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Enhancing Technology Education at Surf Science: A Collaborative, Problem-Oriented Approach to Learning Design, Materials and Manufacturing of Surfboards

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This paper presents the results of a study on the influence of blackboard assistance and lecturer's initiative on student's achievements (measured via quality of individualised surfboards). In addition it looks at student attitudes to project related issues in technology education, derived from the pre-test and post-test experiments and surveys. The researcher employed a 2-group design with two pre-tests and one post-test experimental scenario. The results were analysed for homogeneity of variances and means by using Fisher test and t-test, respectively. It was found that the students from pre-test (blackboard-oriented) group achieved the 17% lower score and the 70% greater variations in score variances compared to the data obtained from the post-test (supervisor guided and video-enhanced) group. Furthermore, the students from the latter group believed they were better prepared for solving technically oriented problems in design and production. They also appreciated help from experienced supervisors and video-links, and reported more satisfaction with their individually designed surfboards.

Keywords: Technology Education, Surf Science, Problem-Oriented Approach, Learning Design, Materials, Manufacturing

INTRODUCTION

The Surf Science and Technology (SST) course is a unique one. It was established at Edith Cowan University (ECU) - Faculty of Regional Professional Studies (FRPS) in South West Campus Bunbury in 2002. It is one of only two such courses offered globally – with another one being conducted in Plymouth in England. When conducting this study, there were around 60 people enrolled at the ECU-SST course. All of them are dedicated surfers who are often concerned about influence of their surf-craft on the surfing performance. Consequently, they are 'searching' for the 'best' surfboard which would suit their surfing ability and style. Traditionally, improvements in the surf-boards are sought via changes in material and design features (Orbelian, 1987). Material changes were found (Warshaw, 2004; Wang *et al*, 1996; Manning *et al*, 1993; and Audy *et al*, 2005) to affect the mechanical properties (Warshaw, 2004; Wang *et al*, 1996; Manning *et al*, 1993) and the service life (Audy *et al*, 2005) while the design changes were shown (Orbelian, 1987; Warshaw, 2004; Hornung and Killen, 1976; and Haines *et al*, 2004) to affect the stability, buoyancy and manoeuvrability. Because of this, the balance between the material and design features is very important from both economic and performance point of view. Recent investigations at ECU (Audy *et al*, 2005 and Haines *et al*, 2004) have indicated that surfboard manufacturers and users did not reach the final agreement about the effects of particular design features and material on performance.

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Consequently it looks like 'the best' surfboard is the one that respond to the type of performance required by its surfer. Bearing the above in mind, over the past three years, a considerable attention has been focused on development of innovative technology education for collaborative team-oriented and problem-focused learning in practical work associated with surfboard design and manufacturing process. The driving force for it was to prepare an innovative teaching and learning module that would link the students' personal experiences with their individual needs. In addition, it was intended to give the students the opportunity to work individually and/or in teams to realize how to apply theory to real situation, and expose them to real life of research thinking and industrial working. In order to create such 'innovative' teaching and learning scenario a literature survey has been conducted. The most important findings from reported data on technology education are summarised below.

