

Project-Based Learning in Technical Institutions

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Abstract - In outcome-based education project-based learning is a strong and direct method to develop programme outcomes, programme specific outcomes, and skills of 21st century in students when it is managed professionally by all teachers at the institute level. This paper is based on SNAP study conducted from May 2020 to December 2020 on 617 faculty members of technical institutes of India. The paper begins with a rationale for project-based learning that is drawn from various research studies conducted, experiences of the researchers, and document analysis. The institute should have a system to design, implement and assess the impact of project-based learning. Significant steps of managing project-based learning are highlighted. The training of teachers in managing project-based learning is highlighted to reap the full potential of project-based learning. Then justification for preparing policy and guideline document for managing project-based learning is stated. The process for selecting the project problems/themes for different level educational programmes (diploma, undergraduate, postgraduate, and Ph. D.) is explained diagrammatically with justification. The quality assurance mechanism at different stages of managing project-based learning is explained. Towards the end of the paper suggestions for the institute, faculty members, and students are noted.

Keywords: Project-based learning, outcome-based education, guideline document for managing project-based learning, 21st-century skills, associated skills, process by-product skills.

I. RATIONALE

The outcome-based education approach has been implemented in higher and technical education for the last ten years. In outcome-based education, there is a hierarchy of learning outcomes at programme level, course level, and unit level. Project-based learning produces strong and direct learning in the domain-specific areas related to core programme outcomes and specific outcomes (Gupta, 2016). It produces associated learning related to the environment, safety, housekeeping, communication, documentation, interpersonal relationship, quality assurance related to domain-specific complex problems or innovation. It produces process by-product learning related to leadership, motivating others, working in a team, listening, investigating, presenting, offering and receiving feedback, and the like (G.E. Veselov, 2019). In other words, it produces domain-specific and interdisciplinary abilities, soft skills, life skills, generic skills, and professional skills. These skills add value to the graduates for getting a better job or job of choice or starting the enterprise. These skills enhance the effectiveness of role performance in the world of work situation. Project-based learning enables students to develop 21st-century skills (Janet, 2018). The empirical evidence support that project-based learning facilitates higher order of learning and change students' attitude towards classification (Wekesa et.al.2016). Project-based learning is challenging to plan and enact (John, 2000, Gimba et. Al. 2017).

The strong and direct evidence is produced by project-based learning which is enough to prove that outcomes are achieved at programme and course level. In higher and technical institutions there is a provision to assign micro-projects at the course level, minor projects at the cluster of courses level, and major projects at programme level. As the students progress in learning they complete micro, minor, and major projects to integrate the learning of the previous courses, informal learning and they also think creatively to complete the projects. There is a provision of integration of abilities at programme level. The problem or theme for the project is chosen to see it in totality from a core discipline point of view and other important points of view such as environment, safety, hygiene, professional ethics, cleanliness, leadership, economics, and sustainability. Some abilities are developed as a part of the process. These abilities are called the process by-product learning. The process by-product abilities are consciously developed using professional project-based learning by trained teachers. At programme level quality of students' major projects is assured by mapping them with programme outcomes and programme specific outcomes. The project problem or theme is selected from the world of work situation in a way to ensure that it contributes to at least one programme outcome substantially and for the other two-three programme outcomes moderately and slightly.

Project-based learning used at the institute level in all programmes by all teachers creates an environment for a student-centric learning approach where students are fully involved in the learning process. The project is selected from world of work situation, so it creates enough challenges for the students and teachers to work on

the problem situation, work in a team, motivate each other to achieve the goals of the project, collaborate with industry people from where the problem is selected and collectively monitor the progress of the project. Project-based learning embraces the constructivism theory of learning which is highly required for adult learning in outcome-based education. Project-based learning encompasses different learner-centric methods such as self-learning, case study, role play, interview, investigation, brainstorming, collaborative learning, group discussion, and cooperative learning depending upon the project situation. It incorporates the benefits of all these methods. The most important thing is it produces a tangible output that can be observed and measured. It produces learning in all the three domains of learning at the higher level which is the requirement of course outcomes and programme outcomes (Pengyue Guo et.al., 2020).

