Implementing PBL to Enhance Technical Knowledge through Design Thinking Process

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Abstract: The traditional method of teaching is no longer effective so every instructor wants to use new pedagogy to enhance students learning and knowledge. Many challenges are faced by the instructors in teaching to Mechanical Engineering graduates where grabbing students' interest towards the concepts is difficult. Hence, there is a need to have different methodologies to understand course concepts. Moreover, without the knowledge of course content the practical implementation from lab to industry becomes a herculean task. Renewable Energy is one of the subjects in mechanical engineering for III year I semester that needs practical application to understand the importance of the subject and its impact in our daily life. Therefore, instructor has conducted PBL (Project Based Learning) for solving society based problems by following design thinking process. This paper gives insight on the conduct of the activity planned, executed and its success by following the design thinking process. The impact of this activity encouraged many students to implement the same way of learning in renewable energy subject.

Keywords: PBL, teamwork, solar cordless grass cutter

1. Introduction

Project based learning is a dynamic approach of learning during which students actively explore real world issues and challenges and acquire a deeper knowledge. The PBL process not only focuses on defined solution, but it also allows the development of other desirable skills and attributes.

S K. Khamuruddeen and AzeemUnnisa[1] have implemented PBL for digital image processing course where they tried to boost students' learning through sensible implementation. They have given different modules to the group of students and asked them to implement mini projects on those modules. Modules were Histogram Equalization, Median filtering, Image Addition, subtraction, multiplication and Division. Weekly 5 hours were assigned for this subject which is distributed into 4 tutorial classes and one practical class wherein they taught topics of 4 tutorial classes to implement in one practical class. In this study they have discovered students' confidence in the data collection which in turn created a great impact on their learning. After using this methodology students attendance has increased in the class. Students participated actively during this activity compared to the traditional approach of learning.

Roohshad Mistry et al [2] has studied the importance of PBL over the traditional approach. These authors have mentioned that curriculum design courses with some simple problem solving methods, but they did not help in solving the real world problems students could not gain any experience through it.

Implementing PBL on Automobile Design and Manufacturing has given the required exposure to the actual need and its implementation. The object of the PBL is to simulate real-world engineering design projects and their related challenges which they can accomplish by participating in any competition. The agenda behind this study was to participate in the SAE and FSAE competitions which are core associated challenges of the mechanical branch, where students have scope to get even placement opportunities. The PBL is implemented for 25 students for 6 months duration. This activity facilitated the collaboration of seniors with their juniors, which helped the students to find the group of their interest for implementation. The activity was a successful achievement by the students, it also helped in attaining a number of the graduates attributes which was the final outcome of the activity.

Reshmi Devi T.V [3] has expressed the success story of the impact of the PBL on mechanism of fluid course in Civil Engineering branch. The study has greatly emphasized more on the practical implementation that is required for solving daily life problems which will give a great scope for students learning. They have framed the rubrics to assess student's progress and might be used for

Continuous Internal Evaluation (CIE). Experiential learning and critical thinking of the teams were evaluated through model demonstration, viva-voce and reports. On the other hand, soft skills like team work and communication were evaluated through peer evaluation. Interestingly, they have formed the heterogeneous groups of 8-9 students in which each group must contain one female and at least one student who has completed Diploma in civil Engineering. It was found that the students liked PBL and improved their knowledge on core concepts.

Edson et al [4] have focused more on the challenges that are faced while implementing PBL. After identifying the challenges, they have found alternatives to deal with those challenges. Through PBL, they desired to enhance students' practical knowledge in addition to participation in Baja SAE Competition. The PBL is categorized in to various modules for learning and then working in teams to utilize their knowledge to form buggy so that they can participate in SAE competition. They have conducted assessment at three different phases to evaluate the students learning.

Shrutika S Sawant [5], in this paper the implementation of PBL has discussed and course is analyzed with direct and indirect attainment of course outcomes. After applying the PBL, methodology students' results have improved.

Srinivasa Pai P [6], 2018 has explained about the issues faced by the faculty while implementing the PBL methodology. They have further mentioned corrective actions should be taken by the instructor to overcome the challenges. They proved through their experience that students are learning the concept taught fast in comparison to traditional method.

Azeem Unnisa et.al [7] 2018, stated that the new model of problem solving game based pedagogy was successfully implemented by the instructor. Students have learned problem solving skills by game based learning that was edutaining to understand technical concepts.

