

**2006-2288: A PARTICIPATIVE PEDAGOGICAL APPROACH TO KNOWLEDGE
COMPREHENSION BASED ON STUDENTS PREFERENTIAL LEARNING
STYLES**

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A participative pedagogical approach to knowledge comprehension based on students preferential learning styles

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Abstract

The reciprocal nature of training efficiency and competence/productivity justifies any attempt to augment instructional training and engineering education. The shift from instructor centred training to a paradigm of autonomous learning has become more prevalent with each passing phase of educational research.

This paper comparatively examines the performance of a control and experimental group on a purpose designed knowledge comprehension assessment. The use of differing pedagogical approaches facilitated the study in examining the potential for an awareness of learning style. Although taking cognizance of the heterogeneity of students, significant homogeneous patterns emerged following the administration of the Index of Learning styles (ILS) questionnaire in relation to the preferential learning styles of engineering students. Subsequent to identifying and grouping the apparent style modes, an instructional design philosophy emerged and manifested itself into the pedagogical tool utilized by the experimental group.

The research discusses the development of the computer assisted participative pedagogical tool that facilitates engineering students within a 'brain –friendly' learning environment. The comparative evaluation of the learning experiences of both groups within the context of the cognitive and affective learning domains is also explored in this paper.

Key Words: Learning Styles, Computer Assisted Learning, Engineering Pedagogy.

Introduction

This research was not intended to represent a 'causality-effect' study but an exploration of the complexities of learning in the context of engineering activities. This paper examines the academic performance of engineering on a purpose designed written assessment. The methodology employs a control and experimental group that engaged in a distinctly different pedagogical approach to learning the theory associated with the milling machine. The control group engage in the traditional lecture series while simultaneously the experimental group engage in a web based tutorial intervention designed to facilitate the learning preferences of engineering students, namely Active Sensing, Visual and Sequential.

Background

The paper stems from a historical investigation into the relationship between technology and society and the impact of engineering education on the performance of technological advancements. Felder defines technology as the discipline that translates the discoveries of science into means of improving the well being of society¹. Engineering education is not the sole influential factor determining the success of technological developments; however it is a significant player.

Many educationalists criticize the shift in teaching methodology, as educators are now more concerned with a more mechanistic approach and not the rationale behind the specific subject area. Engineering education (education in general) has regressed to the memorization and routine applications instead of the analysis, synthesis, and evaluation. This would suggest that engineering education is only meeting the fundamental stage of educational taxonomies.

The efficiency of any technological advancement is directly linked to the quality and competencies of the educator. Technical education in practical engineering while of great importance in the realization stage is sometimes arbitrary and its quality depends to a large extent on the pedagogical skills of the instructor. The didactic approach taken to convey engineering principles is the most commonly used mechanism for teaching/training. Practical demonstrations where availed of, tend to have high demands on resources to work efficiently and effectively. Despite the significant technological advances in recent decades, change in the area of engineering education relating to the application of technical knowledge and machine control and operation, has not kept pace with developments.

Central to this is the understanding of the idiosyncratic nature of the student. The change in approach, behaviour or value as a result of education is a subordinate of the characteristics of the individual. Together with clearly defined aims and objectives, one must understand the student as an individual for effective learning to take place.

Concerns arise when the traditional approach of faculty meets the characteristics of engineering students. A mismatch in the instructional approach and learning activity can hinder any level of learning. The high attrition rates in engineering subjects may be a result of the inability of students to perform in a system alien to their learning characteristics. Many faculty console themselves with the notion that students who drop out of engineering courses are of lower ability or disinterested and were never likely to qualify or succeed as engineers. Seymour contradicted this notion when he found that grade distributions of students who left the course were essentially the same as the students who continued².

The complexity of the learning activity is defined by a series of dependent and independent variables and the relationship between these variables. Aside from the pedagogical approach adopted by faculty, student motivation, ability, experience, stage of maturation, cognitive style and learning strategy (the last two combine to form learning style) significantly affect the learning activity.

The following questions were investigated as part of a preliminary study of Engineering students at the University of Limerick.

- Can engineering students be classified into a specific group of learning styles?
- Will matching the instructional style empirically prove enhanced performance?
- Can a strategic approach augment the learning experience of engineering students?

