



Redesign of a Module for Learning by Doing

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Abstract: Course content delivery method plays a vital role in enhancing the students learning experience. The teaching method must be aligned with the nature of course content. In the curriculum of mechanical engineering program, there are certain courses that deal with industry related issues such as workplace safety, ergonomics, productivity improvement, method study and time study etc. In the conventional way of delivering the course content of such courses, the students are least motivated in the class as passive recipient of the knowledge. In order to improve the students' engagement in the class, a module has been redesigned for a particular course "Work study and Ergonomics" taught in final year of BE Mechanical engineering at TIET Patiala. The intent was to align the teaching method with the concept of learning by doing. In the modified content delivery method students were asked to complete certain tasks in the lab class in a manner similar to the related industry. In the process of module redesigning, all the elements such as delivery method, content, assessment and feedback from students were addressed. A group of students (n=35) were asked to provide feedback on the aspects of new method of learning through a questionnaire. It was observed from the students' response that they liked the changes made in the instruction delivery method and were willing for a shift from the conventional mode of learning to this new

redesigned method. However, from the educators' view point there were certain challenges involved in conducting the redesigned module. These challenges have also been discussed in this paper.

Introduction:

Regular changes in the content delivery method are essential based upon the type of course content and learning outcome of students. Since the student community is changing at an incredible pace due to various cultural, societal and technological advancements. Therefore, in the recent times, the students have multiple platforms to access the subject related knowledge. In this scenario, if the teaching method adopted is still traditional, students feel less motivated which results in lower degree of learning. Apart from the technical knowledge, the students should also be prepared for certain other attributes such as team work, communication skills and time management etc. so that students could work efficiently in the industry Felder (2006). Thus, educators must focus on updating the teaching method in order to prepare the students as per industry needs. In engineering education, the student learning could be improved using problem-based learning (PBL) (Helle et al., 2006; Jollands et al., 2012; Litzinger et al., 2011; Prince & Felder, 2006). In PBL approach, students work in teams to solve problems related to the course content and not only gain the content knowledge but also acquire other skills such as reasoning, communication, and self-assessment. Based upon the literature review, it is perceived that students participating in active learning are able to apply the acquired knowledge more effectively (Lu 2007). Work study and Ergonomics (WSE) is one of the various elective choices given to final year BE Mechanical Engineering students. Work study and Ergonomics (WSE) aims towards efficient and safe working of organisations. The key concepts of the course include developing the most efficient method to perform certain job, optimising the time taken to complete certain task and safe design of the workplace. The implementation of these concepts in industry not only require sound technical understanding of these concepts but also demands behavioural shifts and effective communication skills to convince task force members as well as managers. Despite the various advances in teaching methods, still the WSE is being taught using traditional teaching methods and hence undermine the learning and development of graduate students. In order to address the above said issues, the modification in teaching and learning styles becomes compulsory. At first, an alternative approach based on active learning methods is proposed and then an assessment of the new teaching

methods' effectiveness based upon student feedback is presented. Finally, the challenges involved in implementing the new method have been discussed.

Rationale for selecting Work Study and Ergonomics for redesign

A course on Work study and Ergonomics is being presently taught in the curriculum of BE Mechanical Engineering and BE Mechatronics Engineering in the final year as an elective course. The module is really sought after and generally a large number of final year students opt for this elective course. This course focuses on two very important aspects of working in any industry. First, 'Productivity of the company' through efficient working and reduction of waste of all resources of materials, energy, manpower and machines and second to ensure health and safety of the employees carrying out various operations. Two major topics in the module are 'Work Study' and 'Ergonomics'. Work study further focusses on two very important parts of work in the industry, that is, 'Method study' and 'work Measurement'. Method study evaluates systematically the present methods of doing work and evolves new improved methods which are efficient, cost effective and safe for humans to perform. Work measurement is a technique to calculate time for doing various types of work which becomes the basis for setting work norms in the industry and devising incentive schemes.

The module is currently taught conventionally in the class room with three lecture classes and one tutorial class per week. It involves analysis of systems and design of new methods or incentive schemes. In the previous years, analysis and design methods were taught with the help of examples and data taken from the text books. Of late, it was realized that students are not really very excited in the classes and take this course as another course which will give them good grades and also some insight into efficient ways of working in industry. It was felt that this course can be taught in a way that will involve a lot of experiential learning on the part of the students, experience of which will always remain with the student.