Therefore, PBL is very important to include in the curriculum to implement active learning in class room. Every course has outcome, PBL is one of the best outcomes to prove students learning in the respective subject. It is not only to enhance students learning but also give them confidence to solve real world problems. Renewable energy resource is one of the courses in the mechanical branch where we can implement project based learning to teach students core concepts. This paper shows the impact of design thinking process to solve real world problems that we need to know from the community and solve by providing engineering solutions. The main objective of this paper is to solve society based problems through PBL by incorporating design thinking process.

2. Method

For project based learning, instructor applied design thinking process to know each and every step in the process and to gain practical knowledge on the renewable energy resources course. Design thinking Process has the following module.

- Problem Identification

It was decided by the instructor to solve the real time problem through the design thinking process. By following design thinking process in PBL, community partner was identified and the related problems were addressed through renewable energy resources course. Our Community Partner Mr.Souraih is a 67 year old person a resident of Gowdavelli village and working as a gardener in HITAM College. His work is to trim & clean the grass of the lawn alternate days. While doing this work, he faces problems to push the heavy weight machine by carrying a direct AC power supply wire all over the lawn. It is time consuming work and cumbersome for him. Due to his age & other health issues, he is facing problem with the existing machine. On interaction with him, we came to know that he requires a machine which can reduce his workload.

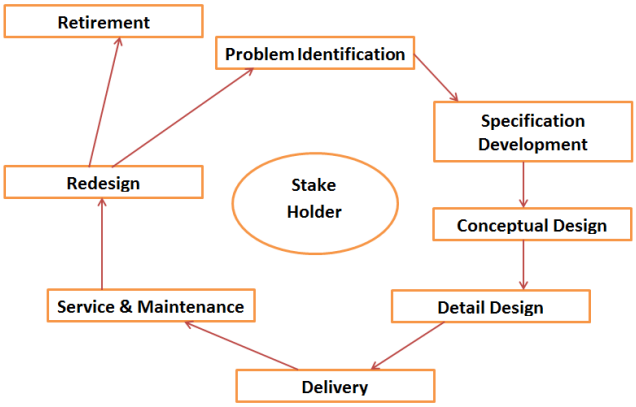


Fig.1 Design process

Fig.2. Grass cutter

- Specification development

Table.1 Product survey

Product name	Patent number	Key features	Draw back
Ride on grass cutter	US 2865159 A	1) More manoeuvrability 2) Better handling	Not suitable for small fields a it is bigger in size 1) Requires fossil fuels whicl in-turn emits toxins 2) Cost for maintenance is hi 3) Mess with oils and lubricants 4) Risk with the oils
Automated grass cutter	US 5974347 A	1) Operating time can be set 2) No emissions 3) Saves time	1) Requires a perimeter wire 2) Hard to maintain 3) Loss of jobs due to comple automation 4) Battery consumption is mo
Hybrid remote control grass cutter	US 7677344 B2	1) Can be operated from a safe place	1) Engine is used to rotate th blades which requires fossil fuels 2) Emission of toxins 3) Mess with oils 4) Expensive 5) Cost for maintenance is hi

After understanding the problem of community partner, the product survey was done and searched for the grass cutter which suits his requirement. Many grass cutters are available in the market but they have their own limitations which will not fulfil the requirement of him. The following table shows the existing grass cutter with its limitation.

- Conceptual Design

Table. 2 Decision matrix

Criteria	Weights	Idea#1	Idea#2	Idea#3	Idea#4	Idea#5	Idea#6
Maintainability	5	5	4	3	3	4	3
Economical	5	5	4	5	5	4	5
Feasibility	5	5	5	5	5	5	5
Sustainability	5	4	4	3	3	4	3
Physical Effort	5	5	5	3	2	5	2
Work Time	5	5	5	3	2	5	2
Sum	150	145	135	110	100	135	100

Fig.3 Prototype

After doing product survey students have come up with multiple ideas to solve the problem. To fill the gap of existing products in the market with the required product as a team they have decided to provide a solution for the community partner by which he can do his work easily and efficiently. Students have done two working prototypes and done the decision matrix to know about which idea is getting maximum efficiency that idea was implemented from prototype to product conversion.

