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Citation: WILLIAMS, P.J., 2008. Outcomes of students’ participation in university based courses. IN: Norman, E.W.L. and Spendlove, D. (eds.). The Design and Technology Association International Research Conference, [Loughborough University, 2-4 July]. Wellesbourne : The Design and Technology Association

Additional Information:

- This is a conference paper

Metadata Record: https://dspace.lboro.ac.uk/2134/3538

Publisher: © The Design and Technology Association

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Outcomes of Students’ Participation In University Based Courses

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Abstract
This research measured qualitative and quantitative outcomes for students involved in a university based Engineering course of study. Ten Year 11 students studied with third year design and technology teacher trainees who engaged in the course through planning and content delivery, and worked with the students on a robotics design project.

The research documented the procedures followed in the project, and the qualitative and quantitative outcomes for students from both the high school and the university.

The hypothesis which underpins this research is that this project is advantageous to both high school students in terms of:

- the development of their engineering knowledge,
- achievement of outcomes, and
- career awareness;

and university students in terms of

- preparation and delivery of theoretical knowledge,
- curriculum understanding,
- student management, and
- pedagogical technique development.

The research questions that were considered in the project were:

a. What are the advantages to high school students of participating in a university based course?

b. What are the advantages to teacher trainees of working with high school students in the delivery of a unit of study?

c. What are the impediments to the provision of integrated educational activity between a university and high school?

The following methods were used to collect the data:

- University student focus group.
- High school student focus group.
- Student records.
- Pre and post treatment surveys

The following data was collected:

- High school student levels of achievement before and after treatment.
- University and high school students’ evaluations before and after the treatment.
- University students unit grades and course averages.

Research Context
Recent strategic developments at Edith Cowan University and the adjacent campus of Mt Lawley Senior High School have been aligned with the development of an educational precinct encompassing both institutions. Physical links have been made between the institutions as well as links between staff, students and courses. The project described in this research was developed in this context.

Both Year 11 high school students and third year university students were studying robotics as part of their Engineering studies. The high school students were enrolled in Engineering Studies Unit 2B which they would continue in Year 12 as a university entrance subject. The university students were training to be Design and Technology teachers of Engineering, and were enrolled in the unit ‘Engineering Design 2’ in their third year of a four year course. It was proposed that the two groups study together in the university workshops, with Design and Technology teacher trainees engaging in the course through planning and content delivery, and working with the students on a robotics project. The project statement was:

A new rehabilitation centre recently constructed with a pool and gymnasium for people recovering from various mental and physical conditions has been designed with one major fault. The pool designed to aid recovering patients from their debilitating conditions was built with no easy entry and exit points other than the standard stairs seen on pools. The centre has asked the students to design a system to aid people without the ability to use the stairs of the pool, an easy and safe way of entering and exiting the pool: a robotic chair lift.
This was a 12 week course, and the students were provided with a prototype, the patterns from which they could either use or modify to suit their designs. The prototype functioned by the use of a range of limit switches, the project task was to program the mechanism to function automatically. This research will document the procedures followed in the project, and the qualitative and quantitative outcomes for students from both the high school and university. The research findings will form the basis of future collaboration between the Design and Technology areas of the university and the high school, and it is anticipated that this project will develop to become a sustainable feature of the education precinct.

Aim of the Research

The hypothesis which underpins this research is that this project is advantageous to both high school students in terms of:

- the development of their engineering knowledge,
- achievement of outcomes, and
- career awareness;

and university students in terms of

- preparation and delivery of theoretical knowledge,
- curriculum understanding,
- student management, and
- pedagogical technique development.

The consequent research questions are:

d. What are the advantages to high school students of participating in a university based course?
e. What are the advantages to university teacher trainees of working with high school students in the delivery of a unit of study?
f. What are the impediments to the provision of integrated educational activity between university and high school?

