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Industry Collaborated Reflections and Scaffolding in Problem Based Learning

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***Abstract*—Problem based learning has evolved in consideration with culture and demography adapting to its social elements and class environment. The research community proves the method to be effective in building problem solving skills and developing cognitive capabilities along with professional and other team building skills. In this paper we propose a model to integrate industry expertise in building reflection and scaffolding constructs in course design and delivery. Collaboration was made with the industry Knit Space to assist in designing course elements meeting the course learning objectives. The syllabus was redesigned to conceptually split the contents as theories, concepts and applications. Reflection videos, three types of case studies and challenges were created accompanying to the problem based learning process adapted as per industry state-of-art. The course was delivered with the contents organized for the known knowledge leading to the discovery of the unknown. The case study research method, thematic analysis, feedback and the scores indicate that the process was effective in delivering the course model. The process can be applied beyond all the courses that are task or process oriented, or algorithmic in nature.**

***Keywords*—Collaboration; Reflections; Problem Based Learning; Problem Solving; Scaffolding**

***JEET Category*—Research**

I. INTRODUCTION

LEARNING is a state of transformation. Learning usually leads to a change where the effects of it can be observed immediately or eventually over the course of time. Learning can happen in structured, semi-structured, or unstructured environments. As for a new born child, most of the learning is unstructured and repeated behaviors, whereas old age learning's are the discovery of new meanings and abstractions of the known. Learning toggles between necessity and compulsion at various stages of a human life cycle. While learning can also be defined as a process of gaining knowledge or being a domain expert, no single definition can bring out all the facades of learning. While theories of learning have been questioned in the past (Skinner, 1950), experimental studies have often been carried out to validate the different methods and their effectiveness. From sensory simulation theories to andragogy theories, researchers have explored the learning principles from numerous viewpoints (Dunn, 2002). Several pedagogies have emerged from the learning styles and principles. Learning environment plays a major role in achieving desired educational objectives. Literature defines a safe learning environment as the one which is like a mirror to real life and professional life and also safe enough to make mistakes and learn through them (Honebein et al., 1993). Problem and problem solving play a major role in this process and has been a principal motivation for emergence of Problem Based Learning (PBL).

PBL instigates from medical education and background (Barrows, 1984). The philosophy of McMaster University medical education included self-directed, problem-based, and small-group tutorial learning as their methodology elements. The emphasis was made on diagnostic evaluation, selective use of learning resources, and integrated learning and educational planning (Neufeld & Barrows, 1974). PBL is identified with the characteristics that it is student-centered learning approach, learning occurs in small student groups, teachers play the role of facilitators, problems form the organizing focus and stimulus for learning. In the pedagogy, problems are a vehicle for the development of clinical problem-solving skills and new information is acquired through self-directed learning (Barrows & Tamblyn, 1980). The core educational objectives that can be met using a PBL methodology are structuring a knowledge based on the domain context, developing an effective domain specific reasoning process, development of effective self-directed learning skills and the increased motivation for learning (Barrows, 1985).

From structured to ill-structured, we have a taxonomy of problems that can be used for delivery (Jonassen, 2000) and those emergent from real–world and professional space have greater impact on achieving student learning outcomes (Hmelo-Silver, 2004). Research classifies PBL into several constellations namely PBL for knowledge management, for learning through activity, project–led, for practical ability, for design based problems, for critical understanding, for multimodal reasoning, collaborative distributed, and for transformation and social reform (Savin-Baden, 2014). And all of these have a dependency on nature and kind of problem that will be used a tool in the course delivery. In order to

effectively bring out the essence of PBL, it is necessary that students get to work on the professional problems and prepare them to be industry ready. This paper proposes one such model where the course is designed with industry collaboration and PBL is delivered with reflections and scaffolding activities to achieve the course learning objectives.

Section 2 presents the literature survey for the context and section 3 presents our model long with research question. Section 4 presents a case study of our model, results and data analysis and section 5 presents the discussion. Section 6 concludes the paper.

II. Literature Survey

This section presents literature review on problem based learning and the efforts towards reflections and scaffolding. In the recent past, PBL has gained prominence because of its effectiveness in developing students' professional knowledge and transferable skills. The knowledge by far acquired by the students, motivation to study and explore further, process of analysis and meeting educational objectives have been major criteria used to construct the problems in PBL (Majoor et al., 1990). PBL has been established as a holistic approach for education from product and process perspective by many educational researchers. (Chan, 2016).