Methodology

The module was redesigned for a class of 175 students including BE Third Year Mechanical (Production) Engineering and BE Fourth Year Mechanical Engineering and Mechatronics Engineering. The students are supposed to have certain pre-requisites (i.e. working system of manufacturing and service organisation) before taking up this module. After complete the module the student will be able to:

1. Understand the concepts of method study, work measurement and ergonomics
2. Apply the knowledge of method study, work measurement and ergonomics to improve productivity of manufacturing and service organizations
3. Analyse productive systems to find out causes of low productivity or musculoskeletal injuries
4. Design new efficient methods or time standards for higher productivity and human health

Composition of Module: Lectures/tutorials/labs

Number of weeks in the semester: 15

Lectures per week: 1 Hour

Tutorials/practical per week: 2 Hours

To make the course (Work Study and Ergonomics) experiential, the teacher created a lot of exercises for method study, work measurement and ergonomics. In these exercises, teams of students, each having 4-5 students were formed (i.e. Performance teams, Videography teams, time measurement teams etc). The teams were given a task similar to a task in the industry. While the performance was going on, the other teams were making a video or noting the time using a stop watch. The videos were then run carefully to find out the deficiencies in the methods of performance and to identify areas of improvement. This was done repeatedly for improvement in methods or for determining a day's work for an individual after allocating necessary allowances. These activities improved the student's involvement and understanding of theoretical concept.

Teaching and learning activities of the module have been designed in such a way that it integrates content of the module with active learning on real world examples in groups of students. Blended and flipped approach has been used in the module. The students will prepare themselves for performing activities by reading the uploaded material. Most of the learning will be by performing activities by the students thus bringing in project-based learning to a large extent which also provides necessary self-regulation and motivation. All teaching and learning activities have been mapped with the learning outcomes. The students while performing activities will not only

attain domain knowledge and skills but will also learn working in teams towards common goals, hone their communication skills, planning and time management skills and human values, thus addressing the graduate attributes and inclusive education. Teaching and learning activities have been categorised as following:

Teaching Activities

1. Explaining the concepts and techniques
2. Forming student teams for:
 - a. Performing activities simulating the industrial work, e.g., pick and place, assemble, move, lift etc.
 - b. Timing these activities
 - c. Making videos
 - d. Analysis and micro-motion studies
3. Uploading required instructional material
4. Discussions on exercises and relating these to concepts and techniques
5. Formative and summative assessment while performing activities

Learning activities

1. Listening to the lectures and instructions for performing activities
2. Arranging materials and consumables for performance of activities
3. Reading the instructional material before and after the performance of activities
4. Performance of activities, timing them and making videos
5. Identifying areas of improvement and performing again after redesigning the process
6. Making presentations and assignments

Assessment activities

In order to know the extent to which the learning outcomes have been achieved, the following assessment activities have been planned.

S. No.	Assessment Component	Marks for assessment	
		Formative	Summative
1	Performance of activities 1	Yes	
2	Performance of activities 2	-	10
3	Presentation 1	Yes	
4	Presentation 2	-	10
5	Assignment 1	Yes	
6	Assignment 2	-	10
7	Mid semester test (Theory and practice/performance)	-	30
8	End semester test Theory and practice/Performance	-	40

As can be seen from the above scheme of assessment, formative assessment is kept in assignments, presentations and performance activities. Students will get feedback on performance activities and presentations verbally at the time of performance or presentations. The assignments will be checked on 'Track Changes', where feedback and comments will be written. When one group is presenting or performing activities, other groups will assess them, thus bringing in Peer assessment. Group work will be

assessed through presentations, teamwork and performance of activities. Most of the other modules do not have these types of assessment activities. This module will thus pave the way for such assessment components in the programme. Assessment components have been aligned with learning outcomes and the graduate attributes like ethics, team work and communication.

The redesigned module has one lecture and two practical classes in a week contrary to three lectures and one tutorial in the currently offered course. The practical classes will be scheduled in the workshop and will include exercises on Method Study, Work Measurement and Ergonomics. These exercises will simulate industrial working and will be carried out by teams of students. Teams will include Activity Performing Teams, Time Study Teams, Videography teams and presentation teams. New aims and objectives, threshold concepts, learning outcomes and session plan have also been designed for the module. The session plans include description of teaching and learning activities. The design is inclusive as all students will be able to perform activities, make presentations and learn by doing. The new design of the module includes active learning on real world problems and situations, has a component of flipped approach, group work, self-regulation and problem-based learning. The redesigned module has appropriate components of formative assessment, summative assessment and peer assessment. Assessment components and methods are aligned with module outcomes.