Literature Review

Most educators agree that neither schools nor universities alone can accomplish the goals of effective teacher preparation (Hall, 1993; Lieberman & Miller, 1990; Ruchcamp & Roehler, 1992). Working together, school and university teachers encourage each other to develop innovative strategies. Morris and Nunnery (1996) found that teachers who engaged in teacher preparation activity became more willing to share and work with their peers to improve the teaching and learning process. Hall (1993) found that collaborative partners are concerned with concepts of reflection, co-operative relationships, and equity. Thus there is a basis for seeking an educational advantage for Edith Cowan University and Mt Lawley High School teachers in this project.

Collaboration has been shown to be a significant factor in the professional development of novice teachers (Ball & Rundquist, 1993; Lieberman, 1995). Partnerships that are formed between universities and schools provide opportunities for developing roles and responsibilities and new ways of constructing teacher professional growth. Both school and university teachers become resources for information, both sharing the responsibility for teaching and preparing future teachers. “These collaborations are based on mutual trust, willingness to communicate, flexibility, and a dedication to renewal in the pursuit of excellence in teaching” (Grisham, et al., 2002). Collaboration between universities and schools is enriching and challenging because it “seeks to reshape fundamental values, beliefs and paradigms for schools and school change while negotiating two worlds and inventing new programs” (Darling-Hammond, 1994:137).

According to research, there is also an advantage to the trainee teachers. Grisham, et al (2002) examined evidence of (1) reflective thinking, (2) risk taking, (3) collaboration, and (4) continuous learning in teachers who graduated from a training program with strong school links, and determined that these four characteristics remained sustainable after 15 years of teaching practice. McKibbon (1999) found that teachers who have significant interaction with students during their training tend to be more diverse than traditional teachers, stay longer in schools, and move to leadership positions faster.

A small number of research studies (Williamson & Cowley, 1995; ASTEC, 1996; Ward, 1997) have been conducted on the topic of professional development for teachers of technology education. In commenting on the particular needs generated by a new curriculum, ASTEC (1996) argued that the changes in terms of the introduction of a design approach has more far-reaching implications for teaching and learning than earlier curriculum initiatives which tended to concentrate on changes to content. In the context of this study, both the content (engineering) and the approach (design) are new to teachers.

A professional development project in Victoria (Ward, 1997) indicated that the provision of appropriate professional development leads to improvements in teaching and learning when co-operation is fostered between different levels of schooling and between different stakeholder groups. The sustainability of changes sought must be considered in the design of projects. Christensen (1997) outlined two types of innovations: sustaining and disruptive. Sustaining innovations
are those which are congruent with existing systems and which can be supported and sustained over time without systemic change, but accompanied by supportive structural and cultural changes (Schlechty, 2005). The aim in this project is for sustainability between the institutions involved.

**Research Plan and Methods**

This project involves students from a high school working with university design and technology teacher training students. Both groups were studying engineering and worked together on a robotics project. In addition, the university students delivered relevant content through presentations to the group, and were involved in preparing the high school students for their external examination.

The following methods were used to collect the data:
- pre and post treatment surveys;
- university student focus group;
- university student portfolios;
- high school student focus group;
- student records.

In addition, the following data was collected:
- high school student levels of achievement before and after treatment;
- university and high school student's evaluations before and after the treatment;
- university students unit grades and course averages.

**Data Analysis and Discussion**

The following discussion integrates the various sources of data that were collected during the project: a pre and a post treatment questionnaire, focus groups and the grades achieved by both groups of students.

As the data was collected and analysed, the following categories developed as organizers:

1. Environment – workshop facilities, equipment, timing, etc.
2. Group Work – how each of the groups functioned.
3. Instruction – the discovery learning model; teaching modules delivered by university students, etc.
4. Assessment – were the assessment requirements clear, fair.
5. Additional comments – after asking a series of planned questions, both groups were asked for any additional insights.

