Tinkering to Fabricating - Developing basic skills of fabrication in Freshmen

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Abstract: Developing the basic skills of fabrication and its knowledge is an important part of engineering curriculum. An immediate necessity could be during student project activities. Students, sometimes irrespective of different streams of engineering, will develop a prototype or Proof of Concept of a system as their Project. This involves invariably usage of different tools at workshop like Files, Drilling Machine, Bench Vice, Hack Saw Blade, etc. Developing these basic fabrication skills has been done through various methods in different universities. One such experiment was conducted in the name of "Design Project" for freshmen at KLE Tech, Hubballi. The prime objective of this work was to check the effectiveness of learning on various basic fabrication skills through Design Project. In this work, effort has been made to introduce workshop as a tutorial component of Basic Mechanical Engineering (BME) Course Curriculum. This course is of 3 credits, out of which 2 are for class room sessions and 1 for tutorial session. Demonstration on usage of tools was given to students during tutorials. To check effectiveness of tutorial component, design project was introduced. After the completion of the course, an anonymous feedback taken by the students revealed that BME curriculum and design project were enjoyable learning processes. 50% of the students agreed that Design Project was the most wonderful project experience. 90% of the students agreed that BME curriculum was exciting. 81% of them agreed that they were able to use different workshop tools for Design Project comfortably. Based on the results of the work, it appears that Design Project along with BME curriculum with Workshop content as Tutorial component could be significantly beneficial. This article showcases the benefits of present model along with BME curriculum with tutorial component, conduct of design project, its assessment and review of feedback taken by the students.

Keywords: Freshman, Course Project, Basic Mechanical Engineering, Basic Fabrication Skills, Workshop, Tutorials.

1. Introduction

The motivation for the authors to enhance the basic fabrication skills into the freshmen was the immediate need for the engineering students to utilize these skills of fabrication during their projects. Students, sometimes despite of being in any stream of engineering will end up doing some fabrication work as a part of their project. In Indian context, until K12 education learners hardly learn anything related to design and fabrication. This necessitates the need for developing basic fabrication skills in engineering students. And sooner could be better.

Various universities across the globe have addressed this in different methods. Visveswaraya Technological University in India is having a separate course called Workshop Practices, which allows student to develop his or her fabrication skills. In Massachusetts Institute of Technology (MIT) the students after gaining the basic fabrication skills also try to build a functioning machine. the First-YearEngineering Project (FYEP) course at the University of Colorado at Boulder(Knight et al., 2003) and Carnegie Mellon University (M. C. Yang., 2003) also have tried to achieve a similar objective.

One such experiment is done at KLE Technological University (KLE Tech), Hubballi, Karnataka, India in the name of Design Project. Basic Mechanical Engineering (BME) is one of the courses at freshman level at KLE Tech, which was utilized to address this issue. BME is a 3 credit course, which is split up as 2 credits for classroom sessions and 1 credit for Tutorial session. The basic fabrication skills were developed during this tutorial session.

2. Methodology

BME is one of the subjects offered by mechanical department to freshmen of KLE Tech. This was the most suitable course for the modification to implement.

A. Earlier Version of BME

Earlier to the experiment was conducted the BME didn't had any tutorial component. This theory course was of 3 credits. All contact hours were utilized for classroom teaching and learning. This didn't have any flexibility to add in any curriculum related to development of basic fabrication skills. This course, despite of being theoretical, is having introduction to many basic fabrication processes, but no practical or demonstration sessions. However, there was a separate laboratory course itself by the name Engineering Practices, wherein students developed the

basic fabrication skills during this lab, wherein students did practical and were demonstrated about various fabrication processes. This laboratory course was of 1.5 credits. This is how the courses are taught in some of the universities of India. This kind of curriculum is having two lacunas. One, students learn without knowing the significance of those fabrication processes. Since there are no any kind of application oriented exercises given to students. Second, the learner may not connect himself with the content being taught in workshop with BME course, since they are learnt asynchronous.

B. New or Modified version of BME

In the new or modified version of BME, the curriculum content of engineering practices lab is merged. And there is no separate course related to workshop practice. The new BME course is of 3 credits, which are split up as 2 credits for classroom sessions and 1 credit for Tutorial session. In tutorial session the workshop curriculum is learnt by students. The curriculum of new BME course is similar to that of old with some amount of modification with regards to tutorial component. The assessment of the development of the skills is made by Design Project.

