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Effectiveness of Parallel and Serial Integration of Teaching Resources in Laboratory Teaching in Engineering Education

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Abstract: Recent advances in the development of 'electronic teaching support systems' make it more attractive to embrace such emerging technology in the conventional teaching programme. Mechanical Engineering subject areas require extensive laboratory activities where teaching and the resources available need to be used optimally to produce engineers with the right skills and knowledge. It is for this reason that attempts are being made throughout the World to include electronic support into the laboratory environment to make learning more effective. This paper undertakes a study to compare two different methods of integrating electronic resources into the conventional laboratory teaching in engineering education and describes the learning experience of two groups of students using each system. Two groups of students were carefully selected to ensure they had the same learning abilities (similar average marks and standard deviations) and each was asked to learn an engraving operation using a CNC machine. The resources available were a facilitator, computer simulation software and the CNC machine. Each group was asked to approach the learning tasks differently. The first group of students (Group 1) were asked to learn the engraving operation using a computer simulation of the engraving operation and were encouraged to carry out actual exercise on a CNC machine in parallel with the simulation. The role of the facilitator was to explain various operations on the simulation software as well as help students on actual machines. The second group of students (Group 2) were exposed to the simulation in a classroom environment which was followed by the entire procedure being explained by the facilitator on a CNC machine within the laboratory environment. The learning experience in this case was sequential in that the learning resources were used in series for the 'Group 2' students. Evaluation tests were used to measure the performance of each group after the exercise. It was apparent from the evaluation reports that the group experiencing the parallel provision of resources achieved a better overall learning rate than the sequential or series group. It is felt this may be answered in two ways: The group receiving parallel input of information had an instant means of self evaluation of progress by comparing performance to the simulation whereas the sequential group had no reference or benchmark. The second reason could be the break in concentration and the 'loss factor' in the transfer of 'classroom knowledge' to the laboratory. Even a short break, or minimum distraction, is sufficient to disrupt the level of concentration and so in-depth learning and memory retention is hampered.

Keywords: Computer Technology, Milling C.N.C Machine, Auto Cad Software, C.N.C Program

Introduction

USE OF COMPUTER technology has become very common in all spheres of our life and education is no exception, so much so that e-learning is now a common term. For future university students digital technologies are natural part of their every day life. The question is no longer whether we should use these technologies rather how these technologies should be used. Engineering education in general and mechanical engineering education in particular have been experimenting with the use of digital technologies for the last two decades and teaching practices in some of the subjects have changed beyond recognition. Various studies have been published in the literature showing positive effects of digital technologies as instruction tools in education [1,2,3,4,5]. With the

advent of multimedia in the 90's more and more educational programs have been adapted to use computer aided instructions [6]. The engineering education and practices being adopted are changing at a very fast rate [7]. The advent of computers and their increased use in industry resulted in computer aided design and manufacturing modules becoming integral to mechanical engineering related courses. These courses came into prominence in early eighties and resulted in extensive modifications of course contents of traditional mechanical, design and manufacturing courses. Courses bearing the titles CAE were very popular because of the inference of them using modern technology. The courses required learners to understand and know the basics of design and manufacturing as well as to use specialist software and CNC machines. Although learning outcomes for these courses have been developed to suite



industrial requirements, very little has been done in terms of integrating various learning resources available for optimum learning benefits. The visual capabilities of computer aided teaching materials have forced educators in utilizing computers to assist in teaching learning process for such modules. At present there are two groups of educators, one who feel that computers can replace class room teachers and the other who feel that computers can not give real life learning experience to students and hence are wary of the excessive introduction of too much student centered learning. In reality, availability of computing resources can result in dramatic improvement in learning experience of students and most educators embrace its contribution when they have experienced its successful and careful integration within the learning ladder. Through computing resources a dynamic system simulation program can be used to further demonstrate the distinction between products, processes and designs. It can also be used to produce graphical representations of machine components in a highly complex geometric environment. Furthermore iterative power of computers can be used to carry out design optimization within the class room in almost no time. At present a lot of literature is being published on making e-learning more effective [1-13] and continuous improvements are taking place. At the same time traditional teaching techniques are being modified to satisfy the stringent quality requirements of education providers. Several research papers are available in literature, which indicate computer aided learning and instruction methodologies are extensively being used in various engineering courses with simulations