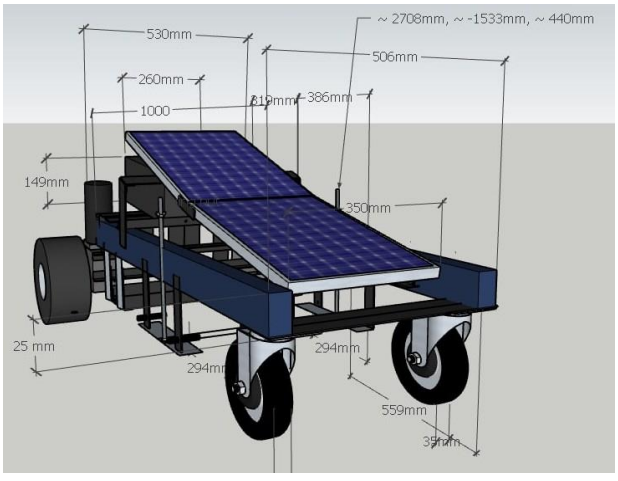
- ❖ Possible Ideas:
- ➢ Solar Powered Cord less grass cutter
- ➢ Cord Less grass cutter
- ➢ Grass cutter with wired remote.
- ➢ Pushover grass cutter with attachment.
- ➢ Bluetooth controlled grass cutter.
- ➢ Pedal operated grass cutter.

From the above decision matrix it has come to know that Idea1 i.e. solar powered grass cutter was the best idea available for implementation.

- ➢ It is easy to maintain and it does not contain the complicated parts, easy wiring and easy to recharge every day.
- ➢ Economical: - By considering the environmental aspects it gets recharge by solar panel therefore no expenses of electricity.
- ➢ Feasibility: - due to the less complexity, product can be manufactured and used.
- ➢ Sustainability: - Sustenance is easy because of the specifications used for making the project.
- ➢ Physical Effort: - As it can be controlled by a remote control, it results in less fatigue.
- ➢ Work done: - Blades and motors will make task easier and faster.

- Detail Design

Cordless Grass Cutter is a machine with the advanced capabilities than the regular grass cutters. This machine is controlled by radio frequency signals.



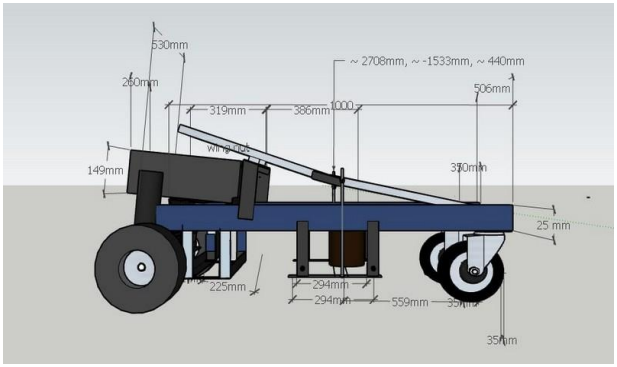


Fig.4 Cordless grass cutter design

The aurdino board is configured in such a way that it can receive the RF signals from the transmitter using a receiver, then drive the motors which are attached to the wheels and a blade. The board is connected to a motor driver, this motor driver which is intact with the motors. The board is powered by a battery which is rechargeable. The control signal is generated in the remote, when the user decides on how to handle the cutter. There are three (3) motors in this machine, two (2) motors are used to drive the wheels of the chassis and the one (1) motor is used to drive the grass cutting blade. The batteries are coupled with a solar panel so that the solar power can be used as backup power source to run the machine.

- Delivery

Fig.6 shows the PBL project is delivered to community partner. Taken the feedback from the community partner and he felt it is very easy to handle and to rotate in all directions. He also told that safety measurements should be taken for safety. Our solution will provide best device which will reduce the human effort and difficulty while doing their job. Apart from this saving electricity is also our concern which is very important for our bright future. While dealing with new technical machines, we generally forget about electricity consumption. Therefore our product will minimize that problem by replacing solar energy for recharging the batteries.

Fig.5 Cordless grass cutter

Fig.6 PBL Project delivered to community partner

- Service & Maintenance.

Yearly two times machine performance will be checked and rechargeable battery will be changed after two years.

Review of the project was conducted in three different phases and each phase has its designated rubrics which were shared with the students before the commencement of the project. Table no 2, 3, 4 are the rubrics of phase 1,2,3 respectively. The main objective of rubrics was to ensure the final product of the project which can be delivered to the community partner that will be achieved through rubrics.