C. Tutorial Sessions

As mentioned, 1 credit of BME course was dedicated for tutorial session, during which students developed their basic fabrication skills in workshop, than engaging in a classroom lecture. The tutorials were so planned to give students adequate exposure to fabrication processes like fitting, welding, sheet metal operations and various machines, etc. Demonstrations by instructors were given on all above mentioned processes. Students also did practical on Sheet metal operations and assembly and disassembly of Bicycle (Kavale., 2015). But no practical were done on fitting, welding and machine shop operations.

D. Design Project

In order to assess the development of skills learnt during tutorial session, a course project was conducted in the name of "Design Project". Design project is an open ended project, where learner will decide to choose the appropriate process for fabrication of a defined product. Some examples of the defined products were Sand Lifting Machine, Water pump, Laptop Table, Fruit or Leaf Plucking machine, Water bottle crusher, Beverage can crusher, Vegetable dicer, etc. The products to be fabricated were so well defined that they invariably involved all the fabrication process learnt. Though the title of the course project was given as Design Project, very minimal attention was given to design process followed by learners, despite of students learning the Engineering Design Process in other courses. The objectives of the design project are mentioned below.

Student should create a simple product or device satisfying at least the functional aspect of the design. No any other constraints were given purposefully. One should note that the products are being fabricated by freshmen who are very new to such processes. Student should utilize the various tools and machinery available in workshop in order to fabricate the product which in turn indicates the development of his or her fabrication skills. Purposefully all products were asked to be made up of scrap material only. Permission for students was given to utilize institution junk yard. Purposefully students were asked to build purely mechanical device than electromechanical or mechatronic, otherwise the major objective of checking the development of skills may get hampered. A small amount weightage was given even to innovation and uniqueness of the fabricated product, in order to ensure not all projects look similar. This made students to think creatively and come up with better designs or value additions in the final design to fabricate.

Design Project was assessed for above mentioned objectives. Rubrics for the assessment were given to students well in advance. The tutorial session is not having any other assessment strategies apart from Design Project.

The time given for the students to complete the project was 2 weeks after the announcement of the design project. Design project was made a team activity rather than individual considering the overall load on the students across all courses during the semester. At KLE Tech, there were 8 batches of freshman classes. Total number of student projects across the freshmen was 130. For a batch one product or device was announced to work upon, which ensured no duplication across batches. Scope for duplication was lesser even within a batch because of some weightage of assessment given to uniqueness or element of innovation.

The kind of the products given for the fabrication was very much related to real world, than usual practical given for assessment. This motivated the learner to develop skills to higher extent. Below figures show some of the projects made by students.

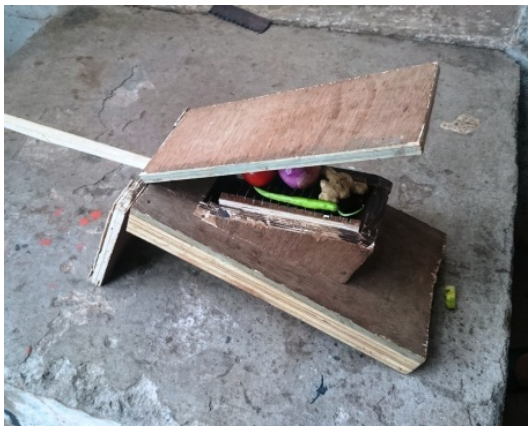

Fig. 1 Vegetable Dicer made by students

Fig. 2 Sand Lifting Machine made by students

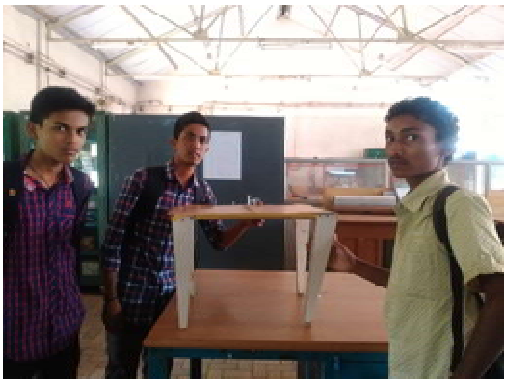

Fig. 3 Laptop Table made by students

Fig. 4 Water pump made by students

3. Results and Discussion

An anonymous feedback was taken after the completion of the course from freshmen. The feedback was on voluntary basis. Total number of students who underwent this course was 520. Out of which 147 gave the response for the feedback questionnaire. Questionnaire was circulated using Google Forms. Some questions were asked on overall course and few on design project.