being extensively used in CAD/CAM area to increase effectiveness of teaching and learning process [4]. In the literature very little effort has however been directed towards integrating classroom teaching with the computing resources [1,2]. This is more so in engineering education is general and mechanical engineering education in particular. These studies however indicate that computer assisted instruction methods need to be carefully integrated with traditional teaching-learning processes for optimum benefits. This proposal examines in detail various issues related to the integration of computer assisted teaching methodologies with traditional teaching methods and compares the effectiveness of teaching and learning in parallel integration mode (teaching in parallel with computing resources) with series integration mode (teaching in series with computing resources) in CAD/CAM subject area.

Study Design

This paper examines a case study of HND students who were exposed to modified programs of teaching in CAD/CAM/CNC of Mechanical Engineering subject area. In this study a class of 30 students was divided into two groups on a voluntary basis. The students were not exposed to any risks or reprisals for refusal to participate. Table 1 shows the achievements of students in pre-course examination. It can be seen that the average marks and standard deviations are almost the same for the two groups. Hence it can be said that the PAA's (prior academic achievement) of the two groups were almost very similar.

Group	No of students	Level of Student marks	
		Average marks	Standard deviation.
A	15	64.13	7.16
B	15	66.13	7.57

In typical manufacturing process the knowledge gained through computer aided design and computer aided manufacturing modules is used in an integrated manner to carry out or supervise efficient manufacturing operations. With the availability of computing resources it is possible to incorporate computer aided instruction into tradition teaching methods. In this study it was decided to carry out two different computer assisted teaching and learning processes one for each group of students to satisfy the following learning outcomes.

1. From a given sketch produce a proper engineering drawing using Auto Cad software.
2. Convert the Auto Cad drawing into engraver C.N.C program using CAD/ CAM software.
3. Verify the drawing to check the setting of the machine and that the drawing is free from any error.
4. Run the program to carry out engraving operation.

Drawing and Manufacturing Process Chart

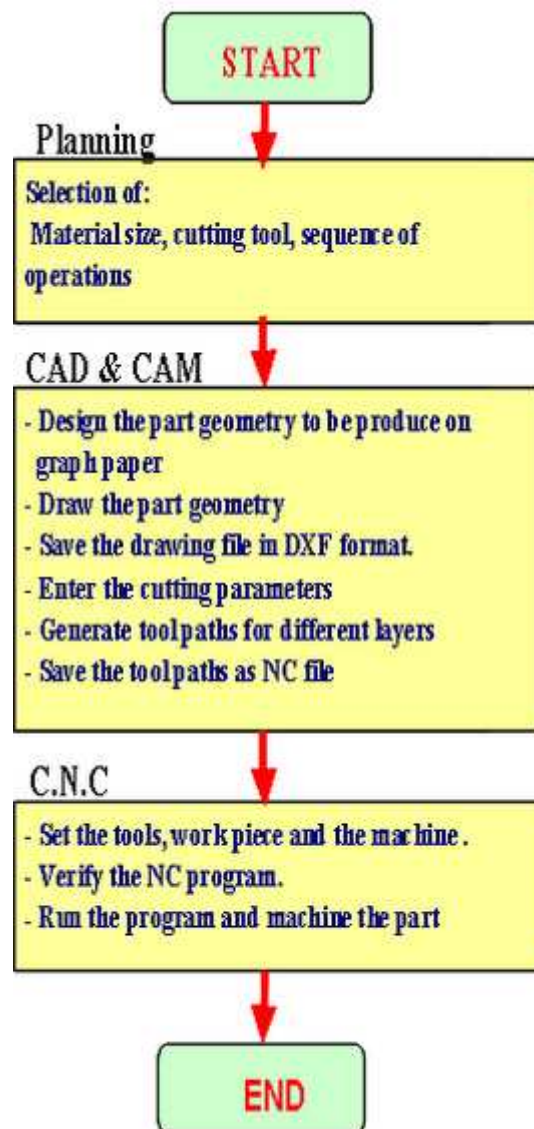


Figure1: Flow Chart Showing Details of Activities Explained in the Class

The chart below describes the activities explained to students during the teaching and learning process. The activities shown were incorporated into the teaching programme of each group. The teaching resources available to students were Instructor, white board, one computer terminal connected to CNC machine for each student, audio visual projection system, CNC simulation package, work books [14-16]. The above teaching resources were used by both

