

One-Day Many-Problems: A Problem Based Learning Approach

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Abstract: Problem Based Learning not only improves problem-solving abilities but also promotes the development of critical thinking skills, involvement in the team, communication skills, comprehending the reflections, and all of the mentioned along with understanding and applying the course content. A considerable number of universities have experimented with variants of problem-based learning on a variety of course content delivery. The methodology has its challenges of crafting a good ill-structured problem, delivery techniques, evaluation parameters, scaffolding, etc. The problem-based learning sessions usually require lengthier time due to inherent nature, while most universities have class hour sessions of one to two hours. Also, the problem-based sessions are generally effective in smaller classrooms of strength up to thirty. This paper presents the One-Day Many-Problems approach, a teaching-learning model, which helps to craft questions, facilitate discussions, trigger motivation, provide reflections, and comprehend using scaffolding activities. The sessions are planned to engage the classes in intervals where a chain of sessions sum up to inclusive conclusions — the approach aids in the attainment of expected course learning outcomes with systematic and meticulous planning and execution. The paper further presents a case study of the model applied to an eight-semester course – Model Thinking. The paper discusses the results and ponders over the achievement of course learning outcomes along with general guidelines and learnings. One-Day Many-Problems approach proves to be a beneficial delivery model for a shorter session and larger strength classrooms.

Keywords: Course Learning Outcomes, Model, One-Day Many-Problems, Problem Based Learning.

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1. Introduction

The academic environment is largely driven by industry requirements, research, and state-of-art societal challenges. The academic environment, so why has seen radical changes with respect to curriculum design, delivery, and assessment over time-lapse to meet the demands of ever-changing essentials. New pedagogies have been timely introduced to meet the necessities. We are no more a simple to-do plan of action society. We are instead in a complex evolutionary adaptive environment. With digitization, collaboration, globalization, etc. phenomenon, the complexity inevitably becomes constituent and nature of the problem. Considering the various roles which come into the picture, one crucial aspect commonly worked towards is problem-solving skills. Companies are looking for graduates well equipped with problem-solving skills. Universities are designing course delivery through problem-based learning. Students are working towards honing their problem-solving skills, realizing its importance. From competitive programming to solving real-world problems, the skill set is most looked for.

As simple as the definition sounds, problem-solving is a process of working towards a solution for the problem at hand, be it using an ad-hoc approach or a systematic methodology. The multi-faceted domain has created interests in several research groups to find effective means and measures of achieving it.

However, from the academic perspective of the problem domain, the inquiry is how effectively can we use problem based learning as a teaching pedagogy. There is no one way, but there is certainly a way out. This is where we aptly come into defining a Problem Based Learning (PBL). PBL is a student-centered pedagogy. It tactics the learning experience through student groups solving an ill-structured open-ended problem. The trigger materials provided usually do not come with a single pre-defined solution. Along with problem solving, students also are benefitted from developing effective communication and collaboration skills.

(Wood, 2003) defines problem-based learning as a process that uses identified issues within a scenario to increase knowledge and understanding. He lists fourteen principles of the method where one of it mentions that it enhances

teamwork, communication, problem-solving, and encourages independent responsibility for shared learning - all essential skills for future practice. PBL can be used to improve content knowledge while simultaneously fostering the development of communication, problem-solving, critical thinking, collaboration, and self-directed learning skills. PBL may position students to optimally function using real-world experiences (Barret and Terry, 2010), (Wells et al., 2009).

PBL methodology has seen its advantages and challenges from various perspectives. The method has its proven benefits and as well as challenges to be adapted into different teaching environments.

The paper is further divided into the following sections. Section 2 presents the literature survey. Section 3 presents the One-Day Many-Problems (ODMP) design goals and the model. Section 4 presents a case study, results and discussion. Section 5 concludes the paper along with the future scope.

2. Literature Survey

There is no one predefined meaning for problem based learning. It has a historical origin from medicine. There have been books published on how it can be used for medical education (Barrows and Tamblyn, 1980). Not only medical, but it has also been an inspiration in and to many fields. The method can morph its forms based on the course and course teacher (Barrows, 1986). It's an experience-based education where students learn with thinking strategies (Hmelo-Silver, 2004).