PBL is known to promote critical thinking where real-life problems are usually used as trigger points. Also the trigger points in the problems help to define the learning objectives. Students and professors play non-conventional roles as they engage in this instructional and learning approach (Nasr & Ramadan, 2008). Students undergo independent, self-directed study which helps them in group discussions and in refining the acquired knowledge (Wood, 2003). Over the decades several systematic and meta-analysis reviews have been provided on history, evidence and student learning outcomes (Dochy et al. 2003) which proves the effectiveness of PBL in higher education (Thomas 1997).

PBL has been practiced at various stages from course level design to institutional level changes. A growing usage of the method has been observed at course level which restricts to one discipline and one semester, cross-course level which is mostly multidisciplinary also spanning for one semester, curriculum level varying from two to four years which combines one discipline and multidisciplinary projects and also at project level that varies from short term to long term (Chen et al., 2021). Though designed at different levels, the courses used problems for self-directed learning to develop practical capabilities and design skills.

The problems designed borrow the constraints and formulations from the real world and are mostly open-ended or ill-structured (Ge et al., 2016). PBL evolves with personalized forms of knowledge. The set of rules designed to ensure convergence of teaching practice and equality of opportunity to students evolve with the community of practice and facilitator. Teachers usually struggle in varying degrees while practicing complex issues and how the method has to be practiced (Kolmos et al., 2008). The team practicing PBL needs to have a vision and form a community of practice and strive to maintain open discussions about teaching and learning (Spronken-Smith & Harland, 2009).

Scaffolding and reflections are major elements of PBL. The case studies used find inspiration from Case Based Learning (CBL). Case method is an active and student-centric learning method which enables students to relate their experiences to the learning process and improve their learning through problem solving activities (Fidel, 1984). Case methods have been introduced in various courses like software architectures (Garg et al., 2015) where results indicate the increased engagement and learning. Open source case based learning platforms have been introduced (Saini et al., 2017) providing guidelines in writes cases. Business-oriented cases have been used for teaching software engineering and results indicate that students became proficient in analyzing and solving unfamiliar problems and providing more than one solution (Burge & Troy, 2006). Using a series of mini-cases has made learning fun and motivating (Hilburn & Towhidnejad, 2007).

Case method has helped students to use their theoretical learning in realistic environment and aid them in decision making capabilities (Razali et al., 2013). CBL has showed the improvements of student in various areas like engagement, critical thinking skills, communication and team work (Kundra et al., 2016). CBL has been effectively used in various modules of software engineering design and delivery like requirements engineering (Tiwari et al., 2018)), risk management (Fuller et. al., 2002) etc.

Reflections emphasize the learning process (Kolmos, 1996). PBL has been used to develop critical reflection skills for professional practice (Williams, 2001). The reflection prompts have been studied to be effective with feedback intervention (Krause & Stark, 2010). Reflections compliment PBL (Ong, 2000). PBL has been experimented with industry collaboration (Teixeira et al., 2020). Spaces and collaboration opportunities have been explored and based on the survey of published research; the recommendations have been proposed (Beddoes et al., 2010). Industry collaborations have been made for course and assessments developments in PBL (Centea et al., 2020). Live cases and industry collaboration can provide new ideas for innovation and development (Laukkanen et al., 2013).

With the presented review and the gaps present with respect to PBL process, we propose a model where case studies, challenges and reflections are intervened in the teaching process with industry collaboration. The interventions are carefully designed to meet the objectives of the course learning outcomes.

III. Model Design and Deliberations

In order to design a teaching and learning space using PBL for the computing courses and to design course specific problems, collaboration was made with the industry Knit Space Software Research and Services Private Limited, Hubli. The industry institute association was to design problems, host contests and make students work on industry need problems. This section presents the research question and process of its design, background and the model design.

A. Research Question

Considering the gaps in the literature and exploration of PBL at course levels, a model was designed to deliver an

algorithm oriented course for second year students. The research question was formulated as follows: what is an effective way of delivering an algorithm oriented course using PBL methods for computer science students with industry collaboration? The research questions further attempts to realize the objective using the following sub questions, considering the gaps from the literature:

- The role of case studies in the delivery and the structure of case studies
- The role of reflection videos in the course delivery
- Problem solving based evaluations for the course assessments
- The role of industry challenges and contests in the course design and delivery

B. Nature of the Course

The model designed is applicable for the courses which are algorithmic in nature from any domain. The model also fits to any other course that articulates process, or which are task oriented, or has emphasis on problem solving. The process is also effective if the course is practical or lab oriented (or at least has tutorial sessions).

