# Imparting psychomotor skills to the learners using computer aided instructions in Engineering Education

**R. Mishra, S. Barrans** and **C. Pislaru**

University of Huddersfield, School of Computing and Engineering, Queensgate, Huddersfield HD1 3DH, United Kingdom

Psychomotor skills provide a capability to learners to perform a task with reasonable competence. Various levels of competencies in psychomotor skills are Imitation / Observation, Manipulation, Precision /Competent, Articulation / consolidation and Naturalization & Mastery. In Engineering education psychomotor skills form a very important set of skills that need to be acquired by the students to satisfy overall employability skills requirements. Computer aided instructions are extensively used for improving teaching-learning process across a wide range of subjects but specially in the cognitive learning domain resulting in improved learning effectiveness in that learning domain.

In this paper a structured computer aided instructions methodology has been developed to improve psychomotor skills in teaching and learning of turbo-machines. This paper addresses the issue of improvement in effectiveness of learning in the psychomotor learning domain through computer aided instructions. This research area requires extensive attention from the researchers to make teaching and learning in this important domain of learning enjoyable as well as effective.

The instructions designed include a brief introduction of the skills set that learners are required to master at the beginning of the laboratory session. Learners are then asked to explore a specially designed computer aided presentation which includes video demonstration of the experiment coupled with suitable animations. This enables students to link skills required with the presentation by identifying skills associated with different parts of the presentation.

The above strategy has been well received by the students and overall performance indicators have shown consistent improvement ever since the computer aided instructions have been incorporated in the overall teaching and learning strategy.

## 1. Introduction

The engineering education and practices being adopted therein are changing at a very fast rate. The visual and simulation capabilities of computer aided teaching materials and inherent flexibility in their use have forced educators to develop computer assisted instructions to assist in teaching learning process. At present there are two groups of educators, one who feel that computers can replace classroom teachers and the other who feels that computer cannot give real life learning experience to students and hence oppose it (1, 2). In reality availability of computing resources can result in dramatic improvement in learning experience of students if integrated properly with existing teaching methods *(3).* It is well known that there are three domains of learning namely, cognitive, psychomotor and affective domain (4). In module development those domains are covered as knowledge and understanding outcomes as well as skills outcomes.

The effectiveness of any teaching/learning activity in lecture class depends on whether the activity is helping in attainment of learning objectives. As per the behaviourist's theory, the learning can be quantified in terms of behaviour change and a change in behaviour of learners takes place because of three domains of learning namely:

1. Cognitive domain.
2. Psychomotor domain.
3. Affective domain.

In engineering education, cognitive domain learning is very important as it deals with imparting didactic information about knowledge and facts. The learning results in understanding learning objectives at a simple level to a more complex level.

The knowledge transfer starts at a very low level, which requires memorisation and recall. In Engineering education for a typical analytical module this can be a simple equation describing a physical phenomenon. In the next level, comes the comprehension, where students learn to interpret the information and understand the meaning behind the information. Other levels of learning within the cognitive domain, which must be employed clearly are, application (application of information to real life situation), analysis (analysis of the system from whole to part), synthesis (combining the analysis results to model a new or existing system), and evaluation (being able to optimise the systems). This model is equally valid for an engineering pathway, a module within the pathway and a component of the module within the module (4). The other domains of learning which are very important in engineering education are psychomotor domain and affective domain. The psychomotor domain of learning equips the learner to do things in a particular way. The 'hands on' approach of learning is covered in this domain. In engineering classes students are given an opportunity initially to imitate the demonstration and then allowed to explore boundaries of the learning outcomes. In a typical engineering analysis module there is always an overlap in learning outcomes to be achieved through lectures/tutorials and laboratory work. It helps lecturers immensely while describing a theoretical concept, for example, regarding a centrifugal pump operation, to explain the laboratory set up in the lecture class itself and inter-relate overlapping outcomes to develop an integrated picture of the learning outcomes. There is a lot work available on use of computer technology on teaching-learning effectiveness but most of this work is focussed on use of cognitive learning domain and the effectiveness of computer assisted instructions fairly limited. In this work a computer assisted instruction has been developed for laboratory teaching in turbo-machine area and effect of the modified teaching-learning strategy on psychomotor skills has been quantified. Furthermore the integrated effects of the modified teaching-learning strategy on cognitive and psychomotor skills have been evaluated.

## 2. Psychomotor learning domain

There are a number of psychomotor skills that needs to be embedded in to the learning objectives in typical engineering modules. As with the other two domains of learning proposed by Bloom, for psychomotor learning domain taxonomy is based on the premise that the categories are ordered in degree of difficulty. In each learning domain the learner needs to master a category before mastering another category at a higher level. As such the categories within each domain are levels of learning development, and these levels increase in difficulty. In psychomotor domain the categories in the increasing order of difficulty are Imitation / Observation, Manipulation, Precision /Competent, Articulation / consolidation and Naturalization & Mastery. In the present study the learning objectives were developed to enable students to understand various elements in characterization of a centrifugal pump and all the above psychomotor skills were incorporated in the learning strategy. A detailed description of various elements of psychomotor learning domain descriptors as proposed by Dave [ 5 ] is given below.