Project-based learning creates opportunities for meaningful, active, reflective, self-directed, and creative learning experiences for the students (C. L. Chiang and H. Lee, 2016), (Maija et.al. 2019). As envisaged in the national education policy 2020 that integration of science, technology, engineering, and mathematics (STEM) results in positive learning outcomes. Project-based learning is considered an outcome-oriented method in all disciplines in general and science, technology, engineering, and mathematics in particular. It results in integrating and developing a wide spectrum of abilities such as problem-solving, critical thinking, innovation, economics, communication, leadership, and working in a team.

The precursors of project-based learning are safe, respectful learning environment, personalized teacher-learner relationship, productive peer relationships, transformed teacher roles, and intensified teacher engagement and commitment (PBL guide).

Studies are available on barriers and challenges to the success of project-based learning. These are limitation of time, physical resources, funds, accessibility to industry, untrained teachers guiding the project, finding problems significantly contributing to programme outcomes, lack of awareness of students on learning in project-based methods, assessment of achievement of outcomes in a group, validity, and reliability of assessment tools. The challenges are related to students, parents, and industry which need to overcome for effective implementation of project-based learning (Shaban, 2018, Maija et.al. 2019, Naji et. al., 2018).

II. TRAINING OF TEACHERS ON PROJECT-BASED LEARNING

The training of teachers in project-based learning is a very important factor for the success of project-based learning in higher and technical education. Professionally trained teachers may harness the full potential of project-based learning for the benefit of the students, teachers, institute, industry, and society. Trained teachers will see the project-based learning in a totally and not in a fragmented manner to satisfy the requirements of the curriculum. They will bring reforms in curriculum implementation for developing higher-order abilities, creative and critical abilities in students (C. L. Chiang and H. Lee, 2016). The innovation-related topics will result in the development of the ability to investigate, reflect and innovate. (Jason et.al., 2012) concluded that professionally trained teachers are more involved in teaching and assessing 21st-century skills such as critical thinking, collaboration, communication, creativity, self-direction, global skills, local connections, and use of technology. Professionally managed (planned, implemented, mentored, assessed, and evaluated) project-based learning at the institute level will result in a higher level of learning, industrial collaboration, generation of revenue for the institute, higher placement of students based on the project they have completed. The trained teachers fetch all these benefits through effectively managing project-based learning at the institute level. Project-based learning requires preparation and integration of soft skills among students (Gimba et.al., 2020).

In the current study, it is found that 66% of respondents attended a formal training programme on managing students' project-based learning. Out of trained respondents, 35% of respondents attended 1 day, 5% attended 2 days, 4% attended 3 days and 10% attended more than 3 days duration training programme and 46% have not attended the training programme.

III. INSTITUTE POLICY AND GUIDELINES FOR MANAGING PROJECT-BASED LEARNING

The student's projects are strong means to link the institute with the industry for understanding the industrial problems, innovations going on, and collaborating with the industry for various purposes such as getting consultancy work, offering continuing programmes, undertaking research work, and developing learning resources for industry personnel. The projects also connect with the alumni, society, and funding agencies (G.E. Veselov, 2019). Therefore, the policy to design, implement, monitor, and assess the learning of the students should be appropriately crafted to implement the project-based learning at the institute level across all the programmes being offered. The guideline document at the institute level for managing project-based learning results in quality assurance in learning, uniformity in managing students' projects at the institute level, declaring the schedule for monitoring the progress, setting a minimum level of standards, providing resources and guidance, having transparency in assessment, and making stakeholders aware about the

expectations of the institute. The monitoring schedule is useful in assuring the quality of project-based learning at the institute level at different stages of project-based learning. Generally, in a project-based learning approach monitoring mechanism is integrated with the academic plan of the institute and departments. It is made mandatory for all project guides to submit the progress of the project according to the mechanism preferably in a learning management system. The institute takes appropriate decisions to improve the effectiveness of project-based learning based on the overall progress of the student's projects. Refer figure 1. (Nizwardi et. al., 2017) suggested seven steps of a project-based learning model enhance productive competencies of vocational students.