Before delving into a design of experiments and a research methodology, it is important to clarify what is an effective learning paradigm. To achieve desired learning outcomes, Biggs claims that the instructor must ensure 'constructive alignment'³. This means ensuring that students must possess prerequisite knowledge and motivation to learn the subject and that there are adequate explanations from the instructor, while also ensuring an appropriate quality of instruction and assessment. 'Alignment' focuses on all factors under the instructor's control. The 'constructive' element applies to the instructional design and its application of principles of constructivism. The following points are summarized from the work of Biggs³ Ramsden⁴ and Prosser⁵. These features were found to constructively align with the adoption of a 'deep' learning approach.

1. An interest in background knowledge is important, as a lack of interest can discourage deep learning.
2. Clear statement of objectives and quality feedback encourages deep learning.
3. The design of assessment methods should emphasise conceptual understanding.
4. Pedagogical approaches must foster active and long-term learning.
5. Choice in content and method is also beneficial for the deep learner.
6. Apathetic or inconsiderate teaching discourages deep learning and is more suited to developing a 'surface' approach.
7. An excessive workload will only serve to encourage 'surface' learning even for the 'deep' students.
8. Previous educational experience that discourages 'deep' learning will further discourage a 'deep' approach.

Use of a problem-based or project-based learning environment will motivate students to learn on a deeper level^{6,7}. A student-centered approach to learning which focuses on active and cooperative learning found a positive correlation between the instrumental method and the students' engagement of a 'deep' learning approach^{8,9,10,11}.

Methodology

The research design was divided into two different areas. The first stage in the research focused on the design of the research apparatuses and secondly the design of the data collection tools. The initial section will discuss the participating cohort, the design of the web-based tutorial intervention (WBTI) and the implementation and procedure adopted for the design of experiments.

Participants

Participation was requested from the entire cohort of year one engineering students within the Manufacturing and Operations Engineering Department at the University of Limerick. The rationale for the selection of this student sample was grounded on specific criteria:

- It could be assumed that the preferential styles of these students are representative of the larger engineering student body as the cohort included students from both core and interdisciplinary engineering courses.
- These students have chosen engineering as a career choice; therefore it is less likely that there would be the same level of heterogeneity in attitude, aptitude, and motivation as could be argued with second level (high school) students.

Resulting from egalitarian access to university, it was assumed that the first year students derive from similar socio-economic backgrounds. However, there can be no generalization made in regard to the students' level and competence in specific research content. A small proportion of the group entered their program of study via the mature students (craft background) route. These students have a very practical and applied knowledge of the research material. Students from the traditional CAO (Central Applications Office) entry may have studied an element of the research material in Leaving Certificate Engineering, although the depth of knowledge would not be as extensive as the Craft (trade) students it would still be a distinct advantage over the rest of the participant group. Therefore it was necessary to stratify the sample of students for the control and experimental group. The following stratum criteria were used to arrange the data.

- Gender
- Student Type (Mature or Undergraduate)
- Course of study
- Completion of Leaving Certificate Engineering

Once students were allocated the control or experimental group, no student was ever informed of which of the groups they were in. Throughout the study every effort was made to eliminate or at least limit the extent of the placebo effect.

The initial participant sample consisted of 107 students (Table 1). After employing a stratified sampling approach a control group of 54 students and an experimental group of 53 was devised.

The participating group had a mean age of 19.89 and a standard deviation of 4.5. Gender distribution was recorded at 18.5% female.

Table 1 - Homogeneity of the subgroups.

Course	Total	Age	STDEV	Female	Male
Material and Engineering Technology	46	18.76	2.67	1	45
Product Design and Technology	23	19.08	2.27	10	13
Production Management	23	18.62	1.78	2	21
Manufacturing System	10	21.40	9.39	1	9
Manufacturing Engineering	5	21.60	6.42	0	5

Due to the nature of the cohort analysis type study, high attrition rates resulted in a final sample of 64 students. A mean age of 19.17 and a standard deviation of 5.70 were recorded for this sample, it also consisted of 15.6% female. Table 2 illustrates the percentage participation from the original sample.

Table 2 – Percentage Participants per course

Course	Total Cohort	% Total
Manufacturing System	3	33%
Material and Engineering Technology	38	63%
Manufacturing Engineering	0	-
Product Design and Technology	13	54%
Production Management	10	30%

Table 3 presents the characteristics of the control and experimental group following the elimination of students based on incomplete data.