Fig. 5 and Fig. 6 show the feedback regarding overall BME course. It appears from the results that students were contented with the curriculum design. Fig. 7 shows the interest of students with respect to different topics in the curriculum. Thermal Engineering 1: PrimeMovers part was the most liked by the students. Possible reason for this result was easily available different pedagogical tools available for lesson delivery. The least feedback was resulted in Introduction to Mechanical Engineering part. This was a new content which was designed by authors for the first time. Possibly some renovations in delivery process will make it interesting and more liking to students.

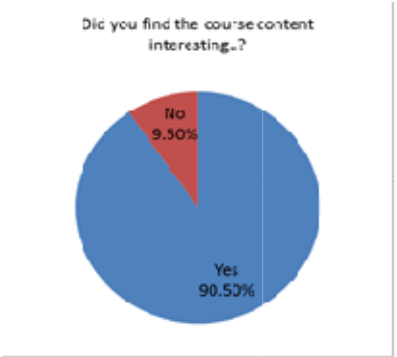

Fig. 5 Student Feedback regarding overall BME Course

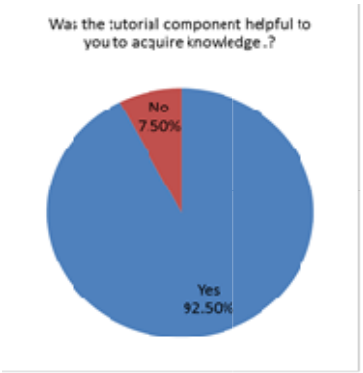

Fig. 6 Student Feedback regarding overall tutorial sessions

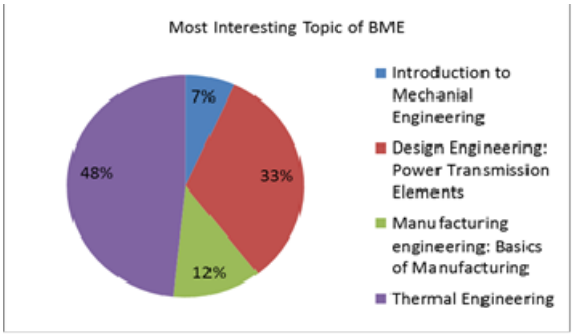

Fig. 7 Student Feedback regarding most interesting topic

As discussed earlier some part of the course was delivered during tutorial session. Fig. 8 shows the students perspective of learning through tutorial session. It appears that students were not satisfied with the current method of delivery. The possible reason for this feedback is the change in teaching instructor during tutorial session. However this can be improvised by a change in pedagogical practice. In current method, traditional teaching learning process is followed. But by shifting to

video based teaching process the results could be enhanced. The same will be tried during upcoming academic year.

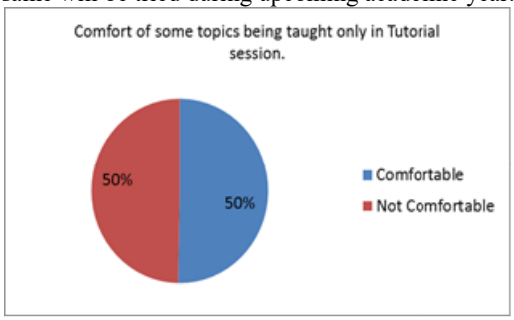

Fig. 8 Student Feedback regarding comfort of topics being taught in tutorial

As mentioned earlier design project was used as a tool for assessing the learning out of tutorial component. It appears from Fig. 9 that students were clear about the objectives of design project.

Sheet metal exercise is one of the exercises which students demonstrated after instructor did show the entire procedure through demonstration. A comparative question was asked to understand the excitement between sheet metal exercise and design project. From Fig. 10 it appears that students were not much excited about design project. Following could be the reason for such results. Sheet metal exercise is a demonstration exercise, wherein students were guided across the exercise. Whereas, design project involved lesser guidance. Students were pushed to bring out creativity during project. But in Sheet metal exercise, there was no such necessity for creativity. Design project was a team effort from students, which involves team dynamics into consideration. However, sheet metal exercise was an individual effort and hence no effect of team dynamics. But despite of lesser excitement shown by students the amount of learning is significantly large compared to Sheet metal exercise.