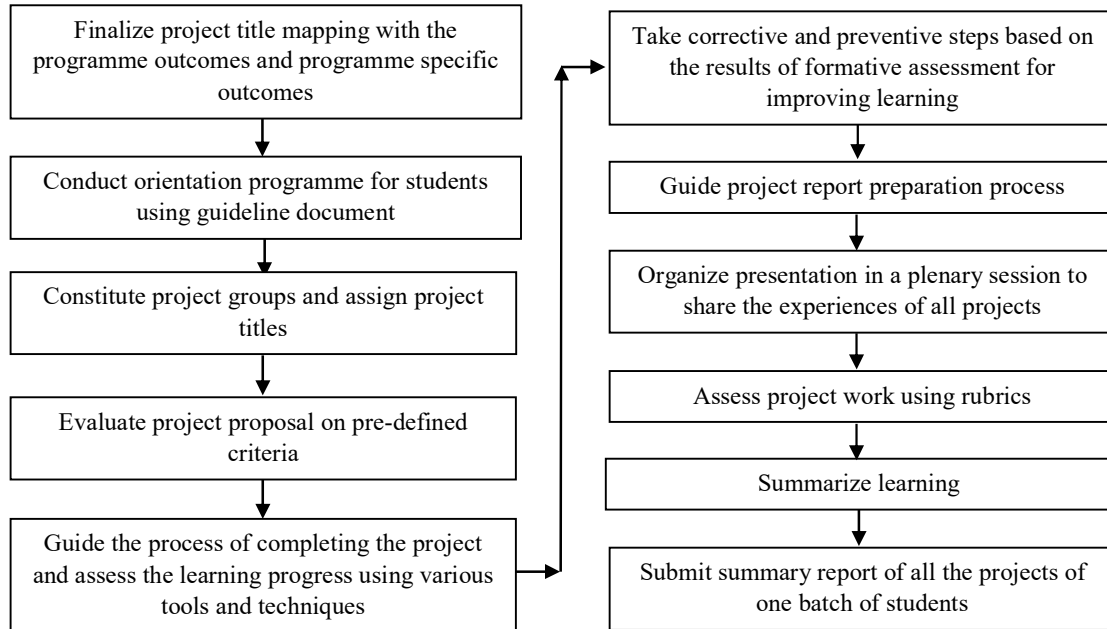


Figure 1: Monitoring and quality assurance at different stages of students' project work

At the institute level, an integrated and collaborative online supervision system for major students projects is created to ease the supervision process, and enhance the students learning experience (ImedRomdhani et al, 2011)

In the current study, it is found that 67% of respondents stated that their institute has a guideline document at an institute or department level to decide project titles, design, implement, monitor, and evaluate projects. It is found that 76% of respondents prepare a monitoring schedule to monitor the progress of major project work of students.

IV. CURRICULAR PROVISION FOR PROJECT-BASED LEARNING

The provision for students' projects should be there in the outcome-based curriculum of all the programmes to have clarity on the type and purpose of the project. The project-based learning is integrated with the programme structure right from the first semester (G.E. Veselov, 2019). The major projects at programme level, minor projects at the cluster of course level, and micro-projects at the course level are considered to constitute an effective approach for implementing project-based learning at the institute level. In the current study it is found that 50% of respondents stated that students are involved in less than five students' projects (major, minor, micro) 24% stated 6-10, 10% stated 11-20, 4% stated 21-25 and 12% stated that more than 25 during the programme. It is found that 80% of respondents stated that they use an outcome-based education approach in assigning the students' projects.

V. SELECTION OF PROBLEM

The problem situations are selected from the world of work which falls under cell 2 where the complexity of the problem is moderate to high and solutions are available but causes of the problem or root causes are not known. The students' major project may be focussed on analyzing the problem and finding the real causes of the problem or root cause of the problem. Refer fig. 2.