the groups. The students were taught in lecture environment for a 3 hours and were allowed 14 hours of laboratory practice.

Initially both groups were instructed on the use of Auto-cad package to create a simple drawing (R) as shown below. During the class room teaching both groups were exposed to the same teaching resources. Given below are the details of some of the activities undertaken.

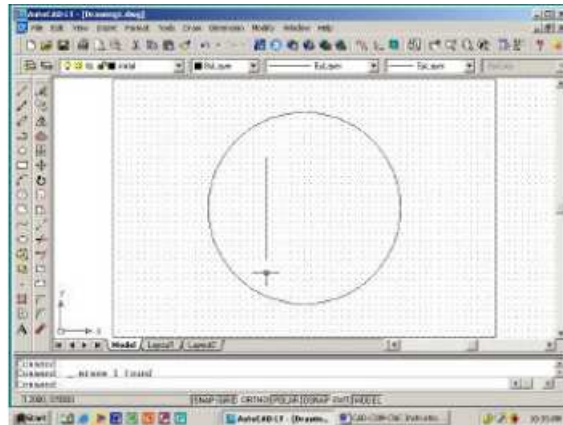


Figure2: Creation of a Circle and a Line

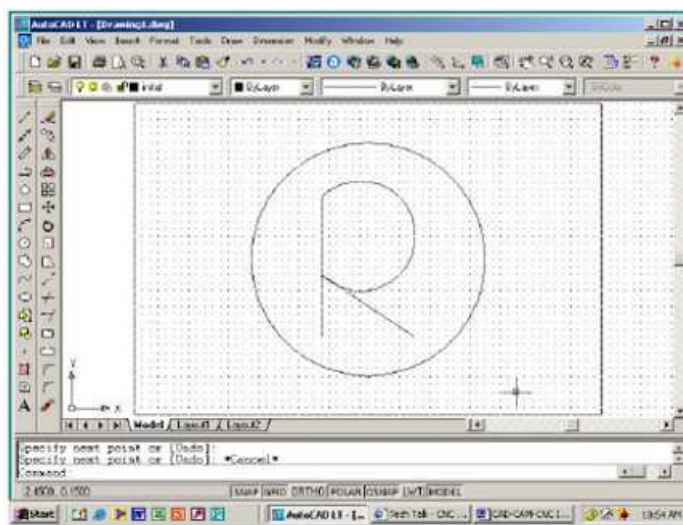


Figure 3: Creation of a Circle

Once students were confident in using auto-cad they were explained the procedure of using Spectra CAM Milling program to create an NC file using Spectra CAM as shown below.

Highlight letter R in red and select “Contour”
Click on the circle around the letter “R” and select “setup”

