely w\others (4)	Total	Average	Standard Deviation
Breeze	1	4	15	9	3	32	2.28	0.924
Standard	7	5	4	2	0	18	1.06	1.056
Total	8	9	19	11	3	50	1.84	0.973

Highly significant difference **between mean rating for Virtual Classroom versus Standard groups** *(5 point Likert scale, t = 4.27, df = 48, p < 0.001)*
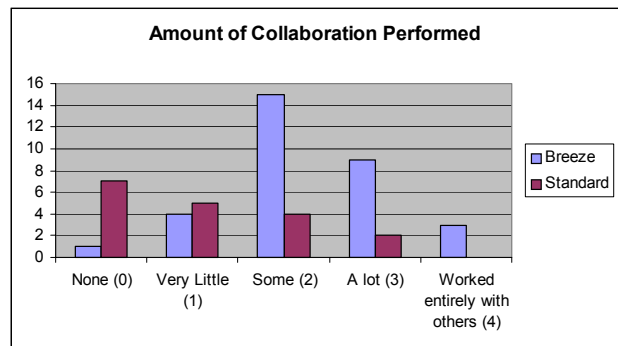

Figure 1: Collaboration - Virtual Classroom vs Standard Lab

Question 3a: "Would you have preferred to (C) collaborate with others during this practical, or (A) just work alone?

Table 3: Collaboration preferences

	Alone	Collaborate	Total	p-value*
Breeze	12	18	30	0.362
Standard	9	9	18	1
Total	21	27	48	0.471

*P-values based upon two-tailed binomial test for difference between proportion favoring collaboration versus working alone. No significant difference between preference for collaborating versus working alone for any groups.
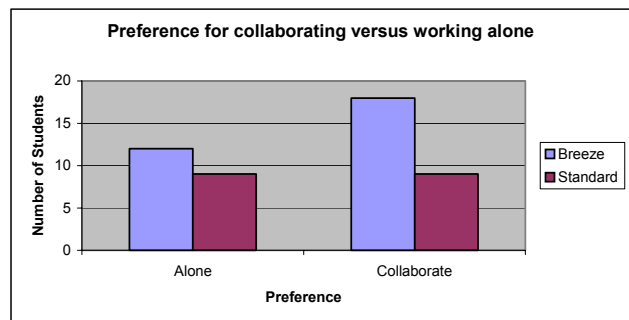

Figure 2. Preference for Collaboration/Working Alone

Question 3b - "How come?"

The open ended responses to this question were classified by reasons for their learning preference. The most common reasons for choosing to work alone were "less distractions" (8), "quicker" (4) and "flexibility" (2). The most common reasons for wanting to collaborate were "get help if stuck" (7), "value interacting with others" (4) and "learn more" (3). There were no outstanding differences between the types of reasons provided by students in the Breeze group as compared to the Standard group. A broad spectrum of responses were recorded, with some exemplary comments provided below, for illustrative purposes.

"Don't tend to get distracted when solving a problem. Don't tend to lose track of thought." (Standard)

"Prac work generally progressed at the speed of the slowest student." (Breeze)

"Less distracted, however, it is good to do a little bit of collaboration in case you get stuck on something." (Standard)

"Collaboration after having a go alone. Good to be able to ask questions and get immediate answer and see the supervisor screen" (Breeze)

"it is easier to work with a group, it prevents you being trapped on a subject that you can't know." (Standard)

Question 4a: "Would you have preferred to collaborate in a (R) regular classroom environment or a (V) virtual/online classroom environment?"