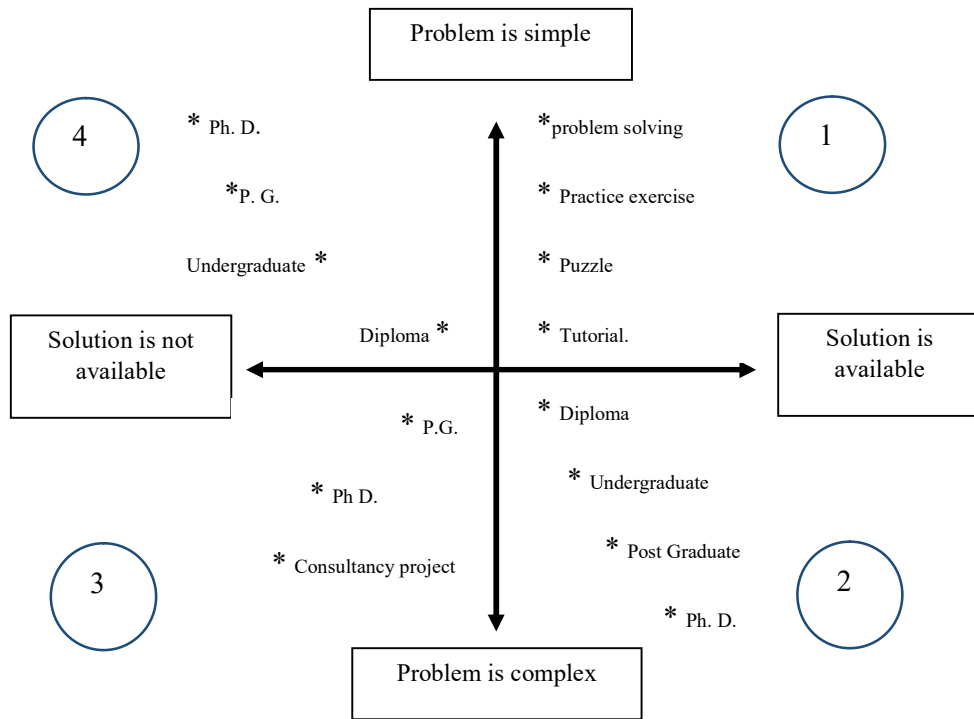


Figure 2: Problems for Educational Programmes

The complexity of the problem for diploma engineering programme will be less and it will gradually increase for undergraduate and postgraduate programmes. It will be highly complex for Ph. D. programme encompassing multidisciplinary dimensions. The problem may be simple, but solutions are not available or innovative solutions are to be generated in that case degree of effective, efficient, and innovative solutions will decide the problem selection for various levels of the programme. Refer to cell 4. The problem is complex, and the solution is not available as is the case in cell 3 the postgraduate, Ph. D. level, and consultancy projects are selected. The magnitude of the problem or the solutions will decide the quality of the project. Cell 1 comprises situations that may be a good situation for the tutorial, puzzle, practice exercise, and problem-solving. The problems for a major project are selected from world of work situations considering the availability of resources, laboratory, funds, and competence of the faculty members.

The quality of major projects is assured by mapping all the project problems selected for a batch of the students with the programme outcomes at a substantial, moderate, and slight level before allocating the projects to the students (NBA, 2019). A thumb rule is followed in ensuring the perfect mapping that there should be at least one substantial mapping in each programme outcome and project title. If this condition is not there the project title should be modified. The project title is crafted in a way to incorporate all possible programme outcomes in the title. The professionally formulated project title will produce conscious learning in students. The project title fulfills the gap between the world of work and the programme curriculum (G.E. Veselov, 2019). As envisaged in the national education policy 2020 the higher education will be multidisciplinary, the carefully selected project situations will help students to develop multidisciplinary and interdisciplinary abilities (NEP, 2020).

In the current study, it is found that 9% of respondents stated that they allocate more than 80%, 18% stated 61-80%, 22% stated that 41-60%, 20% stated that 21-40%, 39% stated that less than 20% industrial problems to students. It is found that 13% of respondents stated that they allocate more than 80%, 22% stated that 61-80%, 25% stated that 41-60%, 16% stated that 21-40%, and 24% stated that less than 20% problems related to laboratory experimentation and workshop for student project work.

VI. THE ORIENTATION OF STUDENTS FOR CONDUCTING THE MAJOR PROJECTS

The expectation and level of learning through project-based learning are stated in the guideline document. The students are made aware through the orientation programme at the beginning of assigning the major project to students so that they know the expectations, get motivated to learn, and complete the project. They are educated on cooperative and collaborative learning, making observations, receiving and giving feedback,

and assess the performance of their fellow students. In the current study, it is found that 70% of respondents stated that they conduct an orientation programme for students to do projects.

VII. FACILITATING PROJECT COMPLETION PROCESS

Professionally trained teachers guide students during significant steps of the project based learning. They monitor the progress of the project. They offer positive, constructive, and encouraging feedback to motivate the students to learn from the project and complete the project timely. Teachers help the students during project report preparation as the students are weak in articulation and report writing. Teachers use a variety of assessment tools such as a checklist, observation schedule, and rubric to assess the learning outcomes of the students during the process of completing the project. They use the assessment results for identifying the learning gaps and provide additional guidance.