Scaffolding in dictionary terms is a support provided during construction. Similar inferences can be drawn in education as the support provided by the teacher to assist learning which is withdrawn later and further provide extension to new understandings, concepts and tasks (Hammond & Gibbons, 2005). Scaffolding engages the learner (Van Der Stuyf, 2002). The course nature must allow a faculty to conduct enough scaffolding activities to keep the students engaged, provide a support and take them to the next level.

C. Case Study Research Method

Case study research method makes it possible to observe a phenomenon as single and also as a whole (Bullock, 1986). The method once critiqued, has recently gathered many researchers interest and almost every fundamental sciences (Starman, 2013). Of the three types of approaches: intrinsic, collective and instrumental, in collective methods several case studies are jointly studied and we adapt to the same approach (Stake, 1994). The method is well known and is used for theory building (Dyer & Wilkins, 1991), (Yin, 2011). Reflections, structured case studies, challenges are all part of our study process to measure the effectiveness.

D. Model Design

We start with the syllabus design and the process employed is presented in Figure 1. In order to use the problem based learning at course level, the syllabus is re-structured to first present principles and fundamentals, then tools and devises and later cover the methods and algorithms. Case studies and reflections are designed as structured enquiry. Reflection videos and case studies were used for course delivery. The syllabus was redesigned to teach algorithms using reflections as tool. The model builds over the traditional PBL models (Kolmos et al., 2009). This study is unique in its own aspects as it designs the reflection videos and short cases studies which fit well to the context of larger classrooms and the sessions with shorter durations. Reflections play a major role in teaching and learning environment also calling for a new epistemology (Schön, 2017).

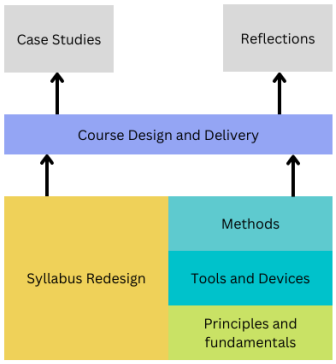

Fig. 1: Syllabus Design

The case study delivery model for the course can be seen in Figure 2. Foundational case studies are designed keeping the course principles in mind. Student discussions are used to arrive at these principles. Using these case studies as a support generic case study is developed. These studies aid in concept delivery. Students would have already arrived at the need and gaps which the concept bridges. Specific application case studies are further used where students use a specific algorithm to build a solution (Farahani & Hekmatfar, 2009).

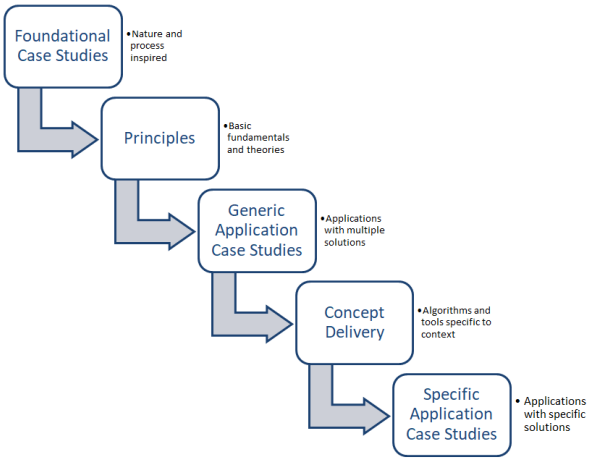

Fig. 2: Design of case studies

As presented in Figure 3, assessment strategies are divided into three major categories: case studies, reflections and challenges.

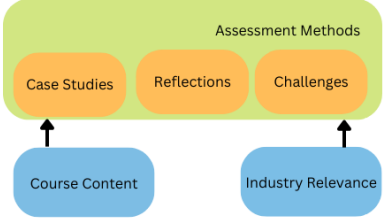

Fig. 3: Assessment methods design

These are drawn from the theories of course syllabus and from the industry relevance. Industry plays a major role in designing and assessing these elements. The case studies are designed with sustained inquiry, which are authentic, which the students use to reflect their learning and are structured with known and unknown from the course concepts. This also adheres indirectly (practices of the model) to the three major components of the gold standard PBL (Larmer et al., 2015).