Table 4 - Preferred Collaboration Mode

	Regular	Virtual	Total	p-value*
Breeze	7	25	32	0.002
Standard	8	9	17	1
Total	15	34	49	0.009

2-tailed p-value for difference between proportion favoring collaboration versus working alone based on a binomial distribution. Highly significant difference between number of students preferring a Regular classroom environment versus a Virtual classroom environment within the Breeze group and for the two groups combined
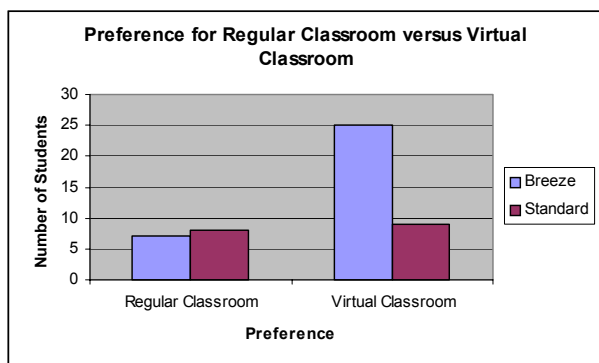

Figure 3: Preferred mode of delivery

Question 4b - "How come?"

When responses to this open ended question were classified into response type the main two reasons that people gave for preferring the Regular Classroom were that it was "clearer" (3) and was "less restrictive" (3) in terms of the pace and material covered. There was no outstanding difference between responses provided by students in the Breeze group as compared to the Standard group. Three representative comments from this group were:

"have to do the prac very quick in the virtual classroom I can take my time to do the prac in regular classroom" (Standard)

"Whilst I thought the online classroom was novel, and could be used well for external teachings, I felt it a bit restrictive in that I felt I had to stay at the same level the class was up to... even if I fell behind." (Breeze)

"I think it's harder to understand online than in the regular classroom, the audio was always breaking up or delayed" (Breeze)

However there was a noticeable difference between reasons provided by the Breeze and Standard groups for students preferring the Virtual Classroom over a Regular classroom. Those who were in the Standard group cited "flexibility" (4) more than all other reasons combined as the rationale for preferring a Virtual Classroom. On the other hand those in the Breeze group cited "more interesting/fun" (7), "clearer demonstrations" (3) and "more interactive" (3) as the main reasons for preferring a Virtual classroom. Some comments from students in the Breeze group expressing a preference for Virtual classroom collaboration include:

"I would prefer both, if I'm late or miss a class. I can go to the virtual classroom and relearn the material. This will obviously give varying advantages. But I like the ability to work from home and really focus on the work." (Breeze)

"I can be more of a participant in the discussion and the virtual (online) classrooom is more exciting and interesting..." (Breeze)

"The interaction between peers appears to be quicker than holding your hand up and waiting for a practical supervisor to come over and help." (Breeze)

Question 5 - "How difficult did you find this practical to follow?"

Table 5. Difficulty following the practical

Group	Very Difficult(0)	A bit difficult(1)	Average(2)	A bit easy(3)	Very easy(4)	Total	Average	Standard Deviation
B	0	9	14	4	4	31	2.10	0.978
S	2	4	9	2	1	18	1.78	1.003
T	2	13	23	6	5	49	1.98	0.989

*No significant difference **between mean rating for Breeze and Standard groups (t = 1.09, df = 47, p = 0.281)***
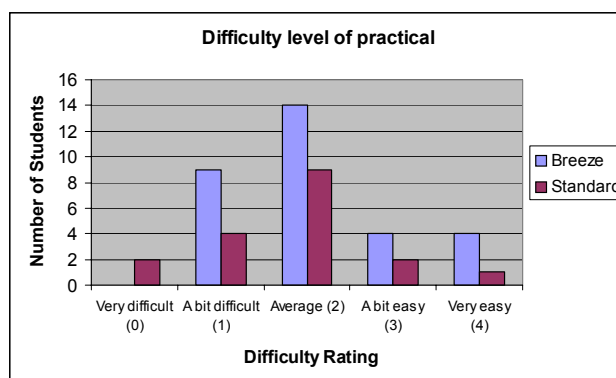

Figure 4: Difficulty of practical – Breeze versus Standard Lab

Question 6 - How much do you feel that you learnt from other students in this practical?

