

Active Learning in Science Education; the Roles Played by Cross-Curricula Integration and Educational Technology

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Abstract

School science teaching and learning is increasingly making use of a constructivist framework, co-operative workgroups and interdisciplinary studies. In addition, computers, both as a learning tool and as a production tool are becoming more commonplace. It is therefore desirable to emphasise all of these aspects in the learning experiences of initial teacher trainees.

This paper outlines some aspects of an action research project on such a programme being developed at the University of New England, with particular emphasis on the integrated and educational technology aspects.

Introduction

School science teaching and learning is increasingly making use of a constructivist framework, co-operative workgroups and interdisciplinary studies. It is therefore desirable to emphasise all of these aspects in the learning experiences of tertiary level students (Daniels, Lobry de Bruyn, & Reid, (1995) and, more especially, of initial teacher trainees (Daniels and Fleming 1996). In addition, computers, both as a learning and as a production tool, are becoming more commonplace. At the University of New England we have for some years now based our science teacher education programmes on a constructivist framework, which has emphasised active learning.

There are three fundamental considerations which underlie the move towards active, metacognitive learning approaches. The first focus is student centredness (Thorley & Gregory 1994); the desire of educators to put the student (rather than the lecturer) centre-stage. Student-centred learning aims to start the students' learning from where they presently are and, through interaction, to assist the student in finding ways to make sense of their world.

The second focus of many innovative teaching approaches is collaborative learning (interactive learning in groups). Group decision making enables students to learn more about themselves and their interpersonal skills, clarifying their thinking and learning through discussion and explanation, and extending their capacity for critical thought (Rudduck 1978; Gregory & Thorley 1994; Tribe 1994). Peer tutoring and feedback through group interaction can be a powerful learning experience, exposing students to a far greater range of ideas and understandings on an issue than can be achieved through traditional learning environments (Rudduck 1978; Gregory & Thorley 1994; Tribe 1994).

The third focus of active learning approaches is experiential learning and the belief that people learn more through their active, personal experience than through passive instruction (Kolb 1984; Faire & Cosgrove 1990).

Added to this was the desire to integrate the Science methodology with a range of other key

learning areas, and especially with English and Mathematics. This has developed naturally from the approach to content using themes which can best be learned in a holistic manner, e.g., flight, the environment, energy. In addition to these aspects, there is a need to familiarise students with computer technology, both as a tool to be used and as an educational resource. Early developments included giving students the opportunity to use straightforward word-processing skills and, in a small way, to explore the web. More particularly, we have cooperated with our English and Mathematics colleagues in a team-teaching approach to the theme "The Sinking of the Titanic". The topical nature of this theme, shortly after the worldwide showing of the film "The Titanic" ensured student motivation and both the CD-ROM of the music of the film and direct access to the relevant website, with its detailed animations of the ship and plans of its structure added to the impact. Student reflections after this module indicated a very high satisfaction, both with the integration across the curriculum and with the use of the educational technology.

As it will be mandatory in New South Wales from the year 2000 for all entrants to the teaching profession to have a demonstrated personal capability in computer usage and a demonstrated ability to use computer technology effectively in a classroom context for student learning, it has seemed appropriate for us to methodically integrate more computer usage in our program and to research the degree of achievement of various outcomes.

This paper outlines some aspects of such an action research project, conducted in the unit CSST 190, Curriculum Studies I.

Research Objectives

Although the overall aim of the research was to determine the feasibility of interdisciplinary curriculum studies, only one facet is reported here, namely the possible role of educational technology in this process. Within this context we have investigated students' attitudes to such an interdisciplinary approach and have measured the ability of students to work with the web and CD-ROM-based resources. In both instances the students have been asked to reflect on their value in classrooms. In addition, students were asked to assess the perceived value of integrated application software as a means of summarising experimental data.

Methodology

In a prior unit (CSST 192, Foundation Studies) students were given basic training in computer skills, including the creation by students of a Home Page linked with a selection of science sites and the use of audio and web resources, with results submitted in portfolio form. The use and extension of these skills were subsequently explored in various ways in the cross-curricula unit, such as; use of the web to access and to use information successfully from the perspective of a school student, with a portfolio of results; evaluation of a selection of resources, including a CD-ROM; a series of pendulum experiments for which the results were recorded both in spreadsheet and graphical form. A database of skills achieved by an imaginary class, using this activity, was also constructed. These activities were conducted over a three-week period. At the commencement of each week students' pre-knowledge, experience and attitudes were determined by questionnaire and changes in their attitudes, learning and satisfaction were measured by assessment of related projects, by analysis of reflections and by post-questionnaires. Gender differences were also quantitatively measured.

Major Findings

The sample consisted of the complete group of students enrolled in the first year of the university's Bachelor of Education programme for the training of primary teachers. There were 162 students involved, of whom only 31 were males. Not all students participated in every activity. The small number of males, allied to the fact that not all students handed in reports each week, indicates that any subsequent data which refers only to males must be taken with an element of caution.