VIII. ASSESSMENT OF LEARNING

Project-based learning integrates the learning of all the courses and informal learning. It creates strong and direct evidence of the attainment of learning outcomes by all the students. It is a powerful student-centric learning method that is very close to the world of work situations. It is a live method of learning for teachers and students. Therefore, at the institute level assessment scheme is incorporated in the guideline document. The assessment scheme acts as motivation for learning, diagnosing the learning problem, receiving feedback, and getting recognition for achievements. The assessment scheme comprises various tools such as a checklist, rating scale, observation sheet, rubrics, interview schedule. The assessment scheme consists of various assessment techniques aligned with assessment tools such as assessment, observation, interview, and viva voice. The assessment approaches such as self-assessment, peer assessment, assessment by a teacher, and assessment by experts are part of the formal assessment scheme. The assessment is a means to learning and a tool for assessing the learning.

In the current study, it is found that 15% of respondents give more than 80%, 25% give 61-80%, 25% give 41-60%, 18% give 21-40%, and 17% give less than 20% weightage to paper and pencil test to assess the abilities of the students in a major project. It is found that 18% of respondents give more than 80%, 30% give 61-80%, 25% give 41-60%, 18% give 21-40%, and 9% give less than 20% weightage to checklist to assess the abilities of the students in a major project. It is found that 21% of respondents give more than 80%, 34% give 61-80%, 26% give 41-60%, 12% give 21-40%, and 7% give less than 20% weightage to rating scale to assess the abilities of the students in a major project. It is found that 29% of respondents give more than 80%, 36% give 61-80%, 21% give 41-60%, 10% give 21-40%, and 4% give less than 20% weightage to the observation sheet to assess the abilities of the students in a major project. It is found that 40% of respondents give more than 80%, 29% give 61-80%, 17% give 41-60%, 10% give 21-40%, and 4% give less than 20% weightage to viva voice questions to assess the abilities of the students in a major project. It is found that 26% of respondents give more than 80%, 30% give 61-80%, 19% give 41-60%, 13% give 21-40%, and 12% give less than 20% weightage to project title for assessing the abilities of the students in a major project. It is found that 28% of respondents give more than 80%, 32% give 61-80%, 21% give 41-60%, 13% give 21-40%, and 6% give less than 20% weightage to project proposal for assessing the abilities of the students in a major project. It is found that 32% of respondents give more than 80%, 36% give 61-80%, 21% give 41-60%, 7% give 21-40%, and 4% give less than 20% weightage to project method for assessing the abilities of the students in a major project. It is found that 23% of respondents give more than 80%, 35% give 61-80%, 23% give 41-60%, 11% give 21-40%, and 8% give less than 20% weightage to diary maintenance for assessing the abilities of the students in a major project. It is found that 46% of respondents give more than 80%, 32% give 61-80%, 14% give 41-60%, 5% give 21-40%, and 3% give less than 20% weightage to project output for assessing the abilities of the students in a major project. It is found that 42% of respondents give more than 80%, 34% give 61-80%, 15% give 41-60%, 6% give 21-40%, and 3% give less than 20% weightage to presentation for assessing the abilities of the students in a major project.

IX. RECOGNITION AND ENCOURAGEMENT

The recognition of achievements through project-based learning is publicized for the learning of the masses. It adds to the profile of the students, teachers, department, and institute. Students' project work publication is a major source of publication for the institutes. The institute has a primary source of information for a research paper, review paper, conceptual paper, case study, video session, and handouts. The publication of one batch of students becomes the source of learning and benchmark for the next batches of students. The subsequent batches of students find out newer and innovative situations for doing the major projects. In the current study, it is found that 84% of respondents stated that they encourage students to publish project work in the form of papers and case studies. It is found that 63% of respondents stated that they encourage students to file patents for project work. It is found that 94% of respondents stated that they encourage students to

participate in project competitions organized by other institutions. It is found that 86% of respondents stated that they refer to and use previous project reports of students in the teaching-learning process.