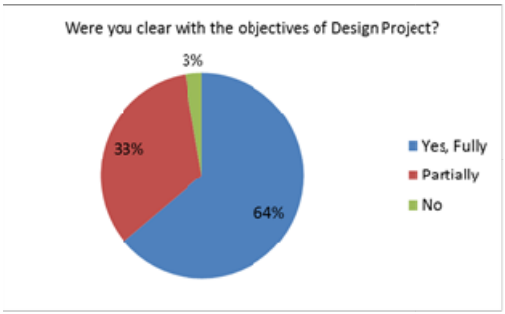

Fig. 9 Student Feedback regarding clarity of objectives of design project

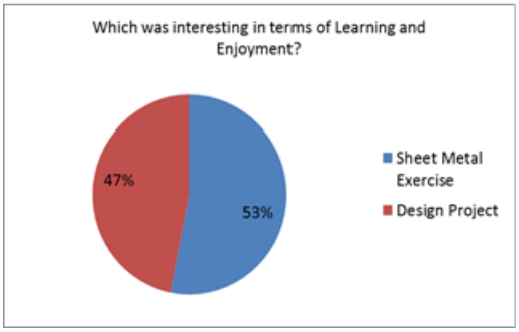

Fig. 10 Student Feedback regarding most interesting between Sheet metal Exercise and Design Project

As mentioned earlier, some part of the tutorial curriculum was only demonstrated by instructors and students didn't do any kind exercise on those learning. Like, various fitting tools were only demonstrated and students didn't do any exercise on their learning. Despite of it students were asked to use those learning in design project. And Fig. 11 indicates that students were at comfort while working with those tools.

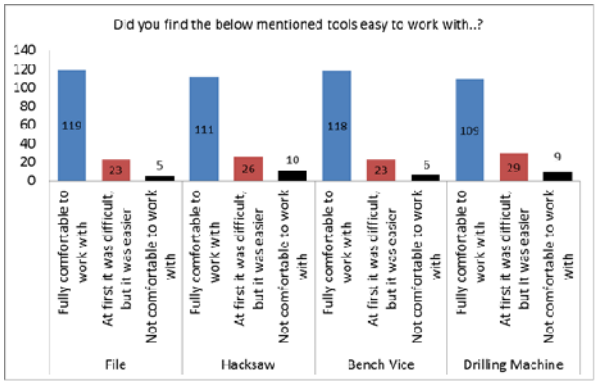

Fig. 11 Student Feedback regarding comfort about various tools utilization in workshop during Design Project

A question was asked to collect a general opinion of students regarding if they felt something missing which they thought they would have learnt as a part of BME course. The response to this question also gives an insight of students' perception about a subject.

The final question in the feedback was regarding the Design project as a whole as a part of BME curriculum. It appears from Fig. 12 that more than 95%of the students appreciate Design Project as a part of BME curriculum.

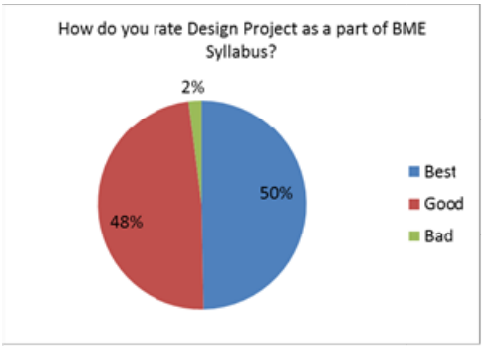

Fig. 12 Student Feedback regarding design project as a part of BME curriculum

As mentioned earlier the Design Project was assessed. Rubrics based assessment was performed with following parameters.

- Functionality of the project.
- Tool Utilization.
- Uniqueness of the model
- Usage of only scrap material

Out of 130 student teams assessment data a random sample of 65 assessment data was selected to do the below analysis. The sample collected is 50% of the data. Care is taken that the data collected is spread across the freshman divisions. Because not all students are taught in the same division nor by the same instructor. Even assessment was also done by 7 different instructors for all divisions.

Figure 13 indicates the students achievement regarding the first assessment parameter, i.e., functionality. From the pie chart it is clear that 92% of the student teams were able to successfully show a functional prototype. The key to achieve such high percentage lies in giving proper problem statement to the students. One should take enough care while selecting the problem statements. Because we should note that the project is being carried out by freshman engineers.