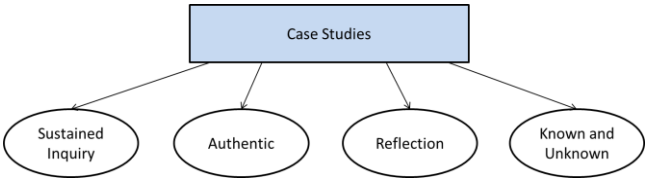

Fig. 4: Elements of case study design

The role of industry in the process is to:

- Assist in creating the reflection videos to arrive at the theories and principles
- Design the structured enquiry questions for the case studies
- Design specific modules for the industry challenges
- Assist in designing the case studies by providing real time requirements
- Prepare industry ready and authentic data and information design

The objective is to create a resource pool that triggers the students to arrive at multiple discussion prompts and ideas. We then use the course knowledge to refine and select the concepts that map to the relating ideas. This can be seen in Figure 5.

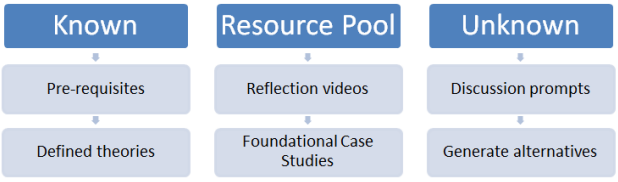

Fig. 5: Creating a resource pool

IV. Results and Data Analysis

This section presents the results and the data analysis of model applied on a course as a case study.

A. Course Background

Data Structures and Algorithms course for a computer science engineer plays a major role in developing problem solving skills by bridging concepts with real time applications. Hence the course was selected for the model application which is offered at III semester. There are five divisions and the method was adapted for two divisions handled by same faculty. The course had a total of six credits divided among theory and lab sessions. Because of lack in faculty motivation it was not as meticulously followed in other three divisions. Hence the paper only presents the evaluation from the two divisions of study.

B. Reflection Videos and Foundational Case Studies

Several case studies were introduced at the beginning of the course where dedicated slots were allocated to carry out the activity. Reflection videos were uploaded on the university LMS. Dedicated threads were created on LMS for each reflection video and case studies. This activity was carried out in the first week of semester commencement. Table I presents the list of nature inspired reflection videos created. These videos were selected form the existing pool of videos from social media.

TABLE I
Reflection Videos

Si. No.	Video	Relevance
1	Chris Gayle hits one handed six	Brute Force
2	Chameleon changes color	Transform & conquer
3	Movie Troy	Divide & conquer
4	Battle at Kruger	Divide by constant
5	Genes	Data Processing
6	Patterns in Nature	String processing
7	Ant colony optimization	Dynamic programming

A sample discussion post from LMS can be seen in Figure 6 below.

Fig. 6: LMS discussion on reflection videos

Five reflection videos were also designed on course contents and the details can be seen in Table II. Reflection videos are those where students are prompted with 5 to 10 minute videos which trigger the known knowledge to further explore them into various application and conceptual domains. All the videos were recorded by course faculty and hosted on LMS with industry guidance.

TABLE II
Course Reflection Videos

Si. No.	Video	Relevance
1	Set Operations	Union-Find
2	String Operations	String matching algorithms
3	Tree Traversals	Level order traversal
4	History from Kashi Vishwanatha Temple	Towers of Hanoi
5	Data Structures Evolution	Trees and variants

A feedback was collected with student consent where the students rated on the Likert scale of 1 to 5 where 5 being the highest and 1 being the lowest. The feedback can be seen in Figure 7 below. All the feedbacks were collected using

Google forms. The X-axis indicates the rating and the Y-axis indicate the number of students.

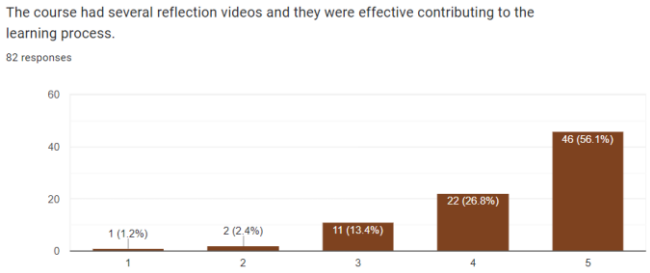

Fig. 7: Feedback for reflection videos

C. Case Study for Post Test

Posts tests are usually conducted with multiple choice questions and for this course descriptive case studies were provided. The case studies were designed in the structured enquiry format where each case study had four sub questions to be answered and each sub-question incrementally built over another. After first post test, a reflection session was conducted on how to answer such question and effective keywords to be used to search, analyze and present answers. The average text scores of both the post tests are presented in Table III.