Reported Data on Technology Education Relevant to Experimental Research Design

The literature survey has shown that the considerable efforts made by technology education lecturers to identify and investigate actual technological practices of students required analysing the current models of design process (Williams, 1996; and Taylor 1992). It has been suggested that technology education should be based on innovative, and risk-taking real-life like problem scenarios (Mawson, 2003) that need to differ for low number of students in a group (McCardle, 2002). Some academics Losike-Sedimo and Reglin (2004: p.222), Oven (1998), Chou and Lin (1998), Burton (2005) warned that teaching and learning out-puts of students belonging to the same group may vary widely due to their diverse backgrounds and skills. There have been some suggestions to encourage team working skills in planned problem based learning scenarios with positive results obtained by Sayer *et al* (2006: p. 158) and Bennet *et al* (2000). Computer enhanced teaching and learning activities including e-learning seem to be frequently used in technology education as reported by Fletcher-Flinn *et al* (1999); Losike-Sedimo *et al* (2004); Reid *et al* (2005: p. 77); Jackson (2004); and Audy *et al* (2005). Literature survey confirmed that the use of computers and e-learning will *firstly* improve students' retention (Bray, 2004; and Hofstede, 1997), and *secondly* help to eliminate a need for empirical testing of product performance replacing this activity with computer enhanced modelling and predictions (Audy *et al*, 2005). The latter will also reduce students' workload and provide enough time to complete the task (Audy *et al*, 2005; and Inglis and Bradley, 2005). It has been suggested by Burton (2005) and Fritz (1996) that consistency in marking is important, and indicated that an assessment is reliable if a student's attempt is awarded similar grades by different markers or the same marker at different point in time. The literature survey has also shown that different questionnaires have been used by academics to evaluate students' research and teaching and learning progress. Some of them, Guilfoyle and Halse, (2004), and Wang and Webster (2004) appeared to experience some difficulties when analysing out-puts from an open type of questionnaires and leading questions. The most often used data evaluation methods were descriptive statistics and multivariable analyses of covariance for analysing group data with respect to more than one dependent variable. Bearing in mind the above information derived from a wide variety of reported sources, the experimental research design was set up as shown in the following Section 2.

Experimental Research Design

The experimental research design is shown in Figure 1. Participants in this study were the surf science students enrolled in the Surf Equipment Design and Materials course unit at ECU-South West Campus based in Bunbury. The task involved designing and producing a wide variety of individual surfboards according to surfing skill and needs of the students. Ten weeks -three hours a week- were allocated for this activity. The first five weeks were dedicated to the lectures/tutorials and demonstrations on design and production of different type surfboards. The rest of time was allocated for shaping-laminating and glassing of individually designed surfboards.

The students were assigned to the two treatment groups – A (control one) and B (experimental one). The former, A, consisted of 15 students, the latter, B, consisted of 13 students. The study was conducted in three stages involving two pre-test experimental designs (A_1) and (B_1), and one post-test experimental design (B_2). The pre-test experimental designs were based on verbal instructions, via three hours seminars (lectures/tutorials and demonstrations), delivered in four weeks, and written instructions distributed to the students through handouts and web-enhanced blackboard. For the pre-test experimental designs (A_1) and (B_1) the seminars were not compulsory and the students had a choice to relay on the information from both handouts and blackboard if they decided to do so. For the post-test experimental design (B_2) students were encouraged to attend all seminars, and to participate actively in researching and evaluating a wide variety of scenarios relevant to surfboard making activities *firstly* from four different videos and *secondly* from two – 3 hours - demonstrations each conducted by a different professional shaper. After this the students were asked

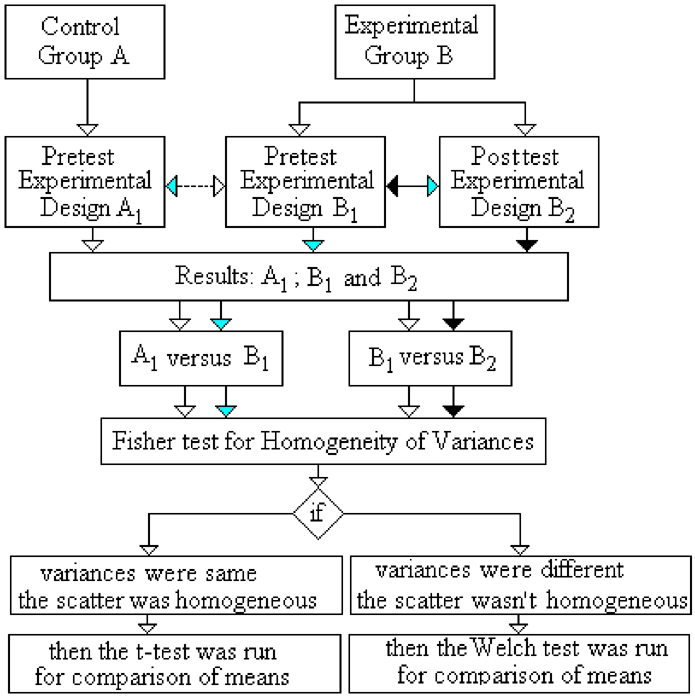

Figure 1. A key to experimental design and subsequent data analyses

to work individually or in group and share their ideas and knowledge when working on their surfboards.
The independent variables examined in this study were learning styles. The dependent variables were achievement scores and attitude scores. Achievement scores were the results (marks) that students obtained from their individually designed and manufactured surfboards including marks for their final reports. The main measures in assessment were: product quality (both intended and final), with comments on reported data on surfboard design and procedures and data analysis. The 50% was the highest possible mark to be achieved by a student for his/her surfboard and report. Other 50% were allocated for the exam.