Results

PBL methodology is successfully implemented in the renewable energy resource course. Students also learnt about design thinking process and how to solve real time problem and team work. Following are the team experiences from PBL approach

- Acquiring experience
- Understanding the value of each activity
- Develops the ability and skills of thinking and doing the activities
- Acquiring the skills and qualities of Group activity
- User involvement
- Clear Statement of Requirements
- Proper Planning

Fig.7 The evaluation done by external

Table.2 Rubrics the evaluation Phase 1

P R O B L E M I D E N T I F I C A T I O N	Community Interaction with the concerned Project Team (3 Points)	3 points. = Clear representation of the community interaction by the team members with appropriate documentation with visuals	2 points. = Clear representation of the community interaction by team members with an appropriate document	1 point. = Oral representation of community interaction (no evidences)
	Necessitate of the problem identified (3 Points)	3 points. = Clearly addressing the problem by statistical representation of either human, educational, health or environmental community	2 points. = Mentioned without statistical representation.	1 point. = Does not mentioned the clear need of the community
	Stakeholder Identification (3 points)	3 points. = Clearly identifies a specific and real user or organization, by name, which can provide feedback/suggestions for the team and receive the project once completed.	2 points. = Mentioned the community but not a specific user who can provide suggestions or feedback over the project	1point. = No clear details of community or specific user
SPECIFICATION DEVELOPMENT	Measurable requirements (3 points)	3 points. = Clearly describes at least 5 measurable requirements	2 point. = Less than 4 described specifications or	1 point. = At least 2 specifications listed
		depending on the project	the ones described are not measurable	
	Identification of existing solutions (3 points)	3 points. = Identification of existing solutions addressing the similar problems with appropriate documentation	2 point. = Identification of existing solutions addressing the similar problems with no appropriate documentation.	1 point. = No clear identification of existing solutions.
	Gaps in existing solutions (3 points)	3 points = A clear explanation / analysis of gaps with the documentation by using the appropriate case studies.	2 points = A marginal explanation/ analysis of gaps by using the appropriate case studies.	1 point = No appropriate case studies for justification of gaps.
	Poster Presentation (Mandatorily) (3 points)	3 points = Creative poster presentation	2 points = Good oral presentation	1 point = Either Creative poster or good oral presentation

Table.3 Rubrics the evaluation Phase 2

Assessment parameter	Good	Average	Poor
Sketches of five concepts (5M)	Novel ideas with clear sketches (5M)	Ideas are novel but sketches are not clear (2.5M)	Ideas copied from other sources (1M)
Relevant images of paper models (5M)	At least 3 mock-up models from those	At least 1 mock-up model from those	1 mock-up model but not appropria

	five sketches (5M)	5 sketches (2.5M)	te (0.5M)
Concept selection table (PUGH'S table) (2M)	Concept selection based on any design tool (2M)	Concept selection without any tool (1M)	concept selection without any logic (0.5M)
Product Architecture (physical and functional) (10M)	Both physical and functional decomposition with neat sketches (10M)	Only 1 (physical/ functional) decomposition sketch (5M)	Not having clear idea about product architecture (1M)
Product details (components/material, dimensions, manufacturing technology and cost) (10M)	Complete details of the product clearly written (10M)	Partial details of the product written clearly (5M)	Product details are not presented clearly (2M)
Poster (3M)	Poster representing all the parameters of assessment and also having good design (3M)	Poster representing all the parameters of assessment and not a good design (1.5M)	Poster representing some parameters of assessment and also not a good design (0.5M)

Table.4 Rubrics the evaluation Phase 3

Assessment Parameter		Good	Average	Poor
Design (15 M)	Product architecture (5M)	Product architecture manual with measurement 2D or 3D (5M)	Without manual and measurement or Related Proofs (3M)	Without manual /only Architecture(2M)
	Design skills (5M)	Providing proofs of number of Iterations covered (5M)	Number of iterations without proofs (3M)	Not covering number of Iteration directly jumping in to design (2M)
	Working status (5M)	Working of the product	Partially working (3M)	Not working (2M)
		(5M)		
Testing (10 M)	Product demonstration(3M)	Product demonstration (3M)	Without product demonstration only video presentation (2M)	No video or product demonstration (1M)
	User testing (4M)	Efficiency and safety usability to community partner (4M)	Not mentioned the safety and usability (3M)	No safety and life span of product (2M)
	Feedback (3M)	Details of providing community partner feedback ,NGO and photo (3M)	No community partner feedback but only photo (2M)	No community partner feedback and photo (1M)

Discussion

S K. Khamurudden et.al [1] stated that project based learning methodology was successfully implemented for final year students. After using this methodology, students' attendance has increased in the class. Students have actively participated in this activity compared to traditional approach. However, the impact of the project on student's learning was not mentioned clearly.