X. ANALYSIS OF PROJECT WORK AT INSTITUTE LEVEL

The institute takes stock of using project-based learning at the institute level which is used for describing the current status, problems, and obstacles being faced at the institute level, taking corrective and preventive actions, deploying additional resources for students' projects, and deputing teachers for training. In the current study, it is found that analysis of the project work of students at programme level is done for achieving the purposes stated in table 1.

Table 1: Purposes of analysis of students' project work at programme level

SINo	Purposes of analysis	Percentage
1.	To explore better possibilities with industry for students' projects	69.2
2.	To know the gaps in attainment of programme outcomes and programme specific outcomes	58.9
3.	To take corrective and preventive actions	53.4
4.	To generate, deploy, and redeploy the resources of the institute	36.5
5.	To allocate additional funds for training	17.7

XI. THE SUCCESS OF THE PROJECT-BASED LEARNING

It is found that 34% of respondents rated highly successful, 57% rated moderately successful, and 9% rated the slightly successful success of students' project-based learning with reference to outcome-based education.

XII. CONCLUSION

Outcome-based education is promoted in technical education institutions of India for the last ten years. A professional approach to project-based learning has been initiated in technical institutions but it has not been institutionalized in letter and spirit. Systemic reform is required in institutions to reap the full potential of project-based learning.

XIII. SUGGESTIONS

For higher education institutes

1. At the institute level, a policy and guideline document should be prepared and approved by a competent authority. The policy and guideline document should be available on the institute website. The guideline document should address all dimensions of managing project-based learning such as rationale, goals, process of selection of problem situation, the format of project proposal preparation, resources to be provided, monitoring schedule, the role of the student, teacher, and industry resource person, assessment scheme, documentation, recognition and publication and the like. Project-based learning should be integrated with the programme structure of all educational programmes offered by institutions.
2. A strong connection among industry, field agency, sister institutions, alumni, funding agency, and professional societies should be developed to facilitate the project work of the students.
3. Alternative funding sources should be explored and rules for funding the students' project should be prepared. The creative projects should be especially encouraged and supported by additional funds.
4. All faculty members should be trained in managing project-based learning at the institute level. They should be made aware of institute policy, guidelines, benchmarks, and the process of managing students' projects.
5. A small team of faculty members should be assigned to guide multidisciplinary innovative projects.
6. The institute should publicize programme wise major project titles on its website for getting support and communicating the quality of the projects to stakeholders.
7. At the institute level project laboratories, incubation centers, and computing facilities should be created and updated to support students' projects.
8. At the institute level, prizes should be instituted to encourage students and teachers to opt for innovative, creative, and unique project titles addressing the world of work problems or innovations.

For faculty members

9. Faculty members should receive training on various aspects of managing students' projects with reference to outcome-based education and the development of 21st-century skills in the students. They should shift in role performance from a teacher to a mentor. Coach, guide, and counselor.
10. Faculty members should receive training in the industry to familiarise themselves with the industrial problems and innovations. During the training, they should develop an institutional relationship with the industry personnel for getting full support to students' projects.
11. Faculty members should try for consultancy projects so that industry will also take an equal interest in the project and students will get access to industrial resources.
12. Faculty members should professionally, plan, implement, mentor, assess, and reward the projects to make the project live, active and continuous source of learning for mutual learning.
13. Faculty members should undertake action research at programme level for a duration of three to five years to professionally institutionalize project-based learning for the programme.
14. Faculty members should plan for publication and patents at the time of awarding the projects to the students and encourage students to do so.
15. Faculty members should consciously develop 21st-century skills in students combining various instructional methods such as brainstorming, group discussion, investigation, experimentation, trial and error, and presentation with project-based learning.
16. Faculty members should consciously encourage students to receive self-feedback, peer feedback, mentor feedback, and expert feedback on the progress of the project and the progress of the learning.
17. Faculty members should use assessment tools and techniques as motivational, learning, learning problem diagnosis, and assessment tools. Self-assessment, peer assessment, and mentor assessment should be part of the formal assessment process. The process and product assessment should be done to ascertain the outcome of the project-based learning.
18. Faculty members should provide adequate guidance to motivate the students to move further where the students are stuck during the project.