The attitude scores were examined from a questionnaire designed in a way to allow studying a relationship between attitude achievement and motivation, if any, occurring in an open innovative and effective environment. It consisted of multiple choice questions and questions requiring written responses to a variety of issues relevant to individual learning. The students are asked to comment on (a) their designing, shaping, laminating and finishing skills (and improvements, if any), and (b) benefits gained from team work, handouts, DVD's and videos. Some additional questions were included in the questionnaire to investigate the students' interest in doing their honours, masters and PhD degrees at ECU in design and production (surfboards, fins and boats), materials (composites, laminates and recycling materials), testing (mechanical properties, failure modes, wear and service life), and modelling (simulations and prediction associated with product design and performance measures).

RESULTS

Table 1 shows variances, standard deviations, and mean – project assessment – scores including the results from comparison of variances and means across the two groups from the pre-test (A_1 and B_1), and one group from both the pre-test (B_1) and the post-test (B_2).

What follows are some examples of questions in questionnaire distributed to the students' and their responses to the survey.

Table 1. Results from descriptive statistics, *test* for equity of variances and *t-test* for equity of mean values on the results from pre-test and post-test experimental designs

Results	Variances	St. dev.	Mean
A_1 (dof=14)	65.2	8.1	37.4
B_1 (dof=12)	53.3	7.3	38.3
B_2 (dof=10)	19.9	4.4	44.8

A_1 & B_1	B_1 & B_2
F=0.81; $F_{critical}$=0.37	F=0.36; $F_{critical}$=0.34
Scatter different	Scatter different
t=0.28; $t_{critical}$=1.7	t=2.7; $t_{critical}$=1.7
Means similar, 37.85	Means different

(1) What follows are some examples of questions in questionnaire distributed to the students' and their responses to the survey.

Everything, from drawing out a template, cutting out, shaping laminating, sanding + finishing. There were so many facets involved it would have been a completely unsuccessful venture without Javo's guidance + interaction with other students.

In comparing what methods i used from my first board i was able to refine my techniques across all areas

(2) Did you benefit from sharing information between the group members?

If yes HOW – able to work things out together, help each other and benefit from others' experience even if they are only 1 step ahead. Also helping others laminate their boards gave more experience therefore more confidence.

Learning there are many different methods adopted by various people. Everyone does it different.

yes by asking people what have already shaped boards. because I have not shaped one before

Sharing ideas and making templates with the help of others

(3) What did you learn from this teaching and learning activity?

Everything, from drawing out a template, cutting out, shaping laminating, sanding + finishing. There were so many facets involved it would have been a completely unsuccessful venture without Javo's guidance + interaction with other students.

In comparing what methods i used from my first board i was able to refine my techniques across all areas

(4) What type of teaching activity and supporting material did you find most useful?

Watching proffesionals do what they do allows basic pick up of their techni

The DVD shaping & glassing 101 were great, most of the tips and tricks in the video I used in shaping my board

It was useful, however I fond Javo's guidance more beneficial as it was 'hands on' in a real working environment.

(5) What would you like o change if you could do this job again?

Go slower with glass job.

There is a need for surf science to invest in better equipment for the activity.

(6) Would you recommend these activities to your friend?

Yes- a really good learning experience

No. not at home but under supervision at UNI definately because chemicals are dangerous

(7) Do you think that what you learned would be useful in your further study or work?

Absolutely. because actively taking part make the learning process easier.

Hopefully, I would like to be a shaper

Yes helpful in 2nd semester of second year

If I went into shaping or glassing of boards it would definantly be useful

(8) Would the strategies used in this T&L program be successful in teaching, laboratory work etc?