PBL has been explored in many areas. It's experimented in a constructivist learning environment (Savery and Duffy, 1995). A meta-analysis has been carried out on the method (Dochy et al., 2003). The benefits of the technique have been psychologically analyzed and reviewed (Norman and Schmidt, 1992). PBL's methods have been effectively employed in entrepreneurship education. (San and Ng, 2006). Not only in entrepreneurship, but PBL's methods have also been studied and explored in schools as well (Achilles and Hoover, 1996). PBL has been studied with instructional methodologies for administrators and to prepare them for the future (Bridges, 1992).

PBL has been explored in various dimensions and depths. Engineering teaching methodologies have been questioned over PBL methods (Mills and Treagust, 2003). The characteristics of the method have been studied (De Graaf and Kolmos, 2003). The effectiveness of the method has been reviewed and concluded to improve the knowledge base (Colliver, 2000). 'What works in PBL and Why' has been studied as well. (Schmidt et al., 2011).

Not only the advantages, but PBL disadvantages and demerits have also been researched and analyzed as well. PBL can be stressful and can get unrealistically costly

(Berkson, 1993). However, the study is domain restricted. The theories and underlying principles have been questioned.

PBL has been introduced for an entire curriculum where one problem is being addressed each day (O'Grady et al., 2012). PBL has also been studied through postholes, where the teacher can occasionally introduce without driving the entire curriculum PBL way (Stepien and Gallagher, 1993). As well, the PBL method has been compared and correlated with other learning methodologies (Savery, 2006).

This paper unifies the theories and principles from two schools of thought – one day one problem and postholes and presents a cohesive approach. Considering the nature of courses that are usually offered in universities and the class strength, the model proposes a workable and potentially effective solution.

3. One-Day Many-Problems

This section discusses the design goals, the model – One-Day Many-Problems, and its characteristics.

A. Design Goals

The design goals of ODMP are the basis to achieve an effective PBL delivery. The model has three design goals. The first one concerns on planning sessions for larger classrooms with shorter durations. The second one is about crafting problems. The third one concerns to assessments.

The first of design goals answer the questions: How can we have PBL sessions to larger classrooms? How can we engage an effective PBL for shorter class sessions of one to two hours? The facilitator might not be able to monitor all the present teams. In the concern, how can the facilitator make sure that every team in a larger classroom is working towards the assigned goal? We need a mechanism where one or two teams lead, and other teams follow-up with thoughts. One team presents, another argues, and yet another concludes. The PBL activity can be split across the sessions. The facilitator needs to plan the sessions to make it logical connected.

The second design goal is about crafting the problems. Crafting a good problem is one of the significant challenges in a PBL session delivery. For a shorter session, the problem can have its pre-defined objectives. The problem can be designed to deliver a principle to aid a concept or to explain an entire concept as a whole.

The third design goal is PBL assessments. Not all PBL sessions need to have an assessment. An assessment can be planned after a set of sessions. Or the assessment can be a reflection activity. The assessment can also happen during the internal exams of the course. The facilitator can plan an appropriate mechanism depending on the PBL sessions structure and management.

B. The Model

The ODMP model is shown in Fig.1, which segregates the engagements based on the involved actors in the process. Here the actors are facilitators and students. With a thin line of orientation, we divide the ODMP model into a four-phase process.