TABLE III
POST TEST ANALYSIS

Division	Number of Students	Post Test 1 Average (10)	Post Test 2 Average (10)
B	56	7.63	8.52
D	58	7.52	8.53

D. Case Studies Design

Several case studies were designed with industry collaboration and a list can be seen below in Figure 8. The caser studies were divided for team and individual discussions on random sampling basis. Students were prompted to discuss these case studies.

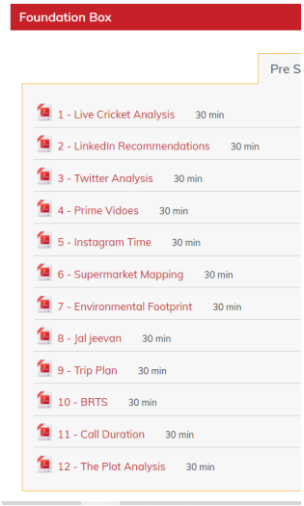

Fig 8: Case studies on university LMS

The feedback from 82 students also indicates that the case studies were effective in the delivery process. The feedback can be seen in Figure 9 presented below. 77 students confirm that case studies were effective.

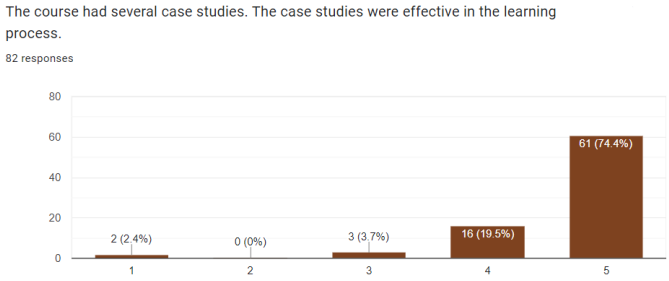

Fig 9: Case studies student feedback

E. Industry Challenges

Several industry challenges were hosted to support the PBL and the designed process. The state-of-art design problems were introduced to in connection to the course relevance. One such was working on Inventory data structure challenge: (github.com/prakashbh/inventory-data-structure). The mean and standard deviation of the challenge across two divisions can be seen in Table IV below.

TABLE IV
INVENTORY ANALYSIS

Division	Number of Students	Average (10)	Standard Deviation
B	56	6.65	1.811
D	58	6.66	1.911

A feedback was collected on hosted industry challenges and can be seen in Figure 10 below. The question asked was: the course had several challenging assignments hosted by industry and if were effective in learning process.

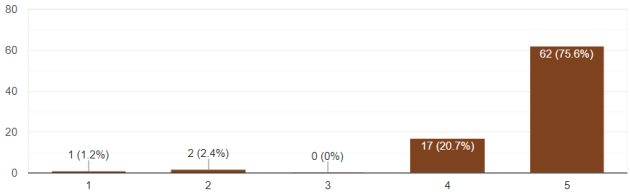

Fig 10: Feedback for industry challenges

V. DISCUSSION

A. Reflection Videos and Case Studies

As seen in Figure 7, the feedback for reflection videos is positive. 81% of students agreed that the method was effective in the learning process. These video discussions were further analyzed and thematic coding (Clarke et al., 2015) was carried out to validate the quality of discussions. The analysis on set operations video can be seen in Table V below. The following terms were used significantly in the discussion initiated by 86 students.

TABLE V
VIDEO ANALYSIS FOR SET OPERATIONS

Keywords	Number of Students
Sets represented as tree	60
Social media platform	58
Facebook	60
Tree traversals	60
Can't be modified	10
Store Unique elements	10
GPS/Maps	20

For example, the terms 'set represented as tree' its relevance in 'social media platform', 'traversals' was most widely used terms along with their synonyms. This also indicates that 70% of students were able to arrive at the right foundational principles using the video prompt.