Table 3 – Control and Experimental Group

Group	Total	Mean Age	STDEV	Female	Male
Control	35	19.02	2.83	5	30
Experimental	29	19.17	5.7	5	24

The Kolmogorov-Smirnov normality test was conducted and indicated a normal distribution for both participant groups.

Design

The design of the research methodology had four distinct elements: a comprehensive demographic data collection method including a preferential learning styles instrument, a pedagogical tool derived from the characteristics of the participating students, an evaluation mechanism to capture the full range of student experiences and an assessment tool that could facilitate an equitable comparative study of performance within both groups.

Demographic Questionnaire

Participant demographics for both the control and experimental groups were obtained on commencement of the study. It was necessary to obtain as much demographic information as possible at the initial stage as it was decided to stratify the sample and it would enable the researcher to employ retrospective analysis if necessary. The requested information included age, gender, school type attended, course of study, Junior and Leaving Certificate subjects, levels and grades. The questionnaire was administrated electronically to each student. Each section of the questionnaire incorporated a field check to ensure that participants could not progress without completing all elements fully.

Index of Learning Styles

The index of learning styles instrument formulated by Felder and Silverman¹² was used to form the basis for the research tool. This questionnaire assesses the preferential learning styles of students on four dichotomous style dimensions. The slightly modified (due to cultural differences) questionnaire was used to assess students' preferences for the Active/Reflective, Sensing/Intuitive, Verbal/Visual and Sequential/Global styles¹³. The ILS instrument comprised of 36 questions, each question gave two possible answers that were polarized to each of the styles within that mode. The instrument was scored on the numeric difference between each opposing style mode, which ascertained the students preference for each particular dimensions. The instrument was checked for validity and reliability and found to be an accurate measurement of the preferential learning styles¹⁴.

Design of research apparatus (Pedagogical Tool)

Selecting an effective medium to present the theoretical material for the experimental group was of paramount importance. A web based tutorial solution was chosen over a stand-alone fully executable program as it could be launched on the University intranet, this was an ideal to ensure complete student accessibility. Along with access, several other advantages were identified with a web-based solution:

- The information technology division (ITD) within the University has a consistent build on all student computer profiles in the College. This enables the designer to make informed decisions in relation to percentage page content and page layout.
- The user has direct access to the central server, thus reducing 'upload' time, and also enabling direct write-access to the server and immediate feedback of student performance.
- Students have the flexibility to use the software in any of the student computer clusters, (10 in total) ensuring ultimate accessibility.
- As the software could be linked to the students profile it ensured that all students in the experimental group could be automatically e-mailed a web access password on completion of the demographic questionnaires.

Design of the website

The objectives for the design of the website are as follows:

- Produce a site that facilitates inclusively and usability.
- Design a tool that augments the learning experience of first year undergraduate students.
- Encourage exploration within a self-paced learning environment.
- Match the design criteria with the preferential learning styles of Engineering Students.
- Enable students to gain immediate feedback on performance and record progression through the necessary material.

Design realisation

The fundamental underlying principle dictating the design of the website was the preferential learning styles of engineering students. Initial findings supported by international research suggested unique preferences for engineering students. With the objective to evaluate the possibility of enhancing performance by facilitating preferential learning styles it was an important consideration at the design stage.

The design realisation phase of the research focused on three main areas:

1. Layout of site
2. Functionality
3. Presentation of material

Layout

On commencing the design of the website, the initial design focused on the layout of content. The visual layout was structured in accordance with the findings of Parush, (2003) who claims content that is grouped in a basic grid format is perceived more effectively and can focus the user's concentration on the specific information. Parush devised three basic layouts as illustrated in Figure 1.

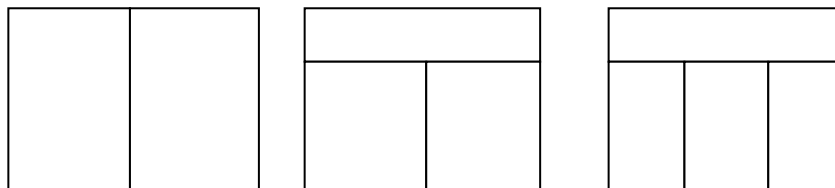


Figure 1– Visual Layout of web site

It was decided to design a template based on these proposed formats.