Table 6: Amount Learnt from other students

	Nothing(0)	A little bit(1)	Some(2)	Quite a bit (3)	A great deal(4)	Total	Average	Standard Deviation
Breeze	7	8	8	6	0	29	1.45	1.008
Standard	11	3	2	2	0	18	1.09	1.074
Total	18	11	10	8	0	47	1.17	1.029

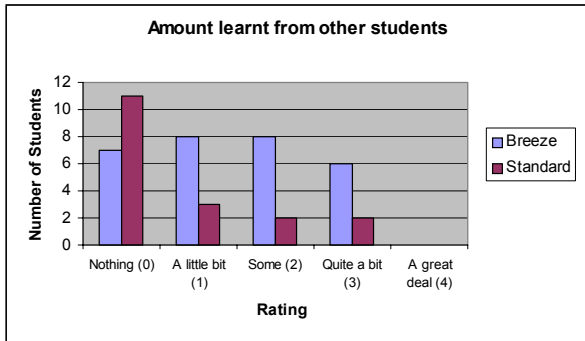*Sig. diff.* between groups (t = 2.23, df = 47, p = 0.030)

Figure 5: Amount learnt from other students

Question 7-"How much do you feel that you learnt from the practical supervisor in this practical?"

Table 7. Amount Learnt from Supervisor

	Nothing (0)	A little bit (1)	Some (2)	Quite a bit (3)	great deal (4)	Total	Average	Standard Deviation
B	1	7	9	11	3	31	2.26	1.032
S	8	4	6	0	0	18	0.89	0.900
T	9	11	15	11	3	49	1.76	1.182

Highly Significant difference between mean rating for Breeze and Standard groups (t = 4.68, df = 47, p <0.001)
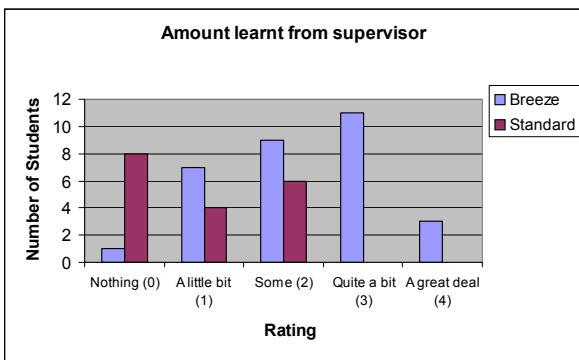

Figure 6: Amount learnt from supervisor

Question 8 -"What were the advantages of the practical you just completed?"

Students from the Standard group cited "learning new concepts" (5) as the main advantage of the practical. There were no other response classifications that occurred more than twice. In contrast students from the Breeze group cited "clearer demonstrations" (10), "interactivity/motivating" (5) and "flexibility" (3) as the main advantages of the practical session. Some comments include:

"Being able to work thru the prac with vocal help. Even though it was choppy, watching the stepthru of the prac steps were a LOT clearer than the steps themselves" (Breeze)

"we can contact with the presenter at the same time, so that we can ask and get the help at the same time, it's cool..." (Breeze)

"Have a base knowledge understanding of how to use CVS" (Standard)

Question 9 - "What were the disadvantages of the practical you just completed?"

The main disadvantages suggested by the Standard group were "inability to ask questions/interact" (4) and "difficult to understand" (2). On the other hand the Breeze group identified "bandwidth/audio quality" (7), "slow progress through the material" (6) and "working with the virtual classroom interface" (3) as the main drawbacks of the practical. Four comments include:

"Very hard to follow what's going on without supervised help" (Standard)

"little interaction with other class members" (Standard)

"our text responses slows things down, plus the audio cuts off and on" (Breeze)

"Hard to multi-task- the breeze window needs to be full screen, and so does the word doc I'm working in- I can't both watch the Breeze window and work. (needs multiple monitors!)" (Breeze)

Question 10-"Please provide any other comments."