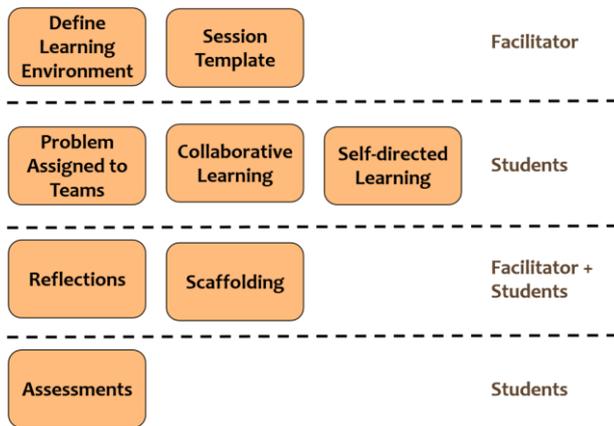


Fig. 1 ODMP Model

1) *Phase I – Definition:* The facilitator here defines the learning environment. The definition is the crucial step of ODMP. The facilitator might decide the entire concept to be covered using PBL, or a basic principle which supports the idea of using PBL or a related application using PBL. This phase includes understanding the syllabus, preparing notes on the connectivity of course contents, identifying the social connection with the concept coverage, abstracting the concepts, and identifying the related real-time scenarios. Then the facilitator prepares a session template. The objective of the template is to monitor and manage the outcome of the session. Each session template may vary depending on the coverage and depth required. The session template here corresponds to the planning of all the four phases of ODMP.

Crafting a problem is equally challenging. The facilitator can create a related scenario, use an existing scenario if it already relates to the concept, borrow a scenario from another domain, create a scenario using real-time events, etc. The facilitator has to decide based on the plan and template of the concept delivery.

2) *Phase II – Learning:* The facilitator here supports the learning environment. The class is divided into teams and assigned problems. The problem can be given as handouts. The student teams brainstorm, discuss the possible solutions, and carry out the activity. This phase may go from thirty minutes to two hours. At the end of the session, the facilitator may provide pointer on concepts to be read as homework activity before attending the next lecture.

3) *Phase III – Reflections:* Depending on the problem type, this can happen on the same day as the case study is given or in the next lecture session. One or two teams present and discuss the solutions, and other teams ponder on the thoughts and conclusion. The facilitator here makes sure

that the view is in-lined towards the desired objective. The facilitator must make sure that students are working in the right direction. This phase can go from thirty minutes to two hours. Even scaffolding activities can be planned to reach up to the desired conclusion.

4) *Phase IV – Assessments:* The assessments can take several forms. It can be a non-graded activity. Or it can be an activity that can stand as a foundation for the next graded assignment. The assessment can happen later during minor exams too. The evaluation can also be yet another PBL session.

A facilitator needs to carefully plan out the four phases of a PBL session. The model is decidedly dependent on the problem crafted for the session. For the challenges it throws, can be mastered with experience and course expertise.

4. Results and Discussion

This section presents the case study of ODMP applied to eight-semester elective: Model Thinking. A part of the course discusses various models as an alternative to address the data science challenges and another on model checking, which verifies the formal properties of the models. The course had 43 registered students from the School of Computer Science and Engineering. The Course Learning Outcomes (CLO) of the course are listed in Table 1.

Table 1. CLO's for the Course

CLO id	CLO
CLO1	Explain the need, advantages, disadvantages, implications, and applications of modeling
CLO2	Infer and explain the model characteristics
CLO3	Use model checking and model system's and concurrent system's behavior
CLO4	Discuss linear time and regular properties through the process of model checking
CLO5	Identify a real-world application and produce a model using Game of Life

Each of the above CLO's is mapped to program learning outcomes, and a threshold is set for each CLO indicating the target attainment. There are two numbers – threshold and target. Target is the percentage of students, and it is a common number set across all. Threshold is set per CLO. Table 2 presents the target, threshold, and methodology used.

Table 2. CLO Threshold, Target, and Methodology

CLO	Threshold	Target	Methodology
CLO1	65%	75%	PBL is used
CLO2	60%	75%	PBL is used
CLO3	70%	75%	PBL not used
CLO4	65%	75%	PBL not used
CLO5	80%	75%	Course project

As an example, the numbers are interpreted as 75% of students must score 65% or more marks allotted for CLO1. For CLO1 and CLO2, PBL was used as indicated in Table 2. This does not mean the entire course syllabus was designed using PBL. Around 10 case studies were designed for the course material. For CLO3 and CLO4, traditional teaching methodology was used. CLO5 is addressed by the course project which does not involve any PBL activity. CLO1 and CLO2 cover 24 hours of the course syllabus and CLO3 and CLO4 cover 16 hours of the syllabus.