This organization provided the data for the following conclusions and recommendations. Overall, the university group had more to say with the focus group discussion significantly more extensive than the high school group. This was not unexpected.

**1. Environment**

The environment in which the class took place was the university Design and Technology space. This consists of two general purpose workshop areas, with adjacent specialist facilities such as computing/design, wood machining, metal machining, CNC machines, spray finishing, welding and various tool and storage rooms. The high school is adjacent to the university campus, and involves a 2-3 minute walk to move to the university workshop from the high school.

For the high school group the environment in the university workshop was a positive factor. They indicated in the post-treatment survey that they liked not being at school, they enjoyed the mentoring by the university students, and the CAD/CAM equipment to which they had access.

The following comments are indicative:

"Far more advanced than our workshop...
...The whole of the thing was pretty good... for all the parts we had to do... it was really good..."

The only negative indicated by the high school group was that the workshop time was outside of their normal school hours.

The university group was initially positive about the suitability of the workshop facilities, but had a few suggestions for improvement which related specifically to the electronics part of the project. Three of the four groups had access to a laptop computer which was owned by one of the students in each group, consequently the group which did not have access to a laptop felt that they were at a disadvantage. The following comments are indicative:

"Yeah, you kind of needed to have a laptop in each group, didn’t you?"
"You’d have to load PICAXE on it."
"And you’d have to get that same one back each time – because you have to plug the picaxe cord into the same COM port and all that sort of stuff..."

**2. Group Work**

Coincidently both the university and the high school groups had nine members each. These were split into four project teams; three teams with two from the high school and two from the university, and one team which had three members from each. This aspect generated a great deal of discussion within both focus groups. It is fair to say that both groups
showed frustration related to the group work, particularly the university group.

The university group felt unclear about the nature of their role/relationship with the high school students: were they teacher, mentor or peer? At the beginning of the semester, some instruction was given to them about their role, but it was not equivocal and up to them to organize in a way which suited their group. For some groups this role organization did not eventuate.

“That to me was confusing... How much was supposed to be instruction - and how much were the kids supposed to do... and how much were we supposed to do...”

The university students were also frustrated with the lack of motivation shown by the high school students; the majority were surprised and disappointed with the effort demonstrated by one or all of the high school members of their team. The university students had successfully passed a number of practice teaching experiences in schools and so had an awareness of high school student motivation, but nevertheless it surprised them.

“...Because I found myself - not bragging - but I found myself doing most of the work... and the high school kids just sitting back and going 'yeah OK, what are we doing next...”

"the boys said: I'll do that - and they didn't do what they said they were going to, they had two weeks to put some limit switches on the model, and they failed, and they actually took us backwards, because they left the whole product in pieces... gear boxes dismantled, the whole thing...”

The high school students were generally more comfortable with the way their groups had worked, but two of the team representatives on the focus group indicated that they were unsure about how to proceed when a particular university team member was absent from the team. These were the leaders in the group, but most of the knowledge needed for progress also resided with them.

“Well I think our group worked pretty good, but when S wasn’t there... we weren't completely sure what we had to do... because in wasn’t really explained to us, like 100%... so we didn't really get much done on days that S wasn't there...”

“...we actually weren't informed enough... because we...had to make so many changes...we didn’t really have like a plan to follow... were like making it up as we went along...”

One group took a different approach to the others which seemed to be more satisfying for the group members. They decided to approach each task as a group, rather than assigning tasks to individuals within the group. All felt that they had come out of the experience with lower expectations of what level of performance might be expected from a high school student.

“Well I reckon in our group, we tried like...splitting up the load evenly...like everyone doing...like everyone would have a job...”

From the high school perspective:

“We tried to work together as a group with equal responsibility, and equal input through the whole thing...whatever ideas we’d come up with, we would discuss them, as a group...”

From the university perspective:

“S and I decided from the start that we wouldn’t appoint a group leader, that we would try to keep everything equal – C and N both seemed quite mature, so we thought that we could all work together on the same level, and experience the whole lot together...”