Prior Computer Experience

Before the three-week experimental period, all students were asked to complete a questionnaire on their use of computers, using a five-point Likert scale for their answers. The average number of years of home usage of computers appeared to be greater for males than females, although a median value of 3 was the same for both.

School and university use of computers was, on average, similar for males and females but the median was greater for females (5) than for males (4). The frequency of computer use for work related to units of study showed no significant gender difference ($\chi^2 = 7.81$ $df = 3$, not significant) and overall, 87% declared that they used a computer at least once a week for such work. Confidence in the use of computers for work related to units of study showed a difference at the 5% significance level between female and male ($\chi^2 = 9.35$ $df = 2$). Even though 88% of females, as compared to 82% of males, felt at least reasonably comfortable using the computer, far more males and far less females than expected (in the statistical sense) were very confident. It is a possibility, not investigated here, that any difference could be attributed to lack of consistency between males and females as to what constitutes "confidence".

Up to the date when the research was done, there had been few attempts in the curriculum studies relating to any of the other Key Learning Areas to integrate the use of computers other than for word processing (4 out of 135 responses reported web use). 57% of students mentioned that they made use of the computer for work in all four of their first-year units of study.

Despite having all been participants in a prior integration activity in which the lecturers made extensive use of the web, only 38% of students reported that their lecturers made use of computers when teaching.

Internet Usage

Students were asked to rate their likely frequency of use of electronic mail before and after completing an exercise which required them to make use of the worldwide web (WWW) for finding two resources appropriate for use by school students, describing how they would use them and communicating their findings by e-mail to their collaborating teams. There was a very significant (1%) change in reported likely frequency of e-mail use ($\chi^2 = 19.83$; $df = 4$). This is mainly due to a big drop in the number of students who initially reported never making use of e-mail. Curiously there was a drop in the number of students who said that they would use it on a daily basis. Only the females ($\chi^2 = 13.05$; $df = 4$) contributed significantly to this difference (for males $\chi^2 = 1.44$; $df = 2$, not significant). Students indicating that they would use e-mail at least once a week increased from 56% to 69%. Student confidence in the use of e-mail did not change ($\chi^2 = 7.38$; $df = 4$, not significant). Some 77% of students feel at least reasonably

confident in using e-mail; a figure expected as students had all previously made use of e-mail, although not in a web context.

The rated frequency of use of the worldwide web showed a significant difference ($c2= 31.47$ $df = 3$, sig 1%) with those rating use of the web at least once a week before the exercise (31%) and after (64%). This difference was contributed to by both sexes; females at the 1% significance level ($c2= 27.22$; $df = 3$, sig 1%, before 26%, after 60%) and males at the 5% significance level ($c2= 6.11$; $df = 2$, sig 5%, before 48%, after 83%). Change in confidence in the use of the web was not significant ($c2= 9.00$; $df = 4$, not significant). This is related to the quite high confidence levels, probably as a result of prior usage in Foundation Studies and at school. Those at least reasonably confident in using the web constitute 67% of the cohort. Confidence using e-mail as an aid for teaching increased, being significant at the 5% level ($c2= 10.79$; $df = 4$). Those that are reasonably confident in using e-mail as an aid increased from 66% to 81%. Confidence using WWW as an aid for teaching also showed a change significant at the 5% level ($c2 = 13.24$; $df = 4$). Those that are reasonably confident using WWW as an aid increased from 64% to 84%.

Students were asked to record ways in which they might use e-mail and WWW with school students. Communication was perceived as the main purpose, although use administratively and as a means of integrating instructional technology were also identified. Not surprisingly, most students viewed the main use of the WWW with school students being as a source of information, with some commenting on the interactive nature as being important.

Students were able to identify a range of problems associated with using the internet with school students. Those related to the learning environment were most reported but technical, usage and management problems were also quoted. The most reported specific perceived problem was the accessing of inappropriate material, which was commented on by 67% (90/134) of students.

CD-ROM Usage

At the commencement of the session, students were asked to identify their degree of usage of CD-ROMs. Students were then asked to evaluate a given CDROM as a teaching and learning aid and to provide a lesson outline showing clearly how they would incorporate the resource. The difference in number of CDs used at home and at school/university was significant at the 1% level ($c2= 40.64$; $df = 4$, sig 1%). Those that said they had not used any CDs were 32% at home but only 9% at school/university, whilst those who declared usage of more than 10 CDs were 23% at home but only 7% at school/university. Similar trends showed for both males and females. The curious discrepancy between these two sets of data, with 32% indicating no home use and 23% indicating high home use is perhaps indicative of the use of CD-ROMs as games by some students. Those indicating high use might well be those whose almost total use is confined to games. Confidence in the use of CDs improved ($c2= 12.99$; $df = 3$, sig 1%). Although those at least reasonably confident only increased from 89% to 92%, there was an increase in level of confidence at the level of those more than just reasonably confident increasing from 40% to 62%, the trends following the same pattern as for use of e-mail and WWW. Females showed a change in confidence ($c2= 11.80$; $df = 3$, sig 1%) in line with the trend in increase in confidence of the whole group, but males showed no significant change in level of confidence ($c2= 1.75$; $df = 2$, not significant). Before the planned activity, about 94% of the students had already evaluated CD-ROMs (in CSST 192). As a result of completing the exercise, students demonstrated a greater confidence in the evaluation of CD-ROMs, ($c2=$

12.57; $df = 3$ sig 1%). Those who are at least reasonably confident in evaluating increased from 77% to 85%, whilst there was an increase in level of those more than just reasonably confident from 18% to 37%.