Table 3 presents the assessment statistics for the mentioned CLO's. The assessments covered in the Table only indicate the minor and semester-end exams. Course project, mapping to CLO5 was evaluated for 20 marks.

Table 3. Assessment Stats

CLO	Minor 1	Minor 2	Semester End
CLO1 and 2	60 marks	30 marks	90 marks
CLO3 and 4	0 marks	30 marks	70 marks

The table above shows the total marks where students have options to attempt selected questions. The assessment is scored on the following basis: if the set target is achieved as per table 2, a number of 3 is scored. If it is 10% less than the set, a number of 2 is scored. If 55% of students score the set threshold, then a number 1 is scored. Anything lesser is scored 0.

For the considered course, below is the ODM presented for two sets of PBL session plans. Table 4 presents the session template for activity 1. The table presents sufficient details to understand the process followed.

Table 4. PBL 1 Session Template

Phase	Activity	Time
I: Definition	Pick the concepts to be covered from the syllabus. They can be from different chapters but needs to be interrelated. Concepts Selected: Rational Thinking, Nash Equilibrium, and Lyapunov functions. Craft PBL problems for each concept.	The facilitator needs to spend at least 3 days. One day per concept to frame the PBL statement.
II: Learning	Make teams and handhold the sessions.	Each PBL session is of 30 minutes.
III: Reflections	Discussion session after all the three sessions	1 hour. One team for each problem present their solutions.
IV: Assessment	A question to be set during the minor exam. Question is another PBL problem which questions if Lyapunov function can be written for Zeno's	Minor exam period.

	paradox which tests all the three concepts understanding.	
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As seen in Table 4, a session was planned and conducted with three PBL problems and assessment question set during the minor exam. Table 5 presents the result statistics of assessment.

Table 5. PBL 1 Assessment Results

Type	Students Number
Total students registered for the course	43
Students who attempted the question	40
Students who scored 4/4	5
Students who scored 0/4	6
Class average	2.025

Most students who had analyzed the problem partially correct had failed to conclude it appropriately for the given case study. The question mapped to CLO2. Table 6 presents the session template for another PBL session.

Table 6. PBL 2 Session Template

Phase	Activity	Time
I: Definition	Craft a PBL problem on Game of Life concept.	The facilitator needs to spend at least 3 days to craft the problem
II: Learning	Make teams and handhold the sessions.	2 hours
III: Reflections	Discussion session in the next class. Discuss the rule formations and applications.	2 hours
IV: Assessments	A question to be set during the minor exam. Question is another PBL problem.	Minor exam period.

During the same time period, India had witnessed two fire events within 24 hours. One during the air show where around 500 cars had caught fire in Bangalore city and another Bandipur forest fire which then went on for weeks (Both events in state Karnataka, India). The question was framed on - what appropriate model can be used to explain and prevent the fire. Table 7 presents the statistics for the question.

Table 7. PBL 2 Assessment Results

Type	Students Number
Total students registered for the course	43
Students who attempted the question	8
Students who scored 6/6	1
Students who scored 0/6	0
Class average	3.25

The question mapped to CLO1. The majority of students opted out not to answer this question. The overall attainment of all CLO's for the course with various PBL sessions can be seen in Table 8 presented below.

Table 8. Course CLO Attainment

CLO	Attainment Score
CLO1	3
CLO2	2
CLO3	1
CLO4	3
CLO5 – Course Project	3

The scores are calculated as explained at the beginning of the section after Table 3. We can see that CLO's, which were achieved using the PBL session (CLO1 and CLO2) has average attainment of 2.5 and CLO's where PBL was not used (CLO3 and CLO4) has average attainment of 2. PBL sessions have benefitted students to understand the concepts better, enhancing the learning processing and applicability of the studied concepts. CLO5 is not detailed as it was for the course project.

Fig 2 and 3 captures PBL sessions in progress. The students have been actively engaged in the activity.