Module sessions were mapped across a period of teaching time based on the ABC curriculum design method (Perovic and Young, 2015) The ABC (Arena Blended Curriculum) design method is a technique of making a visual ‘storyboard’ outlining the type and sequence of learning activities required to meet the module’s learning outcomes. The story board is prepared from the six pre-printed cards representing the type and sequence of learning activities required to meet the module or programme learning outcomes. The brief description of six pre-printed cards is given as follows:

Acquisition: Learning through acquisition is what learners are doing when they are listening to a lecture or podcast, reading from books or websites, and watching demos or videos.

Collaboration: Learning through collaboration embraces mainly discussions, practice, and production. Building on investigations and acquisition is about taking part in the process of knowledge building itself.

Discussion: Learning through discussion requires the learners to articulate their ideas and questions and to challenge and respond to the ideas and questions from the teacher and/or from peers.

Investigation: Learning through investigation guides learner to explore, compare and critique the texts, documents and resources that reflect the concepts and ideas being taught.

Practice: Learning through practice enables the learner to adapt their actions to the task goal, and use the feedback to improve their next action. Feedback may come from self-reflection, from peers, from the teacher, or from the activity itself, if it shows them how to improve the result of their action in relation to the goal.

Production: Learning through production is the way the teacher motivates the learner to consolidate what they have learned by articulating their current conceptual understanding and how they used it to practice.

Using these pre-printed cards concept, all the sessions of the module were designed. Many of these sessions did not start with 'Acquisition'. These rather started with 'Investigation' or 'Practice' or 'Production' thus making it 'Learning by Doing'. Some part of the designed module was delivered in the tutorial classes in which the students did the assembly work while they were being videographed and timed. The students could easily understand the topics with an extensive coverage of theoretical concepts normally covered in the theory classes. Formal feedback taken from the students show a high level of satisfaction on their part and a very good level of understanding and retention of the topics covered.

S.No	Session lab/lecture	Topic	Sequence of Teaching Activities	Grad Attributes critical thinking, creative thinking, communication	Assessment formative quiz, self, peer
1	Lecture	Introduction: Definition, Scope, Historical review and areas of application of work study in industries,	Acquisition, Discussion, Investigation, Acquisition	Domain knowledge	Formative, oral quiz for recapitulations

2	Lecture	Inter-relation between method study and work measurement, Reaction of management and labour, Role in improving plant productivity	Acquisition, Discussion, Investigation, Acquisition	Domain knowledge	Formative, oral quiz for recapitulations
1,2	Practical		Practice, Collaboration, Investigation, Discussion, Acquisition	<ul style="list-style-type: none"> • Team work • Communication • Domain knowledge and skills • Creativity 	Peer to peer evaluation both formative and summative
3,4	Lecture	Method Study: Objectives and step-wise procedure for method analysis, Recording & evaluation techniques,	Acquisition, Discussion, Investigation, Acquisition	Domain knowledge	Formative, oral quiz for recapitulations
3,4	Practical		Practice, Collaboration, Investigation, Discussion, Acquisition	<ul style="list-style-type: none"> • Team work • Communication • Domain knowledge and skills • Creativity 	Peer to peer evaluation both formative and summative

5,6,7	Lecture	Micro-motion and macro motion study, Therbligs and Simo-charts, Principle of motion economy, Normal work areas and design of work places, Principles of work design, Multiple activity chart, Flow process, chart, String diagram, Travel charts.	Acquisition, Discussion, Investigation, Acquisition	Domain knowledge	Formative, oral quiz for recapitulations
5,6	Practical		Practice, Collaboration, Investigation, Discussion, Acquisition	<ul style="list-style-type: none"> • Team work • Communication • Domain knowledge and skills • Creativity 	Peer to peer evaluation both formative and summative
8,9	Lecture	Work measurement objectives, Techniques & criteria for selection of technique, Stop watch time study, Systems of performance ratings, Calculation of standard time, Introduction to allowances, Production study	Acquisition, Discussion, Investigation, Acquisition	Domain knowledge	Formative, oral quiz for recapitulations
7	Practical		Practice, Collaboration, Investigation, Discussion, Acquisition	<ul style="list-style-type: none"> • Team work • Communication • Domain knowledge and skills 	Peer to peer evaluation both formative and summative