**Table 1**: Psychomotor descriptors (Ref 5)

| **Level** | **Category or 'level'** | **Behaviour descriptions** | **Examples of activity or demonstration and evidence to be measured** | **'Key words' (verbs which describe the activity to be trained or measured at each level)** |
|---|---|---|---|---|
| 1 | **Imitation** | Copy action of another; observe and replicate | Watch teacher or trainer and repeat action, process or activity | Copy, follow, replicate, repeat, adhere |
| 2 | **Manipulation** | Reproduce activity from instruction or memory | Carry out task from written or verbal instruction | Re-create, build, perform, execute, implement |
| 3 | **Precision** | Execute skill reliably, independent of help | Perform a task or activity with expertise and to high quality without assistance or instruction; able to demonstrate an activity to other learners | Demonstrate, complete, show, perfect, calibrate, control, |
| 4 | **Articulation** | Adapt and integrate expertise to satisfy a non-standard objective | Relate and combine associated activities to develop methods to meet varying, novel requirements | Construct, solve, combine, coordinate, integrate, adapt, develop, formulate, modify, master |
| 5 | **Naturalization** | Automated, unconscious mastery of activity and related skills at strategic level | Define aim, approach and strategy for use of activities to meet strategic need | Design, specify, manage, invent, project-manage |

## 3. Learning objectives in laboratory experiment:

In the present work the details of the laboratory session are presented through which the above mentioned psychomotor skills have been imparted. The objective of this experiment was to enable students to be able to develop characteristic operating curves for a typical centrifugal pump. These operating characteristic curves indicate interrelation among different operational parameters such as head developed, flow rate, speed of the pump and efficiency of the pump.

The typical experimental setup is shown in figure 1.

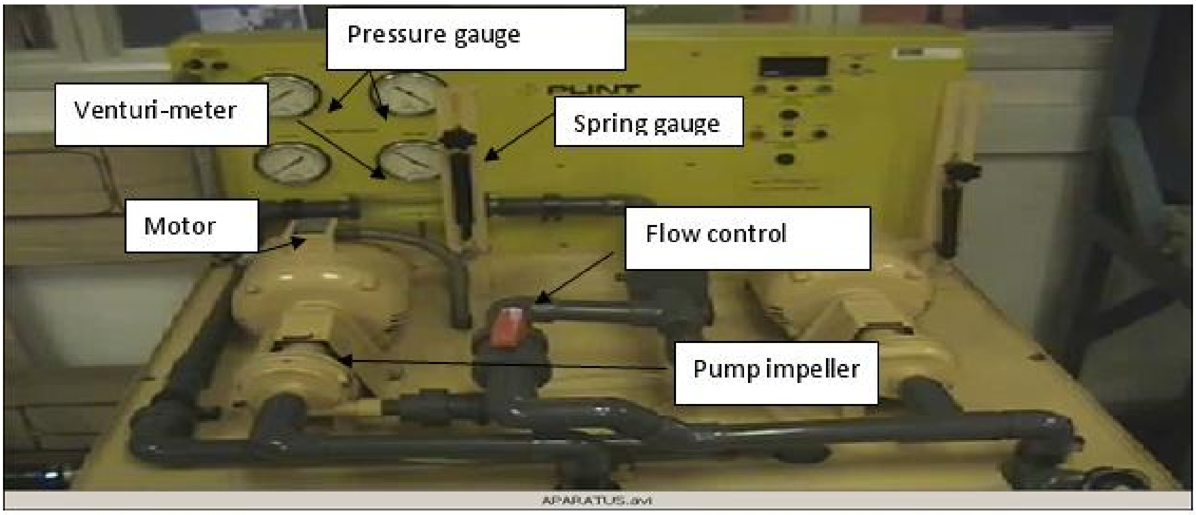


**Figure** 1: Experimental setup used in the analysis

The figure 1 shows the pump-motor arrangement, pressure gauges , a flow control valve, a venturi-meter and a spring gauge to measure power input to the pump. To obtain operating characteristics the pump is made to run at a constant speed and the head developed is recorded by measuring pressure values before and after the pump impeller. The flow rate is measured as well as power input is calculated by measuring spring gauge force and hence torque acting on the pump shaft. The above procedure is repeated at the given speed for various flow rates that is achieved by using flow control valve. The above operation is repeated for different pump speeds. The efficiency of the pump for each operating is calculated by obtaining the ratio of power input to the power input. Typical characteristic curves for a centrifugal pump are as shown in figure 2.