An effort was made to ensure that all site pages (forms) were approximately the same dimensions as the screens used in the research, so as to eliminate scrolling. Fargular et al (1997, p.44) explains, “*People don’t like to scroll. When learners come to a page they are looking for interesting and important information. Give them the information they need and want as soon as possible.*”

With an appropriate layout and size for each page, a template was produced to aid consistency. Consistency in the user interface enables the users to build an accurate mental model of the way that it works (Ambler, 1998). Along with perceived visual layout, the allocation of material on each page was examined; the overall density of material on each page on average did not exceed 40% (Ambler 1998). The site was developed in accordance with the general guidelines suggested by Schneiderman¹⁵ and Preece et al¹⁶.

The chronological order of material was carefully arranged as the ‘sequential learner’ learns best in a linear fashion, and when information is orderly, as they learn best in small incremental steps¹⁷. The site lists four main areas within the subject matter; each link is in order and can only be activated by the user achieving an adequate grade in the previous section. Therefore material is presented ideally for users with a preference for the ‘sequential style’.

Functionality

On completion of the site, a pilot study was conducted to ensure correct functionality. Access to the site was via a logon and password. Once students logged onto the homepage users could only access the safety link.

At the end of each of the four sections of the site a compulsory assessment was presented to the student. The assessment consisted of five multiple-choice questions randomly taken from a database of 40. A minimum of 4 correct questions was necessary for progression to subsequent material. The site was also constructed to give immediate feedback to the user on submission of their attempts. Completion of the multiple-choice assessment linked the user to a certificate of competence form that was automatically linked to the title of that section; this form displayed the user ID number and the percentage score for that particular section. The site then suggested a course of action for the user, progression to the next stage for the competent student and encouragement to re-examine the specific content for the user with inadequate performance scores. This immediate reinforcement either R+ or R- (R- not to be mistaken for negative reinforcement) enables students to be the master of their own learning experience. The assessment process facilitates students with the innate preference for ‘Active learning’; however in theory a trial and error type approach could be used. Two factors limit this approach as students do not know how many questions are in the database (numerous Combinations) and secondly the site also records the number of attempts and scores obtained for each section. The record of attempts was incorporated into the functionality of the site so as to screen the data at the analysis stage.

The active learner was also facilitated throughout the site as not all information is presented directly to the user. As a result, to ensure progression to the next stage of the

site the user must access additional information for example the names of parts and functionality of components.

Content and Medium

The layout and functionality directly facilitates the preferential styles of the 'sequential' and 'active learner'. Two prominent style modes in the engineering students are 'sensing' and 'visual'. The safety section of the website is structured in a linear fashion (sequential learner) and portrays the information in a very practical manner, giving concrete examples and procedural information. The 'sensing learners' learn best when information is orientated towards the factual.

As the visual style preference is particularly evident within engineering students, it was important to focus on presentation of the research material. As it was impossible to deliver all necessary information via imagery, textual information was used to contextualise the imagery. A key consideration for any information presentation (especially for low aptitude learners) is that both the visual and verbal information must not exceed the processing capabilities of the learner (Kearsley and Hillelsohn 1982). As well as minimising the textual information, care was also taken to ensure that the level of textual information did not extend beyond the ability of the user, as engineering students are least likely to learn through this medium. Mielson et al (2002) goes a step further when he states generically that the simplest reading level should be employed irrespective of the sophistication of the student.

Three key features for the presentation of information are listed below.

- *Interactive imagery (often of 'real' situations, procedures and artefacts) – sensing, active and visual learners.*
- *Video imagery (Convey machine functionality and advanced processes) – sensing and visual learner.*
- *Animated imagery (Convey cutting technique best practice and safety) – visual learner*

Evaluation of the theoretical learning experience

As the control and experimental groups utilised different instructional approaches it was necessary to evaluate their learning experiences. A generic evaluation instrument was designed to compare the experience of both groups. This questionnaire comprised of ten statements that were directly applicable to both groups and aimed at examining their learning experiences. Each statement was ranked on a 5 point Likert scale that ranged from strongly disagree (1) to strongly agree (5).