A video on batsman Chris Gayle was presented and discussion forum was kept open for students to put forth their views. The following was recorded for 96 responses presented in Table VI. It can be seen that most of them used strength, angle and timing to describe the batsman hitting ability and these are the perspective that define the Brute Force, the intention with which the video was used for the prompt.

TABLE VI
VIDEO ANALYSIS FOR GAYLE HITS SIX

Keywords	Number of Students
Timing	74
Strength	70
Angle	20
Pressure on bowlers	5
Recursive shot, angles	5

A video on Data Structures Evolution found the following important terms as presented in Table VII by 115 students in the forum. The data was analyzed using thematic coding and bag of words API (Zhang et al., 2010). The frequency terms for tree, graph and memory are high which the expected objectives from the video are.

TABLE VII
DATA STRUCTURE EVOLUTION VIDEO ANALYSIS

Keywords	Number of Students	Keywords	Number of Students
Tree	238	int/float/char	20
Graph	280	dynamic	52
Non-Linear	104	linked lists	100
Data Structure	544	heap	10
Nodes	200	set	15
Memory	242	arrays	75
Hierarchical	50	static	25
Network	35	queues	25
Connections	56	fifo	04
Loops	35	stack	30
Cycle	51	searching	11
Vertices	109	algorithms	10
Edges	119	binary	16
Nodes	20	organizing	10
Allocation	83	managing	10
Address	22	homogenous	12
Storage	20	efficiency	20
Continuous	30	social media	20
Sequentially	08	shortest path	21

A video on Tree traversals found the following important terms by 115 students in the forum as presented in Table VIII. The video made students to think and come with different ways for tree traversals from which the level order traversal was explained in the class.

TABLE VIII
VIDEO ANALYSIS FOR TREE TRAVERSALS

Keywords	Number of Students
Tree traversals	370
Root or head	300
Search efficiency	100
No of arrangements = n! or nPn	50
Non-linear	52
Hierarchical data	40

Similarly thematic analysis was carried out on several other videos. The quality of videos were analyzed with discussion forum comments and on an average 70% of discussions were found to be effective meeting the course learning outcomes.

From Table III we can observe that there is an increase in average scores after the reflection session. The industry expert reflection session on how to answer the case studies have benefitted the students. The respective feedback from Figure 8 confirms the effectiveness.

A discussion on Amazon Prime's recommendation system from 50 students found the following keywords mostly commonly used as presented in Table IX. All identified words are the criteria for application design, indicating the positive quality of discussion forum comments.

TABLE IX
PRIME – CASE STUDY ANALYSIS

Keywords	Number of Students
Rating	45
New release	48
Search history	45
Language	42
Actors	45
Genre	30

B. Industry Challenges and Process

As seen in Figure 10, the challenges hosted by industry have made the positive impact on student learning process. Even the semester assessment papers were designed with a real-world perspective as against the traditional way. Figure 11 presents the analysis on the feedback collected where more than 90% agree that the process was effective.

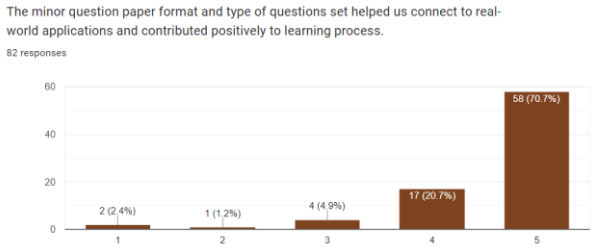

Fig 11: Feedback for minor assessment

More than 96% of students agree that the course made them think like a problem solver as seen in Figure 12.

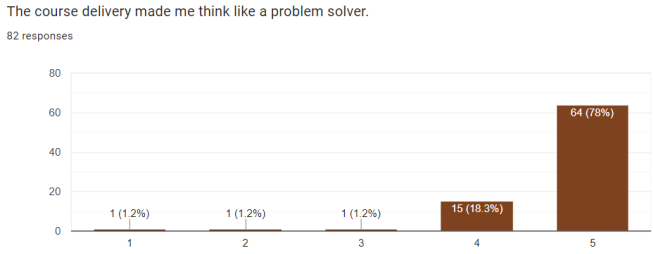

Fig 12: Feedback on problem solving skills

VI. CONCLUSION

A new model was developed with industry collaboration to deliver a course level PBL and the method was evaluated to be effective on several fronts. The reflection videos, several types of case studies designed, industry challenges were effective in realizing the course learning outcomes. All case studies generated were from real time and industry perspective. It helped students to connect with real world concerns and applications. The data analysis and discussion infer that reflections and scaffolding play a major role in achieving PBL objectives in support to the formulated research question. The work needs to be further extended in building validated instruments for effective assessment methods using the designed models.