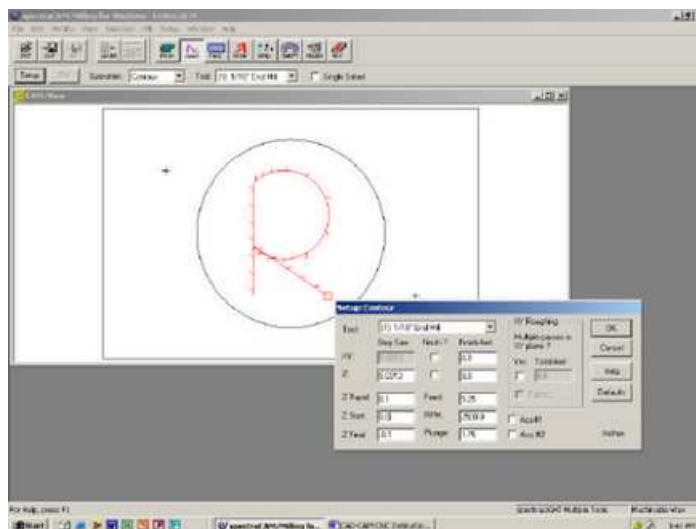


Figure 4

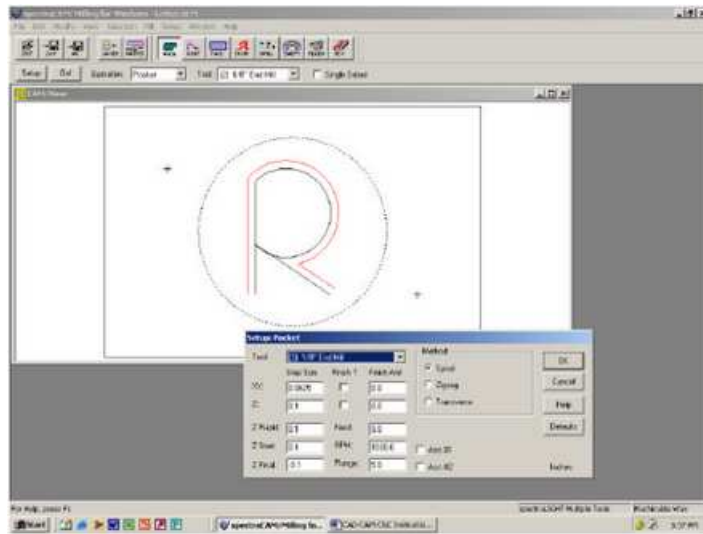


Figure 5

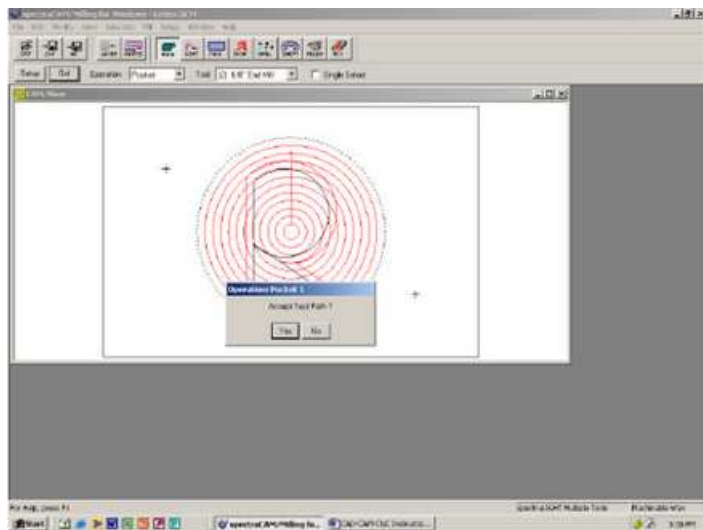


Figure 6

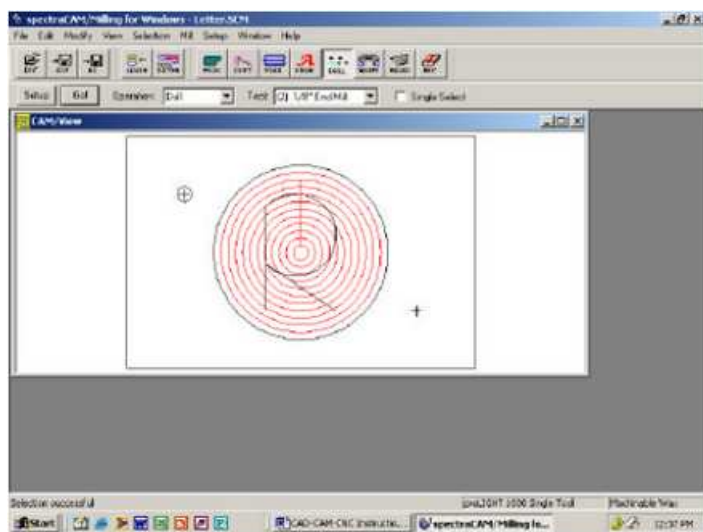


Figure 7

Click “OK” to close the setup screen and then click “Go!” to generate the tool path and select “Drill” from the “Operation”. Repeat the drill process oper-

ation for each of the points required in drilling operation.

