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INTERACTIVE LEARNABILITY ASSESSMENT FOR CNC MACHINES VIA SIMULATION AND HARDWARE ENVIRONMENT IN CIM LAB

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ABSTRACT

Computer Integrated Manufacturing (CIM) is used to combine integrated systems and data communication with new managerial philosophies that improve organizational and personnel efficiency. As technology improves, CIM is getting more important and popular in manufacturing area due to increasingly greater flexibility, quality, speed and productivity. However, the exploration and exploitation of sophisticated CIM systems required effective learning. Learners can experiment through simulations and remote laboratories, and express acquired understanding in a runnable computer model. In this paper, we examined the influence of motivation; GPA and gender on learnability of the CIM system. A sample of 46 industrial engineering undergraduates was educated on turning and milling CNC machines using the simulation software and using both of the machines respectively. Finally, all participants are evaluated according to their learning success by comparing with two-dimensional (turning) and three-dimensional (milling) CNC machines methodology. Turning and milling test results compared with students' grade point average (GPA) score. General learning trends are investigated by a motivation survey to investigate correlation between learning success with learning indicators.

Keywords: Computer Integrated Manufacturing, Computer Aided Learning (CAL), Computer Numerical Control Machines

1. INTRODUCTION

Nowadays, organizations and universities are more frequently benefiting from computer-aided learning(CAL). However, some educators have queried the effectiveness, quality, flexibility, speed, productivity, usability, lower-costs of computer technology in the learning process. A remarkable example can be given with [1]'s claims, which supposed most computer technology-delivered education has promised more than it has delivered. Computers have effectiveness' on education can sometimes be seen as wishful. Moreover, some people have characterized the personal computer as the ''impersonal computer'' due to the loss of an interpersonal dimension in the human–machine interface [2].

In CAL, difficulties are growing from the differences between software controlling for the machine and the machine itself. These environmental differences transpire, whether the machine uses software and whether the software serves its intended purpose, along with a vast number of other pedagogical and situational issues.

2. METHODOLOGY

Technological media are seen as particularly suitable for learning by declarative and procedural domain with general knowledge [3]. It can be derived from learning logic and computer programming [4]. For this reason, participants were selected from undergraduate level of Industrial and

Mechatronics engineering students. All of the students completed courses about CIM system and CNC machines. This paper exploring on the CAL supported courses about the CNC machines. In these courses, there is an opportunity of examining the software applications that emphasizing CAL and machine operations. Participants, who have been successful in the software applications of the CNC machines, were selected to training for machine operations. The education was given on two different CNC machines, namely CNC Lathe (xz dimension) and CNC Milling (xyz dimension). The course assignments and exams were identical, and presentation materials were similar. The only thing, which causes this difference, was the dimension of the machines. The following figure demonstrates the steps for CAL supported education in CNC Machine.

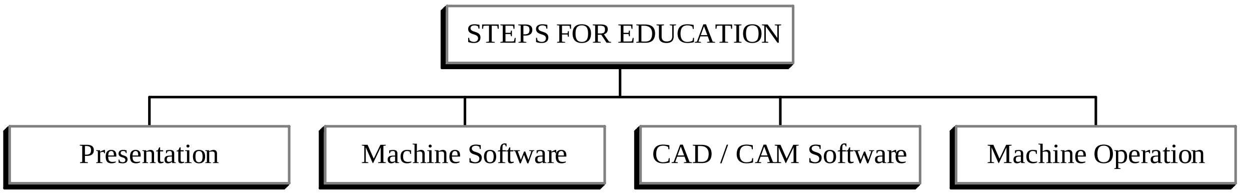

Figure 1. Steps For CAL Supported Education

Students were introduced with two different CNC machine systems according to the following main presentation topics;

- A brief history of CNC lathe and milling machines
- The evolution of both machines in the industry
- The variety of conveniences that the machines accommodate in production
- The structural features of both machines
- The sort of materials that can be engraved
- The range of cutting tools that are commonly used in cutting operations
- The operational mentality of both CNC machine's coordinate axis
- NC codes
    - Brief historical development (NC, CNC, DNC evolution)
    - Operational ranges
    - Types of NC codes (Especially M codes, G codes are underlined)
    - Development of various examples

CNC machines can be controlled with software which was presented to the students. The CNC Machine's interface is composed of various parts. The middle part of the screen displays the 3D working of CNC Machines. In this area, students can be zoomed in to/out of the machines. Also students can observe the machine movements during its operation. They can select various tools for experimentation and modeling from the tool bars. In keeping with the machine metaphor, different tools are available in different cutting tool holders, so the content of this part of the screen depends on the machine. The NC Code edit window provides participants to edit and follow up their codes. The below-hand side of the screen houses machine information panel as well as verify window has been, for the learners to see tool and machine movements. The right-hand side contains jog control and operator panel.