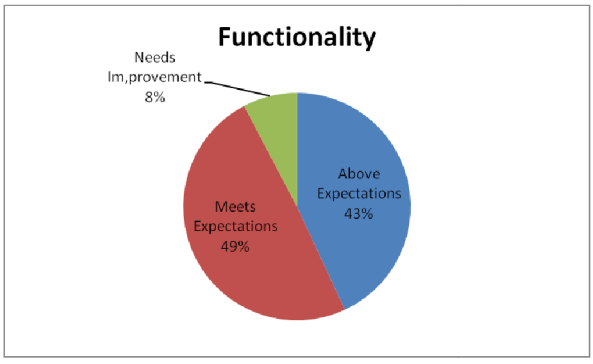

Fig. 13 Student teams performance towards functionality of the project.

Figure 14 indicates the effectiveness of various tool utilization at workshop. From the graph it is evident that 85% of the student teams have used all tools needed for fabrication which were demonstrated during tutorial sessions. Tools were such as, files, hack saw, sheet metal operating tools, welding tools, etc. This particular graph is very essential for observation. We should note that, despite of no traditional workshop sessions, 85% of student teams were successfully able to perform basic fabrication processes.

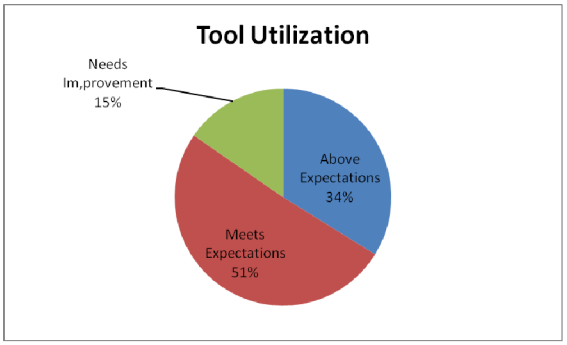

Fig. 14 Student teams performance towards tool utilization in the project.

Figure 15 indicates the extent to which the students were able to come up with unique, unconventional and innovative project idea within the problem statement given. It is found out that only 23% of the project ideas were unique. One should understand that not every project idea need to be unique. But from the assessment point of view one should also ensure that some weight should be given to uniqueness so that not all project ideas will become similar. In order to encourage unique ideas some amount of marks was given. From the graph, it is observed that only 23% of the project ideas were unique.

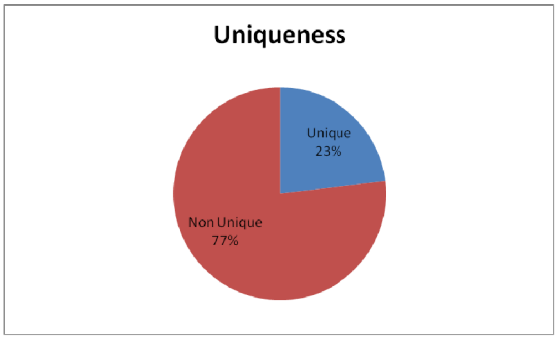

Fig. 15 Indication of uniqueness in project ideas.

The last parameter in the assessment was the use of scrap material only. A 100% achievement was observed for this parameter. Efforts are being put to revise this parameter in the next academic cycle.

4. Conclusion

It appears from the feedback taken from the students that it was joyful learning experience out of tutorial sessions and design project. It is also to be noted that, there were certain lacunas even in this experiment. However they can be filled

up with many other pedagogic practices, which authors would try out in upcoming academic year.

Despite of the lacunas, the new model of BME which has integrated workshop into is having many advantages. Few of them are mentioned here. Firstly, there is no separate workshop laboratory course because of which few credits are reduced. One should understand the significance of reduction of these credits. Many of the Indian universities are trying to reduce credits and bring down to global standards. Although, many of the traditional universities have a mandate of 200 credits for the successful completion of engineering degree. However slowly the things are changing in many autonomous institutes and private universities including KLE Tech, wherein the total credits have been reduced to 176.

Secondly, the synchronous learning of theoretical and practical knowledge in the same session is another advantage, which was not happening in the earlier version. Students will be able to connect to the topic easily. Thirdly, Design project is a unique process of assessing student's skill development. Design Project is a creative method which is more connected to real world because of which student's motivation level is maintained across the project experience. Fourth, students were not burdened of unnecessary report work, which could have otherwise made students overloaded. The only deliverable was the fabricated product which satisfied the objectives of design project.

The projects done by the students were well documented in the form of videos. Students created videos while explaining the working principle of their machine. Some of them are compiled together by the authors and published on YouTube. The link for the video is:

https://youtu.be/_W6xqkF1ku4

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