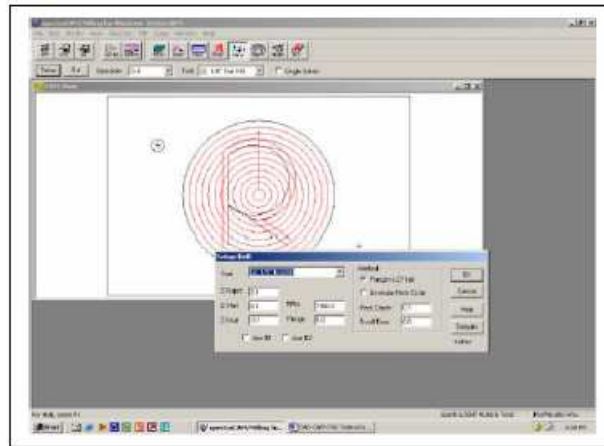


Figure 8

At this point students are explained three basic machining operations of contouring, pocketing and drilling, and how to save the NC file which could then be used on a CNC Milling machine. Students were explained that they can now start the Spectra CAM Milling operation. Then they were explained verification procedure, loading procedure, setting tool at zero position procedure as well as emergency stop procedure. The total lecturing time required is typically three hours for this task which was scheduled over two days. After giving full demonstration of the procedure the two groups were invited to the laboratory session of 14 hours (7 hours each day after 1.5 hours lectures). The group 1 students were allowed to use simulations in presence of the teacher to perfect their skills whereas the group 2 students were allowed the use of work books and assistance from the teacher. The group 1 students were thus exposed to parallel simulations along with instructions whereas the group 2 students, although familiar with simulations, were not allowed this during practice sessions and they thus received computer simulations exposure in series.

Students Evaluation

After having undergone teaching and learning in the use of CAD/CAM/CNC students were tested for their abilities in this subject area by asking them to engrave A. Appendix 1 shows the examination evaluation sheet. All the results have been analyzed under six categories namely, knowledge, comprehension, application, analysis, synthesis and evaluation.

Various skills observed under the six categories are mentioned below.

1. In the **knowledge**: the ability of the students to recall of information when needed like define, identify and list the CAD/CAM/CNC feature.
2. In the **comprehension**: level of understanding the ability of the students to communicate in order to make use of information like describe, discuss, locate, explain the use of CAD/CAM/CNC features.
3. In the **application**: the ability of the students to use a learned skill in a new situation like apply, demonstrate, prepare CAD/CAM/CNC feature for the drawing and manufacturing.
4. In the **analysis**: the ability of the students to compare analyze and contrast like analyzing and comparing during generation of tool path for different lyres (direction, depth of cut, cutting loop, feed and speed).
5. In the **synthesis**: the ability of the students to combine existing elements in order to create something original and modify i.e creating drawing parts as DXF file, converting it to the numerical control file (NC), using CAM and modifying the file after verifications in case some errors are present.

In the **evaluation** the ability of the students to judge the product using a standard like when verifying the drawing the students judged and agreed according to the standard criteria using manufacturing checklist.

Table 2: Achievement Rates of Two Groups of Students

Six hierarchical levels, of cognitive and psychomotor learning domain	Total No of students in each group	Students achievement							
		i- Creation of drawing and design using CAD		ii- Using data exchange format (DXF) to create numerical control file		iii- Setup check		iv- Final manufacturing	
		Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
Knowledge	15	13	10	13	12	15	12	-	-
Comprehension		14	12	13	12	13	12	-	-
Application		13	15	14	10	13	10	-	-
Analysis						14	11	-	-
Synthesis		13	13	14	11	15	13	-	-
Evaluation		12	5	-	-	-	-	14	8
Achievement % for each group		87 %	73 %	90 %	75 %	93 %	77 %	93 %	53 %