Yes, however we benefited from the low numbers of students. A group of >10 would be difficult.

Some but not all, the 'experienced' members were not 'experienced' enough!

Yes Team Work helped The Laminating process

(9) Describe the most significant difficulties you experienced when doing this project

The glassing process is very tricky I had lots of trouble with air bubbles

Finding some of the correct tools, eg. a sander w/ a soft pad to finish the board so not to sand too much off the finished project

Glassing the board on my own without assistance (everyone was busy) & making a few mistakes

Trying to help others with their questions when they seemed not to listen to the answer.

Obtaining a symetrical board. (template, rails rocker etc equal on both sides)

(10) Would you be interested in doing a postgraduate degree at ECU in product design, material and testing?

probably Masters Design + production + testing Materials testing & design of surfboards

boards fins boats materials history

The set of photographs in the following Figure 2 depicts the several stages in the surfboard making processes where the students experienced the major difficulties. The blank spaces in the photographs were used to protect identity of students.

Tables 2 to 5 show the percentage analysis for the two groups of students referring to the dimensional features of their individualised surfboards. Table 6 shows 'production' time data relevant to the shaping, laminating and finishing activities of the individually designed surfboards by the groups A and B in the pre-test (A_1 and B_1) and post-test (B_2) experimental designs.

Table 2. Tail shapes relevant to ECU surfboards produced by Group A and B

Tail Shapes	Swallow	Rounded Pin	Rounded Square	Diamond	All round	Swallow with wings	Square
Group A [%]	47	40	7	0	7	0	0
Group B [%]	44	11	11	6	6	6	17

Table 3. A type of surfboard design produced by Group A and B

Surfboard Design	Three fin fish/short board	Twin fin short board	Mini Gun	Mini-mal	Malibu	Bodyboard
Group A [%]	67	13	7	0	0	13
Group B [%]	71	6	0	17	6	0

Table 4. Some of the design data relevant to ECU surfboards produced in 2004 and 2003

6'2"x19"x2$^5/_8$	5'10"x19"$^1/_2$x2$^3/_8$	6'6"x19"$^3/_{16}$x2$^9/_{16}$	6'3"x18"$^1/_2$x2$^1/_4$	6'0"x18"x2$^1/_4$
6'4"x18"$^1/_2$x2$^1/_2$	5'11"x18"$^3/_4$x2$^1/_2$	6'2"x19"$^1/_2$x2$^1/_8$	6'0"x18"$^3/_4$x2$^1/_2$	6'3"x19"$^1/_4$x2$^2/_4$

(a) Cutting the shape
(~20%, mostly females)

(b)Skinning the blanks
(~30%, both genders)

(c) Shaping the rails
(~70%, both genders)

(d) Working with Glassed-in Ornaments (~60%, both genders)

(g) Drilling Holes
(~30%, mostly females)

(h) Positioning and Setting up the FCS and the Glassed-on Fins
(~40%, both genders)

Figure 2. Photographs showing some stages in a surfboard making production with percentage and gender of students experiencing most difficulties

DISCUSSION

Table 1 showed that the variances of the result 'score' data between the two groups in both cases (A_1 and B_1) and (B_1 and B_2) were not equal or homogeneous. In contrast, differences in mean values of score *i.e.* 37.4 for A_1 and 38.3 for B_1 were found to be not significant at 95 percent and higher confidence level. This suggested that one common grand mean of 37.85 will apply for the two groups from the pre-test experiments. The relatively small (but statistically significant) differences in variances, 65.2 and 53.3, and the same grand mean value of 37.85 for both Types $A_{1\ (dof=14)}$ and $B_{1\ (dof=12)}$ from pre-test indicated that students had diverse skills but same background. The post-test experiments (video assistance and lecturer's interactions) appeared to be very successful in improving students' achievements. The student scores improved (increased) by about 18 percent (from 37.85 in A_1 and B_1, to 44.8 in B_2). In addition the standard deviation in mean score was reduced from 8.1 for the pre-test A_1 and 7.3 for the pre-test B_1 to 4.4 for the post-test B_2. This improvement was found to be statistically significant at 95 percentage and higher confidence level.