				<ul style="list-style-type: none"> • Creativity 	
10	Lecture	Work sampling	Acquisition, Discussion, Investigation, Acquisition	Domain knowledge	Formative, oral quiz for recapitulations
8	Practical		Practice, Collaboration, Investigation, Discussion, Acquisition	<ul style="list-style-type: none"> • Team work • Communication • Domain knowledge and skills • Creativity 	Peer to peer evaluation both formative and summative
11	Lecture	Standard data usage, Engineered time standard, Predetermined motion time system (PMTS).	Acquisition, Discussion, Investigation, Acquisition	Domain knowledge	Formative, oral quiz for recapitulations
9	Practical		Practice, Collaboration, Investigation, Discussion, Acquisition	<ul style="list-style-type: none"> • Team work • Communication • Domain knowledge and skills • Creativity 	Peer to peer evaluation both formative and summative
12	Lecture	Ergonomics Engineering Anthropometry: Significance of human body measurement in design of equipment, Facilities, Work place and operation, Static and dynamic anthropometry, Anthropometric data	Acquisition, Discussion, Investigation, Acquisition	Domain knowledge	Formative, oral quiz for recapitulations

10,11	Practical		Practice, Collaboration, Investigation, Discussion, Acquisition	<ul style="list-style-type: none"> • Team work • Communication • Domain knowledge and skills • Creativity 	Peer to peer evaluation both formative and summative
13	Lecture	Task Analysis: Task description, Posture measurement, RULA and REBA analysis and evaluation	Acquisition, Discussion, Investigation, Acquisition	Domain knowledge	Formative, oral quiz for recapitulations
12	Practical		Practice, Collaboration, Investigation, Discussion, Acquisition	<ul style="list-style-type: none"> • Team work • Communication • Domain knowledge and skills • Creativity 	Peer to peer evaluation both formative and summative
14	Lecture	Lifting & lowering tasks, Lifting index, Lifting & carrying tasks, NIOSH lifting equation.	Acquisition, Discussion, Investigation, Acquisition	Domain knowledge	Formative, oral quiz for recapitulations
13	Practical		Practice, Collaboration, Investigation, Discussion, Acquisition	<ul style="list-style-type: none"> • Team work • Communication • Domain knowledge and skills • Creativity 	Peer to peer evaluation both formative and summative
15	Lecture	Biomechanics: Introduction to levers of Human Body,	Acquisition, Discussion, Investigation, Acquisition	Domain knowledge	Formative, oral quiz for

		Ligaments & Tendons, Joints. Kinetics to include forces producing			recapitulations
14, 15	Practical (Project)	Project on any of the topics from the syllabus	Collaboration, Discussion, Practice, Investigation, Production	<ul style="list-style-type: none"> • Team work • Communication • Domain knowledge and skills • Creativity • Synthesis • Reflection 	Peer to peer evaluation both formative and summative

Results and Discussion

A feedback form in the form of questionnaire was designed to obtain students' response. Students were asked to provide their feedback on level of understanding the concept, extent of retention and their overall learning experience.

Table 1 presents the response of the students to various questions contained in the questionnaire.

Students' Feedback Questionnaire	
Course:	Work Study and Ergonomics
Instructor:	Prof. T.P. Singh and Dr. Anu Mittal
Term and Year:	July- Dec. 2019

Learning Outcomes	New method is much better (5)	New method is slightly better (4)	Both are equally good (3)	Earlier conventional method was slightly better (2)	Earlier conventional method was much better (1)
1. Understanding of the theoretical concept	28	4	-	-	-
2. Retention of the concept	25	9	-	-	-
3. Did the students enjoy while learning?	32	-	-	-	-

Based upon the students' response, it could be seen that out of 35 students, 28 students found the new teaching method a better option for understanding the concept. Similarly, it has been indicated that for concept retention also new method was the preferred choice. At the same time, students participated in the learning process with enhanced enthusiasm.

Conclusion and Future Scope:

In the present paper, a module has been redesigned for Work Study and Ergonomics based on learning by doing approach. The proposed model helps in enhancing the students' learning experience and apart from providing technical aspects, inculcates additional

attributes for making students to fit in industrial environment. In spite of positive feedback from students, implementation of this module involves certain challenges as following:

1. Currently this module is being taught as a conventional module with significant time devoted to lecturing in the class. Most of the other modules in the program are also taught in this manner. Teaching one single module in the programme in an experiential manner amounts to breaking conventions and old practices, hence requires a lot of thinking, initiative and persistence.
2. Available classrooms and other spaces need to be oriented to implement experiential learning.
3. For experiential learning, a large number of exercises need to be designed, equipment for performing exercises, time study, videography and editing videos need to be arranged for smooth planning and conduct of the module, a variety of consumables are also required.

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