Open ended responses to the survey clearly indicated that the university students had developed a deeper understanding of high school students:

“Contact with the students has helped me have a more realistic view of student’s attitudes and abilities.”

“It has allowed me to question the students on a more personal level and receive truthful answers.”

An item on the post treatment survey asked the university students to comment on the group work. They suggested that the groups would function better with more external guidance in terms of roles of group members and the establishment of periodic goals to be achieved. This was reinforced with similar comments by the high school students on their post treatment survey.

“Yeah – I think that the unit could have benefited from a little bit more structure - I feel the same as you: that it wasn't clear to me what my role was, in terms of the ML kids, because I wasn't their teacher...”
A final comment from one of the university students represented a summary of their feelings about the group organization:

“Yeah – I think that the unit could have benefited from a little bit more structure – I feel the same as you: that it wasn’t clear to me what my role was, in terms of the school kids, because I wasn’t their teacher…”

3. Instruction

This category focuses on the two groups’ responses to the content which was delivered and the instructional organization of the unit. There were two apparent learning objectives in the content associated with this unit:

• Learning associated with solving the design problem – the design and manufacture of the robotic project, including the electronic programming (PICAXE) part of the project.
• Learning associated with the broader outcomes of the Engineering Course of Study. For the high school students this was the Engineering 2B unit and for the university group, it was the Engineering Course of Study in general.

A discovery learning approach was adopted by the lecturers with the groups. Basic information was presented, and sources of information were given to the groups to access when needed according to the group’s stage of progress. This was not seen as the most efficient method of learning.

“I think we’ve done it once or twice already… and we just seem to keep repeating ourselves… now whether it was put on for the ML kids, I don’t know…”

The content rationale for the high school students was that this would assist them in their end of year external examination, and for the university students, it would enable them to develop expertise and a deeper level of learning in this course that they would have to teach after graduation. The university students’ responses on the post treatment survey indicated that the unit ‘has helped me to understand the focus and structure of the curriculum’ (X= 3.27 on a 5 point scale). This was a significantly higher score than their anticipated understanding on the pre treatment survey (X= 2.66). The majority indicated on the post treatment survey that becoming involved in this unit had made them more likely to teach robotics as a part of the Engineering Course.

The university group:

“I feel like we could have had, four, five, maybe even six weeks of structured activities in PICAXE, and we might have come close to sorting that problem out… but I feel like I haven’t come out of this with any clear idea of how much the high school kids know about PICAXE… I suspect it’s not a lot…”

“Because you are experimenting, and if you don’t have a path to go down, you’ll spend hours going in the wrong direction…”

4. Assessment

The group portfolios and projects were assessed jointly by the lecturers. The university students were further assessed on their individual portfolios and their mini lesson presentation and handout. The table below is part of the assessment criteria that was used on the group work.
There was not a great deal of feedback from the high school group regarding assessment, but the following two comments indicate some confusion.

“Personally, I’ve been confused about the assessment…”

“It… it was a bit… it threw us off a bit in the first half… well we’ve got this one, how are we going to improve on it… or… we had a lot of different design ideas coming out at the start…”

All members of the university focus group indicated that they had been unclear about the assessment for the unit. This discussion then spilled over into frustration about the perceived lack of effort from the high school group. The following comments are indicative of the discussion which took place.

“Like it says: 10 marks for whether you got the PICAXE going… well hang on, how can you give a mark out of 10 if you’re not taught how to use the bloody thing!… and to me that’s not fair…”

“I was a bit confused about what the relationship between the group portfolio and the individual portfolio was, and um… it turned out that we weren’t being assessed on the group portfolio, but we were required to input to it – I think that if you have got to input, then it should be tied to some assessment, so there is an incentive there – even if it was only 10%, just… to me that is logical…”

All the students, both university and high school, performed at least at a level equal to their course average in the tasks for this project. The university students’ course average was 70.4%, and their average performance in this project was 77%. The high school students received marks in letter grades, 50% of whom scored the same and 50% greater than their average grade. Of course caution must be exercised in the conclusions drawn from student grades as so many variables are involved, but the students marks did not suffer as a result of this experimental project.