From Tables 2 to 4 it is evident that a Type 'short' and 'swallow' tail - three fin - surfboards were the most popular in both groups. This is perhaps not surprising given that Simon Anderson – Sydney Shaper, presented his three fin surfboard design known as 'thruster' with a great success in "Bells Beach' in 1981. In addition, the most of ECU surfboards were those of a concave shape and had hard rails on tails and soft rails from middle to

Table 5. Templates used for shaping ECU surfboards by the Group A and B

Templates for shaping obtained	from 'reported' surfboard design features	from friends and/or shapers	by copying from an existing board	by designing and calculating
Group A [%]	55	25	6	12
Group B [%]	10	75	10	5

Table 6. Comparison of time (average and range in hours) needed for finishing individually designed surfboards by the groups in pre-test and post-test experimental design

		Surfboard making Activities [hrs]			
Group	Test Design	Shaping	Laminating	Fin Setting and Finishing	Total
A	pre-test (A_1)	$13^{\pm 4.5}$	$5.4^{\pm 2}$	$9.4^{\pm 3}$	$27.7^{\pm 6}$
B	pre-test (B_1)	$11.8^{\pm 4}$	$4.8^{\pm 3.5}$	$8.3^{\pm 3}$	$24.9^{\pm 6}$
B	post-test (B_2)	$7.9^{\pm 3.5}$	$3.2^{\pm 2}$	$5.3^{\pm 2.5}$	$16.4^{\pm 5}$

nose. Former was to reduce the surface tension in tail area, while the latter was to improve both stability and manoeuvrability.

From Table 5 it appears that about 55% students from Group A made templates for their surfboards by magnifying the design features of 'as published' surfboards in various magazines, while 25% of students got the templates from friends or shapers. The trend reversed a year later when 75% of students from Group B obtained the templates from friends or shapers and only 10% opted for those reported in magazines. Majority of the SST students opted to make a light surfboard. They did it by reducing the surfboard thickness features during shaping, and / or by using a light 135gsm cloth for laminating. Consequently, the total weight of the glassed surfboards with fins was low and it varied from about 2.8 to 3.3 kg. The production cost was about $230 for a complete surfboard (without fins) compared to around $600 for a commercial surfboard.

Finally, referring to Table 6, the total production time spent on shaping and laminating of ECU surfboards varied from three weeks to nine weeks. There was no big difference in the total average production time $27.7^{\pm 6}$ hours and $24.9^{\pm 6}$ hours between the two -A_1 and B_1- pre-test groups. However, the significant drop in production time (to $16.4^{\pm 5}$ hours) was observed in the pre-test group B_2. This trend was evident in all three individual surfboard making activities that included *firstly* shaping, *secondly* laminating, and *thirdly* fin setting and finishing. The individual time factor for A_1 and B_1 (pre-test) designs was greater than that for B_2 (post-test) design.

Final Conclusions

This study confirmed that quality is rarely produced by chance but never produced consistently by chance. It appeared that two -A_1 and B_1- pre-test groups had the same background (because of statistically similar 'mean' score of 37.85) but diverse skills (because of statistically different variances being 65.2 and 53.3). The intervention had a significant effect on attitudes and scores (both mean and variances) compared to pre-test levels. The students from intervention group B, post-test design B_2, reported higher level of understanding and they also achieved much higher mean score of 44.8% from possible 50% compared to the pre-test designs from last two previous years (on average 37.85% from possible 50%) for both B_1 and A_1. They appeared to understand the interaction between surfboard design features and performance in deeper content and were able to link it together with production and material issues.

Their positive remarks in questionnaire indicated good reactions to the lecturer's initiative. In addition, the students from post-test group produced high quality work because of a real-time feedback from an independent observer *e.g.* teacher helping them to monitor and control the quality of their work in individual production stages. Such real-time feedback from the project supervisor and/or individual team members enabled the students to visualise, and understand, the contrast between theoretical and technical knowledge, and to alter a work-in-progress in order to improve the overall quality of their product. Consequently, each student was given opportunity of being an active member of a group with ability to produce, be self-monitoring, critical, and knowing how to compare his or her work against others not just by activities engaged in, tasks completed or work done, but by what they learned or mastered and can carry with them.

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