As the experimental group utilised a novel instructional approach it was necessary to gain feedback from each participant. A separate evaluation questionnaire was designed to assess the experience of the experimental group. Students were requested to rate particular medium within the site as learning aids. Responses were ranked using a five point Likert scale that ranged from very poor (1) to very good (5). The questionnaire also comprised of closed questions, which were specifically aimed at obtaining the overall

perception of their learning experience. Open-ended questions also featured, which encourage pupils to give additional feedback.

Assessment

To facilitate a comparative analysis of the performance of each group a traditional written assessment was designed. The theory assessment was structured in accordance with the traditional end of semester written examination as it was deemed necessary to assess students' performance within the constraints of the current academic structure. The content of the examinations was clearly defined by the material covered in both the lecture and website.

The assessment contained four sections with ten questions per section. Each section was comprised of five written questions and five questions that were supplemented with visual imagery. Questions were categorised into:

- Knowledge questions
- Knowledge with an expression of understanding
- Knowledge and understanding

The initial section assessed the safety precautions associated with the milling machine. These questions for the most part were open ended and students could have listed numerous safety precautions. The assessment was not seen as a sorting mechanism nor was it designed to examine exam technique. Students were encouraged to attempt all questions through whatever medium they preferred.

Procedure

Collection of demographic data

Regardless of the workload implications for the user as discussed by Bruneau,¹⁸ it was decided to electronically collect the data from the participants, as timetabling and time constraints limited access. The electronic questionnaire solution was the most feasible and cost effective means of data collection.

Participants were requested during their initial laboratory session (Introduction to Computers module) to access the questionnaire and complete all aspects. Students were given one week to ensure correct completion of the questionnaire, as stratified sampling took place at the beginning of the following week. On submission of the questionnaire all data was immediately transferred to the research database.

Index of learning styles

The 36 questions were administered electronically to all participants. The following instructions were given to the participants before commencing:

- All questions must be answered.
- If both answers apply select the one that applies most frequently.
- Click the appropriate button for your selected answer.

Theoretical evaluation questionnaire

Consideration was given to the timing of the administration of the evaluation experiences. Administering the evaluation after the assessment would undermine its objective as it could be used as a tool to grade the student's performance subjectively. For example a student who felt that they performed poorly in the exam may rate their learning experience poorly so as to excuse their low level of performance and vice versa. The evaluation questionnaires were administered and returned prior to the theoretical assessment.

Theoretical assessment

The theory assessment was conducted during a normal lecture session, during week 10 of a 12-week semester. Students were informed of the in-term assessment at the beginning of the semester but were unaware of the examination content. Students were advised of the examination topic two weeks prior to the exam date. The examination date was selected to give a four-week interval between that and the learning activity (Lecture or web).

Exam material was presented in the traditional lecture format for the control group over two one-hour lectures. Simultaneously the experimental group were assigned a P.C. in the computer cluster and invited to examine the necessary content on the milling machine. The examination was conducted with regard to University academic rules and regulations.

Findings

Assessing any learning experience must measure the student's performance and evaluate their experience. Having experienced significantly different theoretical approaches it was decided to evaluate the experience of both the control and experimental group.

Evaluation of learning experience

As presented previously, the results indicate a significant difference between the experiences of both groups. The significant difference ($p = 0.001$) between the evaluations of the learning experience is illustrated in Figure 2, which presents the mean scores for both the experimental and control group on each element of the evaluation instrument.