Computer-aided design (CAD) is the use of a wide range of computer-based tools that assist engineers, architects and other design professionals in their design activities. It is the main geometry authoring tool within the Product Lifecycle Management process and involves both software and sometimes special-purpose hardware.

Integrating computer-aided manufacturing (CAM) with computer-aided design systems produces quicker and more efficient manufacturing processes. This methodology is applied in different manufacturing areas. In CNC manufacturing, the CAM system is used to simplify the machining and design process. In most cases the CAM system will work with a CAD design made in a 3D environment. The CNC programmer will just specify the machining operations and the CAM system will create the CNC program. This compatibility of CAD/CAM systems eliminates the need for redefining the work piece configuration to the CAM system. The main function of these tools [5] is to create the geometry of the design, which is essential for the subsequent activities in the production cycle (Figure 2).

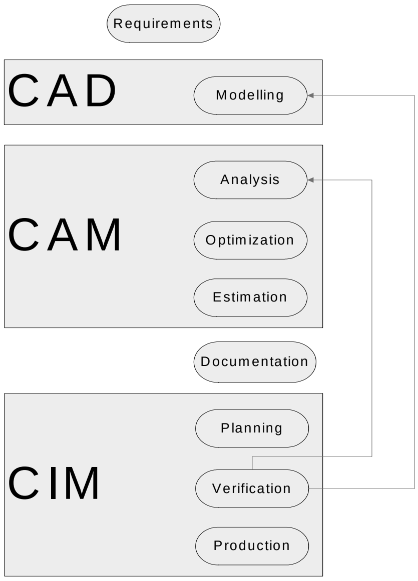

Figure 2. Production Cycle

The participants were asked to design a project with initially given information. Projects have the dimensions of the samples that will be produced on the CNC Lathe and Mill. The students sketched a scaled design of their own sample designs for both machine products. Subsequently, they decided on whether using the CAD/CAM programs or the NC codes. Nearly all of the participants preferred to use CAD/CAM software for their designs. Consequently, they verified their designs in the software to prevent potential machine hazards. If a mistake has been occurred during verification, they would return back to the design stage and followed the same steps until the verification stage accomplished. The product has been carved out after operating the CNC machine.

3. TEST RESULTS

Motivation test has following evaluation metrics: planned working, efficient reading, taking notes, attendance to course, writing, preparation to exam and motivation parameters to determine individual differences on learning phase. Turning and milling test results compared with students' GPA scores and motivation test parameters correlated with these scores. WEKA data mining software is used to run Model Tree to analysis for total quality management in higher education [2]. Regression trees developed for prediction of numeric output as regression model. Regression trees are special form of decision trees that include numeric values rather than nominal values inside the leaf nodes. Individual leaf nodes obtained by numeric average of the output attributes for all instances. Regression trees are more accurate than linear regression equations when the data to be modeled is nonlinear. Regression trees have only one disadvantage that can become quite cumbersome and difficult to understand. For this reason, regression trees are combined with linear regression to form as called model tree [3]. Model tree generates a decision list for regression problems using separate-and-conquer. In each iteration, it builds a model tree using M5 and makes the best leaf into a rule [1].

4. CONCLUSIONS

GPA is highly correlated with CNC lathe test grades and taking notes during the courses. The cross validation values have a mean absolute error less than and equal to 0.1841 and root mean squared error less than and equal to 0.2143. Sum of all totals is highly correlated with CNC lathe test grades. The cross validation values have a correlation value of 0.6597.

The following rules are obtained by processing dataset with M5P algorithm. Rule 1 depicts the relationship between GPA and CNC Milling Machine and the rule 2 indicates the relationship between GPA and CNC Lathe Machine.

Rule: 1
IF gpa > 2.87
THEN
CNC Milling Machine= 0.4993 * Learning + 0.5731 * Note Taking
+ 0.7568 * Writing + 1.2066 * gpa (Correlation coefficient=0.82
Mean absolute error=0.18
Root mean squared error=0.21)

Rule 1 indicates that learning of the CNC milling have correlation with learning effects, note taking, writing and high gpa(>2.87) score.

Rule: 2
IF gpa > 2.585
THEN
CNC Lathe Machine= 0.6346 * Learning + 0.5865 * Effective Reading
+ 0.2043 * CNC Milling Machine (Correlation coefficient=0.63
Mean absolute error=0.12
Root mean squared error=0.18)

Rule 2 indicates that learning of CNC lathe machine has high correlation with learning, effective reading with successiveness in exams of CNC milling machine. Statistical evaluations show us that students' gpa(>2.585) scores have high correlation with turning and milling exams. Also, other motivation factors have great effect on both exams and learning motivation parameters.

As a conclusion, CNC lathe and milling machine can be learned with CAL based system effectively, but, students motivation factors should be take care of to handle teaching problems.

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