The responses to this open-ended question were roughly equally divided between positive and negative comments for both the Breeze and Standard group. The most notable aspect of this section is that 5 of the 7 negative responses relating to the Breeze practical were related to bandwidth/audio quality, particularly from students completing the work from home. A range of responses to this effect are provided below.

"I'm connected to the system from college within uni, but it cost money!! It's still okay to me, but when I got suck at step 9, the class still solving the problem of step 4. I don't really want to waste my money and wait for it, so I give up and haven't completed the prac. Now, I still dunno how to do it. Alright, no choice!!!" (Breeze from Home)

"Breeze was excellent! I have broadband and a few words dropped out here and there, but this was not a problem. Quality of speech was excellent, quality of video was good but not required. Mostly was perhaps difficult for [the supervisor] answering different questions about different parts of the prac. Would be better perhaps if students were encouraged to go through the prac at their own pace and ask questions." (Breeze from Home)

"didn't finish the prac. coz the 56k internet connection is too slow for this... if only by typing important messages... I prefer icq or msn. well, still it's good" (Breeze from Home)

5. Discussion

There were several statistically significant results uncovered by the experiment, each with implications for Computer Science education.

The first significant result was that students in the virtual classroom environment on average felt that they performed more collaboration than their peers who completed the standard practical session (ref. Question 2). Reasons for this could include that these students were able to review the text chat from other students in the class and even see their screen on occasions. This speaks well for the potential of virtual classrooms to implement collaborative learning.

The second significant result from this trial was that students who completed the Breeze practical expressed a preference for virtual classroom collaboration over regular classroom collaboration (ref. Question 4a). Obviously students from the Breeze group were as a whole making a much more informed decision about what collaboration in a virtual environment would entail because of the treatment to which they were exposed. It is difficult to ascertain how much of the preference was due to a novelty effect; the main reason provided for preferring the platform was that it was "more interesting/fun". Also, the possibility of an effect caused by different practical supervisors needs to be considered in responses to this, as other questions.

Thirdly, students who completed the virtual classroom session had a significantly higher average rating of "amount learnt from other students" (ref. Question 6) than the Standard group. Assumedly this is a directly related to the fact that students in this group on average (felt like they) collaborated more than students in the Standard group (ref. Question 2). This provides formal evidence that students feel a virtual classroom environment can improve learning outcomes.

Finally, there was a significantly higher average rating of "amount learnt from the practical supervisor" in the virtual classroom group as opposed to the standard classroom group (ref. Question 7). Note that this again may be due to an effect caused by the practical supervisor rather than the Breeze environment. On the other hand it is encouraging that virtual classrooms can be used to provide a learning experience that students feel is substantially better than the practical classes they normally attend.

There are other notable findings from the data collected in this experiment. Firstly, the majority of students surveyed indicated that they preferred a collaborative approach to learning (ref. Question 3), which is encouraging in the context of the number of computer science educators who are shifting to this paradigm. Secondly, students who attended the virtual classroom session did not find the laboratory any more difficult than the face-to-face group (ref. Question 5).

On a practical level Questions 9 and 10 revealed limited bandwidth was the main drawback of the virtual classroom environment trialed. This impacted upon audio and video quality, which are obviously core requirements for effective educational instruction. However it should be noted that the server used for this experiment was based in the US, and that deploying a local, campus-dedicated server may significantly improve performance. Also, as users gain more experience with the platform they may be able to adjust some of the media settings within the Breeze application to positive effect.

Throughout all open-ended responses words like 'fun', 'exciting' and 'motivating' were used in reference to the virtual classroom environment nine times but not at all for the Standard web module. On the one hand this could be discounted as merely a novelty effect. On the other it is reassuring to know that there is scope to improve levels of student engagement and satisfaction in Computer Science Education through the online medium.

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