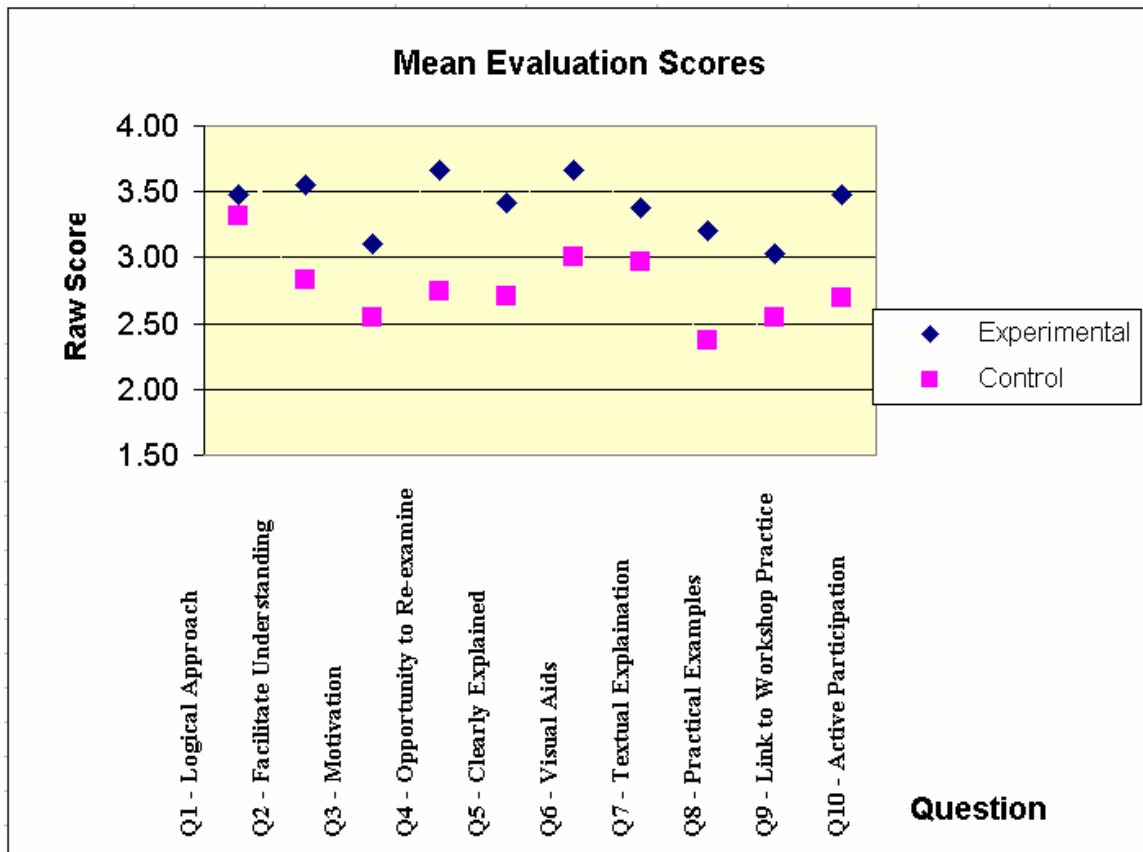


Figure 2 – Mean learning experience evaluation scores

Two questions are noticeable in the scores of the experimental group. Question 3 examined the use of the presentation medium as a means of motivating the student. The mean recorded score for both groups is well below average and raises important questions about pupil motivation. Question 9, which examines the link between theoretical knowledge and the practical application of knowledge, records a lower mean score. This was expected as the practical element of the course was covered following the completion of the evaluation. Students from the control group rated the logical sequence of material highly (Q1). A big failing of the traditional approach as perceived by the control group was the lack of practical examples (Q8). The failing to contextualise the material within the concrete applications is particularly obstructive for the learning process of the ‘sensing learner’.

Students experience of the website

Although the intrinsic motivation of the students is questionable, students still perceived the site as an effective learning aid. 86% of students claimed to have found the website beneficial. Students were asked to rate the feature of the site as to the extent that they facilitated learning. Scores were recorded on a Likert scale where 1 represented ‘very poor’ and 5 represented ‘very good’.