5. Additional Comments

Having covered the areas which had been targeted for discussion in the focus groups, both groups were asked for any
additional comments. Once again, the university group had several ideas, while the high school group made only limited comment. Given that most of the feedback from the university group had been somewhat negative, it is interesting that when asked the open questions: what was good?, what was not?, what might be done differently next time? The first response is a positive one:

“I feel that it's... a good idea to give it a shot”
“Oh absolutely.”

The discussion then came back (again) to the lack of motivation that the university group perceived in the high school group. Because the joint class was after school hours, the high school students were given the equivalent time, when they were scheduled for this class, as free time.

“They didn’t use that extra time... but we have... like our thinking is different... that our free time that we have, we put towards university work – getting things done... they don't!... they've got this free time...”

The only comment of note from the high school group forum was that some were not happy about coming over to the university after normal school hours. In the post treatment survey, all the high school students recommended that the arrangement of studying at the university is beneficial and should continue, the best aspects being the facilities and working with the university students.

And finally, asked: So would it be fair to say that: we all feel like it was a worthwhile unit... that it should be continued with, in some form?
“Yeah sure...”
“I think it should be given another go... but I think it... the lecturers and teachers need to really get together and plan it a little bit better...”

The researchers were interested to determine the effect of the experience on the high school student's career aspirations. One item on both the pre and post treatment surveys asked them about their intent to study at university at the completion of their secondary schooling. They were very positive about this in the pre treatment survey (X = 4.33) but less positive at the end of the unit (X = 3.87). The reason for this is not clear, but it would seem that this was not a positive experience in encouraging students to pursue university study.

Conclusion
The overwhelming conclusion is the disparity in expectation between the two groups. The high school group expected to be mentored, and were grateful when they got what they expected, and the university group expected the high school students to contribute equally to the team activities in achieving the task.

As a result of this disparity the university students became very frustrated when the high school students failed to contribute to the team at a level which they perceived as adequate. The exception to this observation would be in Team 3 which decided to only progress together as a team, at the pace of the high school students. The high school students in Team 3 were very positive about what they got from the project:

“Yeah definitely!... we all got on... C and I definitely benefited from our experience...”
“Yeah... if we didn’t know how to do anything, C and S would be right beside us...”

All of the university students in the focus group felt that they had come out of the unit with lower expectations of what might be expected from a high school student. This is not entirely a negative outcome. But if the expectations that the university group had of the high school students were unrealistically high, it may be equally true that the high school group were not prepared to contribute sufficiently for this to be a group project.

Whatever may have been the disconnect between the expectation of the two teams, the fact is that none of the teams were able to produce a robotic arm which performed the task. Two of the teams decided that they needed to design a new model from scratch, and spent a great deal of time on the physical aspects of the product. Consequently these groups were left with little time to do the programming of the robotics.

One group adapted the existing plans to produce a simplified version of the demonstration product – using two motors instead of four. This group made the most progress with the electronic programming. But with no specific directions regarding how to integrate the respective elements of their programming boards, were unable to produce a product that performed in the required way.

Both groups were asked in the post-treatment surveys whether they would recommend the continuation of the activity in future. The high school students were also positive, having felt

To summarize the findings in terms of the research questions:

a. What are the advantages to high school students of participating in a university based course? While the career education value of the experience seemed to
be limited, the students felt that they had gained a broader knowledge and understanding of engineering through working with people and in facilities they would not normally have access to.

b. What are the advantages to university teacher trainees of working with high school students in the delivery of a unit of study? The university students unanimously responded positively to continuing the experience, having gained a deeper understanding of students and improving their behavior management skills.

c. What are the impediments to the provision of integrated educational activity between university and high school? The main impediments related to clear role definitions for both groups and designing a task that is achievable within the time frame.