For students

19. Students should read the institution policy, guideline document, objectives of the project, monitoring schedule, and assessment scheme before undertaking the project.
20. Students should attend the awareness programme conducted by resource persons on completing the project and learning from the process.
21. Students should use collaborative and cooperative strategies of learning within and intergroup members.
22. Students should proactively come forward to explore an innovative theme or problem for the project and willingly work on it.
23. Students should reflect on the progress of the project and learning through the project. They should organize a presentation for taking the views of other groups to improve the quality of the project.
24. Students should see the problem holistically on programme outcomes and programme specific outcomes to analyze the problem and generate a solution. They should see the problem from the environmental, social, safety, sustainability, quality aspect.
25. Students should use self-assessment, and peer assessment techniques for getting feedback to improve the project quality and presentation.
26. Students should consciously develop 21st-century skills working on projects. These skills they can develop using intensive interaction, discussion, self-reflection, conducting an inquiry, refereeing literature, receiving peer feedback, seeking guidance from the mentor and industry experts, careful observation of the phenomenon.

REFERENCES

- [1] B. L. Gupta and Meenakshi Gupta(2016). *Journal of Engineering, Science & Management Education*, NITTTR, Bhopal Vol 9 Issue 1 Jan-April 2016.
- [2] C. L. Chiang and H. Lee (2016). The Effect of Project-Based Learning on Learning Motivation and Problem-Solving Ability of Vocational High School Students, *International Journal of Information and Education Technology*, Vol. 6, No. 9, September 2016.
- [3] G.E. Veselov, A.P. Pljonkin, A.Y. Fedotova (2019). Project-based learning as an effective method in education, Conference paper.
- [4] GimbaDogara, Muhammad Sukri Bin Saud, Yusri Bin Kamin, MohdSafarin Bin Nordin (2017). Project-based learning conceptual framework for integrating soft skills among students of technical colleges, *IEEE Access*, Volume XX 2017.
- [5] ImedRomdhani, Martin Tawse, Safa Habibullah (2011). Student Project Performance Management System for Effective Final Year and Dissertation Projects Supervision.
- [6] Janet Quint and Barbara Condliffe (2018) Project-Based Learning a promising approach to improving student outcomes, *ISSUE FOCUS* January 2018.
- [7] Jason Ravitz, Nate Hixson, Mary English, John Mergendoller, (2012). Using project-based learning to teach 21st-century skills: Findings from a statewide initiative, AERA –Vancouver BC (2012).

- [8] John W. Thomas (2000). A review of a research project on project-based learning.
- [9] MaijaAksela and OutiHaatainen (2019). Project-based learning (PBL) in practise: active teachers' views of its' advantages and challenges, *5th International STEM in Education Conference Proceedings: Integrated Education for the Real World At Queensland University of Technology, Brisbane, Australia, 21st to 23rd November 2018*, pp 9-16.
- [10] NajiKortam, Ahmad Basheer, AviHofstein, Muhamad Hugerat (2018). How Project-Based Learning promotes 7th-grade students' motivation and attitudes towards studying biology, *Action Research and Innovation in Science Education*, 1(2), 9-17.
- [11] NBA (2019). Self-assessment report, *National Board of Accreditation*, New Delhi.
- [12] NEP (2020). National Education policy 2020, *Ministry of Education*, Government of India.
- [13] NizwardiJalinus, RahmatAzisNabawi, AznilMardin (2017). The Seven Steps of Project-Based Learning Model to Enhance Productive Competences of Vocational Students, *Advances in Social Science, Education and Humanities Research*, Volume 102 Atlantis press.
- [14] PBL Guide: Instructors and programme coordinators, National Academy Foundation and Pearson Foundation.
- [15] Pengyue Guo, Nadira Saab, Lysanne S. Post, Wilfried Admiraal, (2020). A review of project-based learning in higher education: Student outcomes and measures, *International Journal of Educational Research*, 102 (2020) 101586 Elsevier, pp 1-13.
- [16] Shaban Aldabbus (2018). Project-based learning: implementation and challenges, *International Journal of Education, Learning and Development* Vol.6, No.3, pp.71-79, March 2018.
- [17] Wekesa, Noah Wafula, Ongunya, Raphael Odhiambo (2016). Project-Based Learning on Students' Performance in the Concept of Classification of Organisms Among Secondary Schools in Kenya, *Journal of Education and Practice*, Vol.7, No.16, 2016.