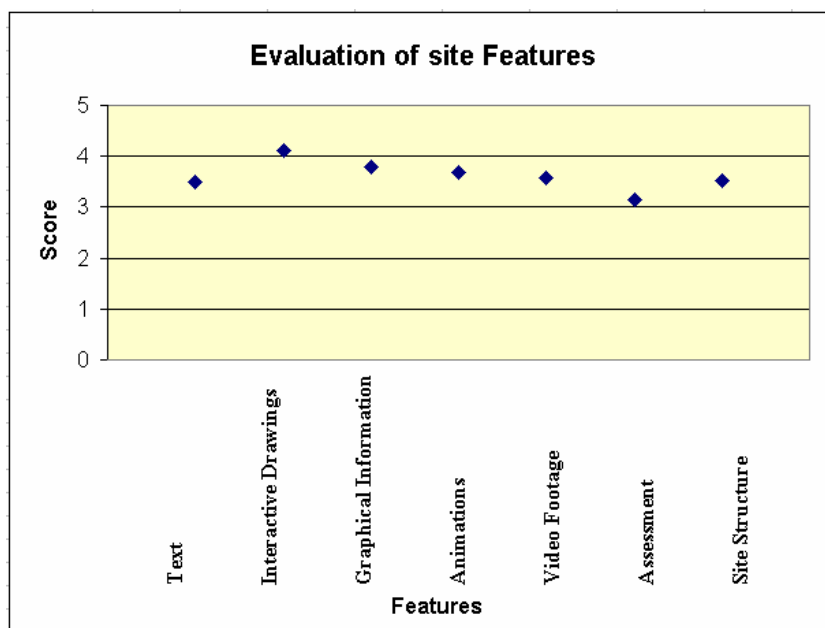


Figure 3 – Evaluation of website features

Noticeable from the graph (Figure 3) is the evaluation of the interactive drawings. These drawings enabled students to explore the imagery so as to identify different features and access additional information. Student’s perceived this medium as beneficial to their learning process. The evaluation of the uses of textual information as a learning aid was rated at 3.5. This is an interesting observation as it was decided to keep textual information to a minimum at the design realisation stage. A student at the end of the evaluation, highlighted a contradiction to this trend, where he claimed,

“There wasn't enough writing on the website and I kept thinking I was missing something with those interactive drawings.”

The poor rating (in comparison) of the assessment stage of the site was also surprising. One student commented, *“You can guess the answers on the website. You have no notes to look back on”*. When asked if they would use this method to supplement other modules, 59% of students responded positively, a synopsis of the positive rationale are listed below:

- *“Graphical & Interactive”*
- *“Easier to learn this way”*
- *“It's easier, more hands on approach, you're actually doing something”*
- *“Because I found it easier”*
- *“Easier to understand”*

In response to whether they would replace the current lecture structure with this student-centred approach, 44% responded positively. The remaining 66% claimed that:

- *“There should be a happy medium”*
- *“You need a bit of both, you need some instruction”*

- *“Website was helpful but you can't beat seeing the real thing! It is a practical subject”*

Overall the site was perceived as being very beneficial, usability was not seen as an issue for any of the students, which would suggest that it was effective in portraying the content and fulfilled the criteria for the ‘ten minute rule.’¹⁶ Matching the preferential styles of engineering students to the functionality and presentation of information on the website ignored the students development of mental dexterity, but enabled students to learn in a ‘brain friendly’ environment.

Performance measure (Assessment)

Reporting a positive learning experience, although an important aspect of the affective domain and contributes considerably to the overall learning experience of the experimental group, is not an indication of understanding or competency. To change the approach or structure of the final assessment would not gauge the student’s performance within the current academic paradigm.

The non-significant difference ($p=0.229$) recorded between both groups in the experimental test suggested that the pedagogical approach was inconsequential. Even though the mean scores indicated that the performance of the experimental group was slightly higher. Retrospective analyses enabled the examination of the difference in Leaving Certificate performance, as an indicator of ability level for each group. A non-significant p-value of 0.849 was recorded with the experimental group scoring slightly higher. The diversity of subjects taken at Leaving Certificate, the almost limitless combinations of subjects, and levels and grades prevented its use as a covariate in the context of the research material.

Performance in the parent module (of which 5% was awarded for the experimental test) was used as a covariate to examine the effect of the pedagogical intervention on the performance of the experimental group. Again a non-significant difference ($p = 0.225$) was recorded for both groups. However, the mean scores indicate that the control group performed slightly better in the overall module. As the research material comprised an element of the parent module syllabus, and the remainder of the contents was related, it was decided to use this data as a co-variant in the research analysis. An ANCOVA (analysis of covariance) was conducted, which indicated a significant performance difference ($p = 0.032$) between the control and experiment groups. Therefore when students’ ability within the subject area was considered, students in the experimental group, who started from a lower ability, actually performed significantly better than the control group.

On comparison of the examination scripts for both cohorts, it was observed that almost all mature students regardless of group used sketches to answer a number of questions. This was not evident from the younger undergraduate students. As students learning style is comprised of their innate cognitive style and devised learning strategy, one hypotheses may be that mature students are not formulated to compete in the academic structure that dominates the Leaving Certificate and presented information via a natural, comfortable medium. Figure 4 illustrates a number of student sketches used to answer specific

questions, where sketches were used no analytical commentary was made and textual information was only used to label sketches.