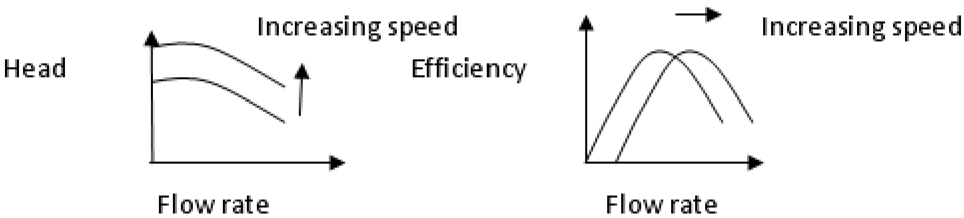


**Figure 2**: Typical operating characteristics of a centrifugal pump

## 4. Teaching and learning strategy

A computer aided learning programme was developed which included the full video demonstration of the experimental procedure. This programme was made available to the students before the start of the experiments. Students were allowed full control over the demonstration and this enabled them to learn the subject matter at their own pace. This enabled the students to acquire first category of psychomotor skills namely imitation. Students were asked to memorise the steps required in the experimentation and demonstrate that they could imitate the steps included in the presentation. Students were then asked to demonstrate the manipulative skills like, changing the valve setting to enable them to understand the inter-relation between the change in flow rate and the head developed as well as the efficiency of the pump. Students were then asked to analyse range of operating conditions and obtain the best efficiency point at a given pump speed. This required students to change various parameters precisely specially near the best efficiency point to exactly locate best point for operation of the pump. Students were then allowed next level of skills i.e. articulation. To reinforce these skills students were asked to repeat the procedures mentioned above at different speeds. This enabled them to understand the effect of speed on the best operating point. Students were then asked to repeat all the above steps and asked to select experimental parameters based on their own choice. They were asked to present results of their experiments in terms of ideal zone of operation for different duty requirements. This enabled them to link the operating characteristic of a centrifugal pump with the pump selection issues. A typical observation table on which students record the parameters is shown below.

**Table 2**: Parameters recorded

| $P_d$ (Delivery pressure) bar(gauge) | $P_s$ (Suction pressure) bar(vacuum) | N' (Speed of pump) rev / min | Q' (Flow rate) lit / s | F (Force on the pump shaft) N | P (Power output) W | η (Efficiency) |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |

Table 2 indicates the parameters to be recorded. These are delivery pressure, suction pressure, speed of the pump, power output and efficiency of the pump.

The above procedure was applied to second year thermo-fluid laboratory class and the competency level achieved by the students in the centrifugal experiment was compared with that achieved in the previous year. For this purpose marks obtained by the students in the year 07-08 were compared with marks obtained in the students in the year 06-07. Various details of the marks obtained are as given below.

**Table 3**: Performance descriptors

| Parameter | Year 06-07 | Year 07-08 |
|---|---|---|
| Average marks obtained | 52.72 | 70 |
| Standard deviation | 8.76 | 10 |
| Minimum marks | 40 | 45 |
| Maximum marks | 65 | 80 |

Table 3 shows that the average marks have increased from a value of 52.72 in the year 06-07 to 70, in year 07-08. Although the standard deviation is almost same the maximum marks have gone up considerably in year 07-08 (from a value of 65 in the year 06-07 to a value of 80 in the year 07-08). This indicates that the students with good ability benefit considerably from the modified teaching and learning strategy. The minimum marks also have gone up from a value of 40 in year 06-07 to 45 in year 07-08, indicating marginal improvement in performance of less able students.

The data shown in table 3 indicate that embedding psychomotor skills based teaching-learning methodology enables students to perform much better. There is considerable increase in the marks obtained by the student when revised teaching-learning methodology has been implemented.

## 5. Conclusions

A teaching – learning strategy for laboratory instructions has been developed by incorporating psychomotor skills descriptor. It has been observed that psychomotor skills based teaching strategy results in better acquisition of hands-on skills. The gradual competence development results in better learning environment with a feeling of accomplishment in students. It has been seen that the new teaching learning strategy has resulted in considerable improvement in students' performance within one year. All the performance indicators have shown significant improvement indicating success of the new teaching-learning strategy.

## References

1) Abdulrassol, S., Mishra, R., Fieldhouse. J., Ward, S., ' Effectiveness of parallel and serial integration of teacvhing resources in laboratory teaching in engineering education'. International journal of learning, volume 13, no. 6.

2. Abdulrassol, S., Mishra, R., Fieldhouse. J., Ward, S.,' Effectiveness of computer assisted instructions: Learning outcomes analysis' , International journal of learning, volume 14, no. 6.

3) 2. Abdulrassol, S. and Mishra, R.' Using computer technology tools to improve the teaching leanring process in technical and vocational education: Mechanical engineering subject area' , International journal of learning, volume 15, no. 9.

4) S. M. Zywno, ‘Hyper media instruction and learning outcomes at different levels of Bloom’s taxonomy, Global journal of engineering education, vol. 17 no. 1.

4) Bloom Benjamin S. and David R. Krathwohl. Taxonomy of Educational Objectives: The Classification of Educational Goals, by a committee of college and university examiners. Handbook I: Cognitive Domain. New York, Longmans, Green, 1956.

5) Dave, R: Psychomotor Domain, International conference of educational testing, Berlin, 1967.