REFERENCES

Barrows, H. S. (1984). A specific problem-based, self-directed learning method designed to teach medical problem-solving skills, and enhance knowledge retention and recall. Tutorials in problem-based learning, 16-32.

Barrows, H. S. (1985). How to design a problem-based curriculum for the preclinical years (Vol. 8). Springer Publishing Company.

Barrows, H. S., & Tamblyn, R. M. (1980). Problem-based learning: An approach to medical education (Vol. 1). Springer Publishing Company.

Beddoes, K. D., Jesiek, B. K., & Borrego, M. (2010). Identifying opportunities for collaborations in international engineering education research on problem-and project-based learning. *Interdisciplinary journal of problem-based learning*, *4*(2), 3.

Burge, J., & Troy, D. (2006). Rising to the Challenge: Using business-oriented case studies in software engineering education. In *19th Conference on Software Engineering Education & Training (CSEET'06)* (pp. 43-50). IEEE.

Bullock, R. J. (1986). A meta-analysis method for OD case studies. *Group & Organization Studies*, *11*(1-2), 33-48.

Centea, D., & Srinivasan, S. (2020). Collaboration with Industry in the Development and Assessment of a PBL Course. In *International Conference on Interactive Collaborative and Blended Learning* (pp. 181-188). Springer, Cham.

Chan, C. K. (2016). Facilitators' perspectives of the factors that affect the effectiveness of problem-based learning process. *Innovations in Education and teaching International*, *53*(1), 25-34.

Chen, J., Kolmos, A., & Du, X. (2021). Forms of implementation and challenges of PBL in engineering education: a review of literature. *European Journal of Engineering Education*, *46*(1), 90-115.

Clarke, V., Braun, V., & Hayfield, N. (2015). Thematic analysis. *Qualitative psychology: A practical guide to research methods*, *222*(2015), 248.

Dochy, F., Segers, M., Van den Bossche, P., & Gijbels, D. (2003). Effects of problem-based learning: A meta-analysis. *Learning and instruction*, *13*(5), 533-568.

Dunn, L. (2002). Theories of learning. Learning and teaching briefing papers series, 3.

Dyer Jr, W. G., & Wilkins, A. L. (1991). Better stories, not better constructs, to generate better theory: A rejoinder to Eisenhardt. *Academy of management review*, *16*(3), 613-619.

Farahani, R. Z., & Hekmatfar, M. (Eds.). (2009). *Facility location: concepts, models, algorithms and case studies*. Springer Science & Business Media.

Fidel, R. (1984). The case study method: A case study. *Library and Information Science Research*, *6*(3), 273-288.

Fuller, A., Croll, P., & Di, L. (2002, February). A new approach to teaching software risk management with case studies. In *Proceedings 15th Conference on Software Engineering Education and Training (CSEE&T 2002)* (pp. 215-222). IEEE.

Garg, K., Sureka, A., & Varma, V. (2015). A Case Study on Teaching Software Engineering Concepts using a Case-Based Learning Environment. In *QuASoQ/WAWSE/CMCE@ APSEC* (pp. 71-78).

Ge, X., Law, V., & Huang, K. (2016). Detangling the interrelationships between self-regulation and ill-structured problem solving in problem-based

learning. *Interdisciplinary Journal of Problem-Based Learning*, *10*(2).

Hammond, J., & Gibbons, P. (2005). What is scaffolding. *Teachers' voices*, *8*, 8-16.

Hilburn, T. B., & Towhidnejad, M. (2007, July). A case for software engineering. In *20th Conference on Software Engineering Education & Training (CSEET'07)* (pp. 107-114). IEEE.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn?. *Educational psychology review*, *16*(3), 235-266.

Honebein, P. C., Duffy, T. M., & Fishman, B. J. (1993). Constructivism and the design of learning environments: Context and authentic activities for learning. In *Designing environments for constructive learning* (pp. 87-108). Springer, Berlin, Heidelberg.

Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational technology research and development*, *48*(4), 63-85.

Kolmos, A. (1996). Reflections on project work and problem-based learning. *European journal of engineering education*, *21*(2), 141-148.