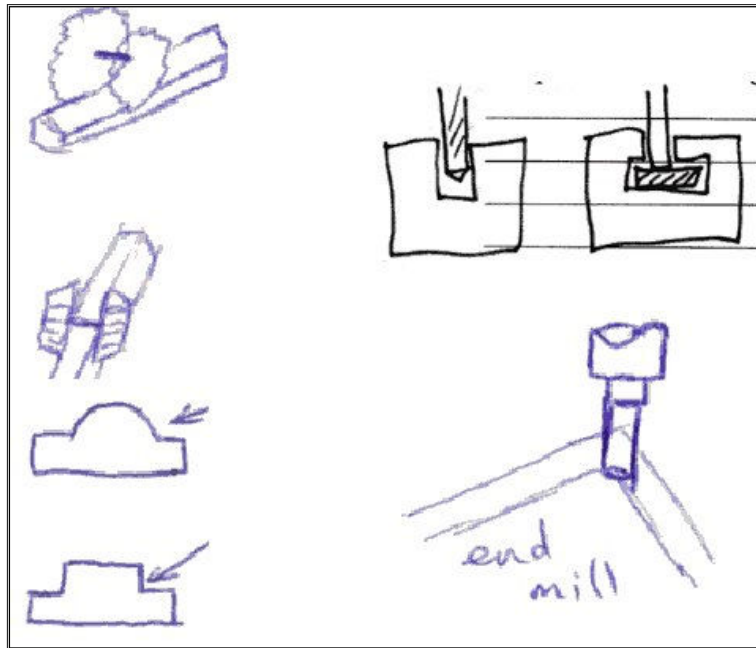


Figure 4 – Example of Mature student sketches

Discussion

Delivery of theoretical content

The use of a control and experimental group allowed the research to draw comparative analyses from the performances and experiences of each group. The control group experienced the traditional approach to teaching and learning, while the experimental students engaged in a tailored approach based on the initial stage of the theoretical foundation of Kolb's (1984) learning cycle and the facilitation of the innate preferential styles of the engineering students¹⁸.

Teacher-centered approach

As presented earlier in the paper, students have innate preferences for the way in which they gather and process information. As engineering students can be assigned a specific style group, so too can we derive the preferential styles of engineering faculty. Felder (1996) claims that engineering instructors have been heavily biased towards intuitive, verbal, reflective and sequential learners¹⁹. This is not surprising as such styles are particularly relevant for successful performance in academia, which engineering faculty have obviously achieved. Lumsdaine (1995) suggests that the majority of faculty are themselves strongly quadrant A dominant (logical, analytical, quantitative, factual and critical)²⁰. Therefore the control groups were somewhat hindered as the mismatch between the teaching styles of the lecturer and learning styles of the student was not

conducive to effective learning. The passive student within a didactic learning environment contradicts the preferential style of the engineering student.

Student-centred Approach

As with the traditional approach to the research material, the experimental group focused on the theoretical aspect of the content. Prior to the initial test, students were allotted a specific time slot to access the web based tutorial intervention. The following table (Table 4) exemplifies the number of students who accessed the site, the average number of attempts it took to complete each section and the average number of days the site was accessed prior to the examination.

Table 4 – Student access to website

No. of students	Safety	Machine Overview	Operating Parameters	Processes	Average Access
29	3.38	3.93	2.59	1.79	1.28

From the table it can be seen that all students in the experimental group accessed the site prior to the retest. This access was independently undertaken by each student and highlights the student's motivation. The average access column in the table identifies the average access date prior to the assessment. Eight out of 29 participants accessed the site two days prior to the exam while the remaining accessed it just the day before. It can be argued that CAL systems enhance student motivation, as all participants in the experimental group accessed the site independently. However, the extensive site access on the day prior to the assessment would suggest that the motivation was predominantly extrinsic.

A lower average for the final two sections of the site is also presented, this may be due to more familiarity with the site and a better understanding of how to engage in the learning activity facilitated by the website.

Conclusion

This paper reiterates the preference of engineering students to learn in the Active, Sensing, Visual and Sequential domains. It also indicates that when information is presented to engineering students in a manner that facilitates these innate learning preferences there is a measurable increase in performance. The use of a self-paced pedagogical tool can facilitate the learning activity and is equally as effective as the traditional methodology.

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