Prior to this unit, students had spent two weeks in schools and it was heartening to find that 33% had already used a CD at least once with students. The unit nevertheless still enhanced students' confidence in the use of CD-ROM as an aid ($c2 = 28.68$; $df = 4$, sig 1%). Those at least reasonably confident increased from 65% to 90%, whilst there was an increase in level of those more than just reasonably confident from 17% to 43%.

Anticipated problems, as far as CD-ROM usage with school students was concerned, were mainly of a managerial nature, such as how to use one CD with 30 students in a class, although some students expressed concern over technical problems and issues related to learning.

Spreadsheet Usage

Students worked in groups to collect experimental data for the factors which affect the time of swing of a pendulum. They were then asked to transfer this data to a spreadsheet, convert the data into suitable graphical form and conclude with a suggestion for making a pendulum with a time of swing of one second. Those that use or plan to use spreadsheets increased from 11% to 35% ($c2 = 34.10$; $df = 4$, sig 1%). A similar trend was evident for both males and females. Confidence in the use of spreadsheets also increased. Those that feel at least reasonably confident at using spreadsheets increased from 55% to 82%; ($c2 = 23.58$; $df = 4$, sig 1%), while those that feel more than just reasonably confident increased from 22% to 42%. A similar trend was evident for both males and females except that there was no increase in the number of females who felt very confident. Confidence in the use of spreadsheets as a teaching aid also increased ($c2 = 20.40$; $df = 3$, sig 1%). Those who felt at least reasonably confident in using the spreadsheet as an aid when teaching students increased from 45% to 73%, whilst the biggest shift was with those students who initially lacked confidence to some reasonable level of confidence.

The main identified uses of spreadsheets with school students were mathematical and statistical, with the only KLAs specifically mentioned being mathematics and science. Disappointingly, 36% of students could not suggest an idea for how to use the spreadsheet with school students.

Class rolls and results and the tracking of student performance were identified as the main administrative uses for spreadsheets. More encouragingly, only 20% of students were unable to suggest an administrative use for spreadsheets.

Database Usage

Students were required to set up a database for an imaginary class of about ten students incorporating a checklist of practical skills (using the outcomes provided in the school syllabus) which could be achieved during the course of the school programme and mark off those likely to have been achieved in the pendulum activity.

Students who use (plan to use) a database more than once a week increased from 10% to 22% ($c2 = 20.07$; $df = 3$, sig 1%). The most noticeable change was in those who had never used (would never use) a database which decreased from 30% to 9%. The most dramatic changes were for the males - those who said 'never' decreased from 43% to 4% (remember there were

only 23 males responding in these categories) compared to females who dropped from 46% to 27%. Males who use (plan to use) a database once a week or more increased from 13% to 39% (compared to females, who remained the same at 17%). (This may be due to males being keener to experiment with something new whilst females are more inclined to want to know more about it before using it). About 57% are at least reasonably confident at using a database; this did not change as a result of the activity ($\chi^2 = 9.04$; $df = 4$, not significant). This is understandable as so few students had time to really get involved in this task. Confidence in the use of a database as a teaching aid also did not increase ($\chi^2 = 6.91$; $df = 3$, not significant), although 45% of students feel at least reasonably confident at using a database as an aid in teaching students. This result is hardly surprising as the task involved the use of a database for the teacher's administration rather than as a learning aid for students. It may be that students have misplaced confidence as far as using database as an aid is concerned. Not many students were able to report that the database would be useful for working with the data in some way. A staggering 61% could not even suggest an idea for using a database as an aid with students.

Recording student details and assessment were identified as the main administrative uses of databases, with some suggestions related to planning. Not surprisingly, 34% could not suggest an idea for using a database as an administrative aid.

Conclusion

In the education of teachers there is considerable merit in integrating across traditional disciplines. The results reported in this paper indicate that integrating instructional technology with curriculum studies improves student attitudes towards, and confidence in, the use of various techniques and suggest that students are likely to incorporate such activities as those reported. We therefore conclude that varied experiences using computers and directly related to pupil learning in the discipline areas should be included in the teacher education programme. There would be benefit in spreading activities over a longer time; the students felt swamped by the heavy concentration of activities in a three-week period.

The science staff involved saw the activities as a significant contribution to their own professional development and it is clear that there will be much more integration, both across disciplines and with instructional technology, in future years with this programme and in other programmes, such as the Graduate Diplomas in Primary and Secondary Education.

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