Fig. 2 PBL Session Picture 1



Fig. 3 PBL Session Picture 2

A feedback form was circulated to measure the effectiveness of the PBL sessions conducted during the

course tenure. 32 students submitted the responses through an online feedback form. For each of the questions, 1 indicates the least score, and 5 indicates the highest score measuring the effectiveness. Three questions and their ratings are discussed further.

Question 1: The Model thinking part of the course had several case studies and activities. Did it help in learning the concepts better?

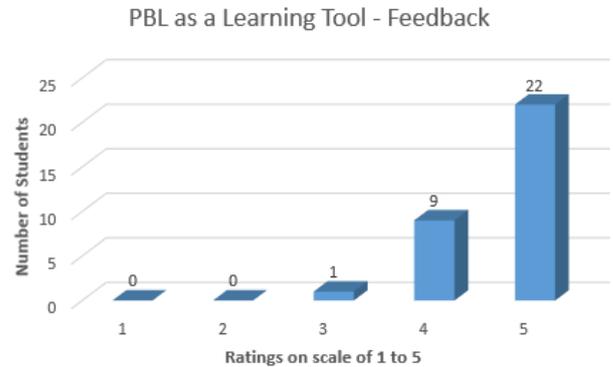


Fig. 4 PBL as Learning Tool Feedback

Fig 4 presents the feedback analysis. 69% of students found it to be highly effective, and 0% of students expressed unhappiness.

Question 2: Did the case studies and problem-based learning help you to connect with the real world better?

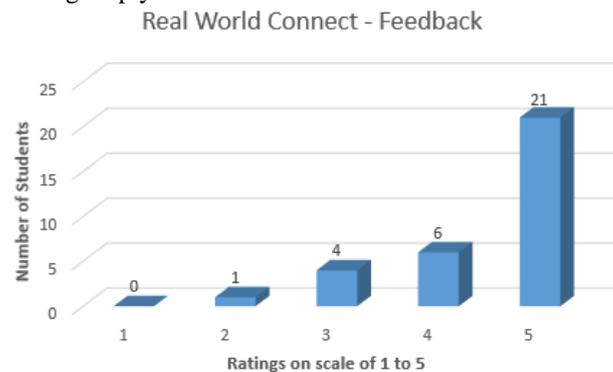


Fig. 5 PBL Real World Connect Feedback

Fig 5 presents the feedback analysis for question 2. 65% of students found this to be highly effective – positively a progressive number.

Question 3: Minor question paper had scenarios based on the concepts learned in the class. Rate on the effectiveness of minor papers in improving learning and problem solving abilities.

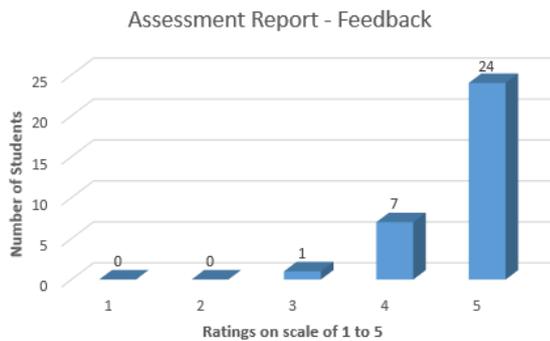


Fig. 6 PBL Assessment Feedback

Fig 6 presents the feedback analysis for question 3. 75% of students found this to be highly effective.

5. Conclusion

ODMP is found to be an effective methodology to deliver PBL sessions of shorter duration and to larger classes. A problem can be divided into smaller sub-problems for PBL sessions. Each sub-problem can be a PBL session. The sub-problems can span across the syllabus. The PBL sessions are usually short, can be as short as thirty minutes. PBL sessions include discussing key insights. Take home study can involve reading about applications of PBL discussed. The assessment can be yet another PBL session. With the results and feedback collected, the employed methods show positive implications.

As a future scope, a formal template can be designed for the session template. A structured template can help and guide the facilitators to plan and implement the PBL sessions meaningfully and effectively. Regardless to mention, also a template to craft a PBL session problem.

While this paper gives an overview of the ODMP model, each of the phases can be a detailed paper compelling its effective form for course delivery. The author's future efforts will be on the same lines.

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