Kolmos, A., Du, X., Holgaard, J. E., & Jensen, L. P. (2008). Facilitation in a PBL environment.

Kolmos, A., De Graaff, E., & Du, X. (2009). Diversity of PBL–PBL learning principles and models. In *Research on PBL practice in engineering education* (pp. 9-21). Brill.

Krause, U. M., & Stark, R. (2010). Reflection in example-and problem-based learning: Effects of reflection prompts, feedback and cooperative learning. *Evaluation & research in education*, *23*(4), 255-272.

Kundra, D., & Sureka, A. (2016, December). An experience report on teaching compiler design concepts using case-based and project-based learning approaches. In *2016 IEEE Eighth International Conference on Technology for Education (T4E)* (pp. 216-219). IEEE.

Laukkanen, M., Mattila, P., Salo, J., & Tikkanen, H. (2013). Using live cases for teaching, industry collaboration, and research. *Marketing Education Review*, *23*(1), 65-72.

Larmer, J., Mergendoller, J. R., & Boss, S. (2015). Setting the Standard for Project Based Learning. Association for Supervision & Curriculum Development.

Majoor, G. D., Schmidt, H., Moust, J., Snellen, H. A. M., & Stalenhoef, B. (1990). Construction of problems for problem-based learning.

Nasr, K. J., & Ramadan, B. (2008). Impact assessment of problem-based learning in an engineering science course. *Journal of STEM Education: Innovations and Research*, *9*(3), 16.

Ong, R. (2000). The role of reflection in student learning: a study of its effectiveness in complementing problem-based learning environments. *Centre for educational development*.

Neufeld, V. R., & Barrows, H. S. (1974). The "McMaster Philosophy": an approach to medical education. *Academic Medicine*, *49*(11), 1040-50.

Razali, R., & Zainal, D. A. P. (2013). Success Factors for Using Case Method in Teaching and Learning Software Engineering. *International Education Studies*, *6*(6), 191-201.

Saini, V., Singh, P., & Sureka, A. (2017, July). Seabed: An open-source software engineering case-based learning database. In *2017 IEEE 41st Annual Computer Software and Applications Conference (COMPSAC)* (Vol. 1, pp. 426-431). IEEE.

Savin-Baden, M. (2014). Using Problem-based Learning: New Constellations for the 21st Century. *The Journal on Excellence in College Teaching*, *25*(3&4), 197-219.

Schön, D. A. (2017). *The reflective practitioner: How professionals think in action*. Routledge.

Skinner, B. F. (1950). Are theories of learning necessary?. Psychological review, 57(4).

Spronken-Smith, R., & Harland, T. (2009). Learning to teach with problem-based learning. *Active Learning in Higher Education*, *10*(2), 138-153.

Stake, R. E. (1994). Case study: Composition and performance. *Bulletin of the Council for Research in Music Education*, 31-44.

Starman, A. B. (2013). The case study as a type of qualitative research. *Journal of Contemporary Educational Studies/Sodobna Pedagogika*, *64*(1).

Tiwari, S., Ameta, D., Singh, P., & Sureka, A. (2018, June). Teaching requirements engineering concepts using case-based learning. In *2018 IEEE/ACM International Workshop on Software Engineering Education for Millennials (SEEM)* (pp. 8-15). IEEE.

Teixeira, R. L. P., Silva, P. C. D., Shitsuka, R., de Araújo Brito, M. L., Kaizer, B. M., & e Silva, P. D. C. (2020, April). Project Based Learning in Engineering Education in Close Collaboration with Industry. In *2020 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1945-1953). IEEE.

Thomas, R. E. (1997). Problem-based learning: measurable outcomes. *Medical education*, *31*(5), 320-329.

Van Der Stuyf, R. R. (2002). Scaffolding as a teaching strategy. *Adolescent learning and development*, *52*(3), 5-18.

Williams, B. (2001). Developing critical reflection for professional practice through problem-based learning. *Journal of Advanced nursing*, *34*(1), 27-34.

Wood, D. F. (2003). Problem based learning. *Bmj*, *326*(7384), 328-330.

Yin, R. K. (2011). *Applications of case study research*. sage.

Zhang, Y., Jin, R., & Zhou, Z. H. (2010). Understanding bag-of-words model: a statistical framework. *International journal of machine learning and cybernetics*, *1*(1), 43-52.