Recommendations

The following recommendations result from the analysis and conclusions, and will be incorporated into the project when it is again conducted.

1. Effort should be made to match the expectations of the respective groups. This could be a directive to the groups which was agreed between the lecturers, or it could be more democratic and involve a discussion and contract made in the opening week of the unit.

2. Restrict the scope of the project to improve the likelihood of the teams being able to complete the product. For example, focus on either the robot arm construction or the programming, and then fully support this approach. If the project is about programming, then limit the innovation in the structure of the model, provide a full set of drawings to support the production and assembly of the model. If the project focus is about innovation in the physical aspects of the robotic arm, then keep the programming aspect very simple, or even optional with the robot operating on switches.

3. Make the learning outcomes of the mini lessons more explicit. These could be specific to the robotic arm, or to the Engineering Course. Make the university students aware that what is being delivered as theory to the high school students is directly related to the Engineering Course.

4. The equipment available to the groups needs to be appropriate and equitable. The groups need access to basic electronic equipment such as soldering irons, multimeters, and modeling boards. The lack of access to a laptop appeared to be a significant impediment to one of the groups.

5. Make the assessment more explicit. Having a group portfolio as well as an individual portfolio was confusing; if the group portfolio is important, then some discussion or guidance as to how team members contribute would be useful.

While both groups expressed some discomfort with the timing, and had various complaints about organization, all members of both focus groups stated, together with indications from the survey, that the unit was worthwhile.

References


California's Teaching Internships. Kappa Delta Pi Record, 36(1), 8-11.

Appendix: Surveys
University student Surveys
Pre treatment survey
Questions 1-4 rated on a 1-5 scale
1. I have a clear understanding of how to prepare and deliver the theoretical knowledge associated with the Engineering CoS
2. I understand the focus and structure of the curriculum which underpins the Engineering CoS
3. My confidence and performance in managing student relationships will improve through working with the students from MLSHS
4. Working collaboratively with existing teachers and my fellow 3rd year students provides an opportunity to witness a range of pedagogical techniques

Questions 5-7 required a short answer
5. Do you believe that working with the MLSHS students will assist your teacher training more than a typical academic unit of study? State Yes or No, and give reasons for your answer.
6. Having (nearly) completed this unit, would you be more or less likely to use robotics as a context in your design and technology teaching?
7. Make one constructive suggestion for how the group-work in this unit could be improved.

High School Student Surveys
Pre treatment survey
Questions 1-4 rated on a 1-5 scale
1. I intend to study at university when I complete year 12
2. I have an intended career path when I complete year 12, If so, what:
3. Working in the university environment will be more challenging than working in my usual school environment
4. Working in the university environment will help to develop my engineering knowledge
5. Working in the university environment will help me to achieve my goals
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Questions 6-7 required a short answer

6. Do you believe that studying at the university campus will assist in your career awareness? State Yes or No, and give reasons for your answer.

7. What do you believe will be the best aspect of studying at the university campus?

Post treatment survey
Questions 1-4 rated on a 1-5 scale

1. I intend to study at university when I complete year 12.

2. My intended career path when I complete year 12 is the same as indicated at the start of this unit.

3. Working in the university environment is more challenging than working in my usual school environment.

4. Working in the university environment has helped to develop my engineering knowledge.

5. Working in the university environment has helped me to achieve my goals.

Questions 6-9 required a short answer

6. Do you believe that studying at the university campus will assist in your career awareness? State Yes or No, and give reasons for your answer.

7. Would you recommend that MLSHS student continue studying at the university campus?

8. What has been the best aspect of studying at the university campus?

9. Make one constructive suggestion for how the group-work in this unit could be improved.