Table 2 shows the achievements levels as obtained from the analysis of results. The evaluation was carried out for both groups of students together. This was done to ensure the integrity of the results and to eliminate any bias that may creep in results because of the prior knowledge of the group to which of students belong. It can be seen that % achievement of group 1 students is higher for all the learning outcomes as compared to group 2 students. 87% of students in group achieved satisfactory level of expertise in learning outcome 1 (creation of CAD drawing) as compared to 77% in group2. The achievement levels in other learning outcomes for group 1 students were

also significantly higher as compared to group2 students. In particular in the learning outcome 4 group 1 had almost 75% better achievement rate as compared to the group 2 students.

The other indicator for students' performance was the number of trails used by groups in completing the tasks given which is shown in figure 9. In CAD/CAM applications it is necessary to be able to build the correct model and use the correct procedure in manufacturing operations. Numbers of trails taken by groups to achieve the stipulated learning objectives indicate the skills learned during the teaching and learning process.

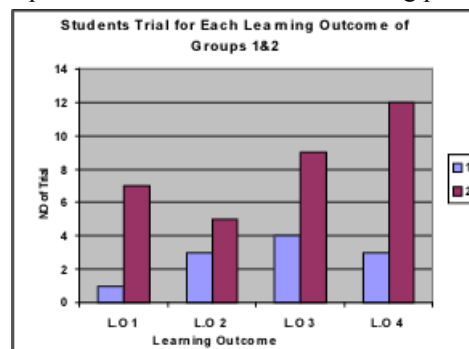


Figure 9: Number of Trails Used by Groups in Achieving Learning Outcomes

Figure 9 shows the comparisons between numbers of trails used by the groups in achieving various learning objectives. It can be seen that group 1 students made far fewer mistakes than the group 2 students resulting in less material as well as time costs in achieving all the four learning outcomes.

Conclusion

This study has indicated that the nature of integration of computer aided learning tools in teaching and learning has significant effect on the performance of students. It was observed that when computing resources were used in parallel student felt more confident and the learning achievement rates were therefore significantly better as compared to group

2 students. The group receiving parallel input of information had an instant means of self evaluation of the progress by comparing performance to the simulation whereas the sequential group had no reference or benchmark. The second reason could be the break in concentration and the “loss factor” in the transfer of “classroom knowledge” to the laboratory. Even a short break, or minimum distraction, is sufficient to

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Acknowledgement

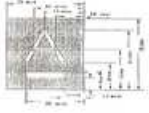
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Appendix 1

Student's performance checklist, Group : _____

		Students task														
																
No	Learning outcomes	Marks	Students No													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
i Creation of drawing and design using C.A.D																
1	Design the part geometry using Auto cad															
2	Draw the part geometry using auto cad															
3	Modeling Utilities															
4	Engineering drawing															
5	Drawing dimensions															
6	Save the parts as data exchange format (DXF) file															
ii Using data exchange format (DXF) create numerical control file																
1	Enter the cutting parameter (cutting tool, tool size, tool materials, work material, material)															
2	Generate tool paths for different layers (X, Y, Z direction, cutting loop, depth of cut, feed, and speed)															
3	Save it as numerical control (NC) file															
iii Setup check																
1	Set the tool zero position.															
2	Set the work piece.															
3	Check direction of rotation for the clutck and the cutter.															
4	Check the work piece and the cutting tool is securely clamped.															
5	Verify the NC program.															
iv Final manufacturing																
1	Run the machine.															
2	Run the program for machining															
3	Check the finished product for quality requirements															
Results																

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Presently Mr Abdul Rasool is pursuing research in the School of Computing and Engineering, University of Huddersfield, U.K. Mr Abdul Rasool has an academic career spanning 20 years. Mr Rasool has worked as lecturer, senior teacher, advisor, quality moderator and technical education specialist in various departments within the directorate of technical and vocational education, Kingdom of Bahrain. Mr. Abdul rasool holds a Higher National Diploma in Mechanical Engineering as well as an Honours degree in Engineering with Technology Management.

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