Roohshad Mistry et.al [2] 2017 has explained about the FSAE project under PBL. Students focus was more towards core jobs than the public sector. Nevertheless, author didn't mention that how many students got placed by implementing the PBL?

Reshmi Devi T.V [3], 2017 mentioned that PBL is implemented for III yr. semester civil engineering course and all have actively participated in the course while working on the real time application. However paper didn't mention even single example which showcased the real time application done by students.

This paper has followed the rubrics in all the phases involved right from identifying the problems until the delivery of the product, all areas of individual and team work performance was taken into consideration. Its impact is seen in the delivery of the product to the community partner and he is satisfied with it. It became more successful as other gardeners also asked students to provide similar devices to make their job comfortable.

Conclusion

Renewable energy resources course always needs practical implementation to prove students efficient understanding and learning. PBL is an additional approach to reinforce

the technical knowledge of the students. This study has verified that by incorporating the design thinking process in PBL, the projects made are effective and are very helpful. However, following design thinking method shapes students understanding the actual requirement and dealing on the distinctive resolution that is not in existence. PBL gives students great scope for employement.

References

1. S K. Khamuruddeen, AzeemUnnisa, Effective Teaching of Theory Course Using PBL, Journal of Engineering Education Transformations, Special Issue, eISSN 2394-1707.

2. Roohshad Mistry,DipaliAwasekar, ShashikantHalkude (2017), Integrating Various Instructional Strategies withProject Based Learning for Enhancing Knowledge andEmployability in Automobile Engineering, Journal of Engineering Education Transformations,Volume 30, No. 3, January 2017, ISSN 2349-2473, eISSN 2394-1707

3. Reshmi Devi T.V (2017), Implementing Project-based Learning inCivil Engineering- A Case Study, Journal of Engineering Education Transformations,Volume 30, No. 3, January 2017, ISSN 2349-2473, eISSN 2394-1707

4. Edson Gesualdo, LuppeMaximiliam, Vilma A. Oliveira, Designing an Engineering Laboratory Course forProblem Based Learning, Journal of Engineering Education Transformations, Special Issue, eISSN 2394-1707

5. Prof. Shrutika S Sawant, Prof. Subodh S Ingaleshwar, Project Based Learning: An Effective Technique ofLearning Programmable Logic Controller, Journal of Engineering Education Transformations, Special Issue, eISSN 2394-1707

6. SrinivasaPai P , NiranjanN.Chiplunkar 1 2, ShrinivasaRao B.R (2018), Project based Learning (PBL): Issues faced byFaculty for its effective implementation, Journal of Engineering Education Transformations ,Volume 31 , No. 3, January 2018, ISSN 2349-2473, eISSN 2394-1707

7. AzeemUnissa, Ashmitha2 , Sanchita (2018), Scaff folding based Problem- Solving Activity inAnalog Communication, Journal of Engineering Education Transformations, Special Issue Jan. 2018, eISSN 2394-1707

8. Prof. R. T. Patil (2016), Comparative study of Problem Based Learning andTraditional Lecture Delivery- A case study, Special Issue of National Conference NCIEME 2016 Organised by Rajarambapu Institute ofTechnology and Walchand College, Sangli ISSN 2394 – 1707

9. Hannabel Hyacinth Alva 1, Uma B. 2, Shruthi D.V. 3, Saroja C (2018), Enhancing Learning Outcomes in Software Engineering
course through Problem Based Learning and PeerAssisted Learning, Journal of Engineering Education Transformations, Special Issue Jan. 2018, eISSN 2394-1707

10. Anitha D, Jeyamala C, Kavitha D (2018), Assessing and Enhancing Creativity in a LaboratoryCourse with Project Based Learning, Journal of Engineering Education Transformations ,
Volume 32, No. 2, October 2018, ISSN 2349-2473, eISSN 2394-1707