POGIL BASED CLASSES FOR COMMUNICATION ENGINEERING COURSE

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ABSTRACT

This paper summarises the research carried out on the active learning technique "Process Oriented Guided Inquiry Learning" (POGIL) in communication engineering course. The contents of Communication Engineering (CE) are highly theoretical and involves more of analytical work. Traditionally this course was taught by mere lecturing in passive learning style. This passive learning made the generation Y learners to do rote learning for the assessment purpose. These series of activities lead to unemployability irrespective of their grades. To achieve the desired learning outcomes, educationalist worldwide follows different active learning techniques including inquiry based learning. Inquiry-based learning incorporates directed questions which enhances the student's critical thinking skills and makes the students to construct the knowledge on their own. Concurrently it needs the following i) specifically designed instructional activity sheets from the instructors for learning ii) Accurate assessment of prior knowledge for overall improvement in learning and iii) scaffolding interventions by the instructor to pay for the increased cognitive demands on beginners. This paper discusses how POGIL can be applied in CE course and how CDIO syllabus can be framed by designing a project based on POGIL approach. It also discusses how CDIO framework can be adopted within the already available curriculum framework with minimal change.

KEYWORDS

CDIO, POGIL, pedagogy, Construction of Knowledge, Standards 2,3 & 5

I. INTRODUCTION

Conceive, Design, Implement and Operate (CDIO) (Crawley., 2012) and Outcome Based Education (OBE) (2013) are two different standards set by education sector worldwide to access the standard of higher education Institution. Both standards talk about innovative pedagogy to promote active learning and to improve the critical thinking skills of the students. Though there are wide number of innovative pedagogy papers in fields like medical science and chemistry, very less number of documented papers exist in engineering education. In India professors got the awareness only when OBE started with an objective of students centred learning. Since the establishment of the student centred learning many active

learning techniques like Think Pair Share (TPS), Peer Instruction (PI) learning and Z-A learning are followed worldwide. The objective of these active learning techniques is to make the students active in the class room and to promote complex thinking skills. In addition, to active learning, CDIO talks about Engineering as a practice, which cannot be obtained by a mere active learning. In other words, the idea of the CDIO initiative is located at the intersection between the notion of active learning and the essential sciences of applied engineering.

Problem based learning (P_1BL) (Barrows., 1980 & White., 2007), Project Based Learning (P_2BL) (WeiZhan et al. 2011), inquiry based learning and Process Oriented Guided Inquiry Learning (POGIL) are some of the other active learning pedagogy widely followed. These pedagogies not only promote critical thinking skills, but also a acts as a guide to solve a real problem existing in practice. CDIO and P_1BL are not mutually exclusive and they are compatible and reinforcing (Edstrom et al. 2012). By defining innovative pedagogy as a tool to provide the three categories of innovation competencies: individual, interpersonal and networking innovation competences Taru & Juha Kontio (2014) have related the innovation pedagogy to CDIO, Though it is true with P_IBL and P_2BL without curriculum change it would be too difficult to bring in networking innovation competence at least with respect to course syllabus completion, i.e. if it is followed for introductory courses like Circuit Theory (CT) one would end up completing only 60% course coverage. In most cases, coherent and ambitious programmes of reform involve project-based education within authentic professional engineering contexts.

This paper has been divided into four parts, where the first part reviews relevant background on active learning and POGIL, compares CDIO to active learning. Second part explains the development of activity sheet with an example for conceptual level understanding topic. The third part analyses the feedback received by the students and the last part relates the work to CDIO standard and finally the paper has been concluded with future direction

II. POGIL ACTIVITY SHEET DEVELOPMENT

The students who have practiced only for what, explain, derive, and solve (all related to what they studied obviously in the class room already) when confronted with even why (why such methodology is not suitable for some X application?) find it very difficult. In such condition the main goal is to guide learners so that they learn to utilize the information in ways that are consistent with the learning objectives, to store the information in long-term memory (Kirschner et al, 2006, Elliot et al, 2014 & Lawson 1995). POGIL appears to accomplish this goal, while still engaging the students and restricting the traditional, lecture format. The necessary information is provided to students in POGIL and hence does not overload the cognitive processing of working memory, as found in the PB_xL method. POGIL, is found to be effective in engaging students because of its carefully structured activities, which focus on the processes of learning (David., 2003).

The following strategy is defined for the creation of learning material. The first step is to systematically analyse the contents to come up with minimum common learning content or a structure to be followed throughout. Next step is to identify if there is any prior learning

required? If so, teach the students the minimum required prior knowledge content along with the required common content and complete it in few classes. Third step is to prepare the activity sheets with critical thinking questions based on their prior knowledge and the minimum common content already taught. With respect to this, two kinds of activity sheets were created based on the content difficulty level. For conceptual understanding, lasting effect on student was made by creating the contents linking with day to day activities. For higher cognitive level, questions were prepared by going deep into the content for activity sheet creation. By solving the activity sheets in group together with the guidance by the instructor, students were supported to master the basic knowledge of communication engineering. Also, it challenges the students to adopt to any new problems.

The POGIL activity sheet has been developed with most care and it followed four level approach (Abraham., 2005) i.e. orientation, exploration, concept formation and application. The orientation stage prepares the students for learning by introducing the learning objective. In the second stage students use the models or activities created by the instructor for analysis and investigation of the data. In the third stage, they invent the concepts. This process is enabled by supplying questions that compel students to think critically and analytically as they engage in the exploration. These questions, which are called guided-inquiry, critical-thinking, or key questions, guide the learner both in the exploration and concept invention stages. The steps are illustrated with two examples.

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POGIL Activity sheet for concept of Modulation

Generally, the concept of modulation will be given as a lecture or like a definition in the traditional teaching format. In contrast, in POGIL a model or relevant data must be provided with structured directed questions. As the concept of modulation is very abstract, a different context rich domain representation was used to visualize and understand the technical concept. The MATLAB simulation can be used in this place, but to make the weaker students also to have the concept in their long-term memory an equivalent day to day model is needed. This facilitates easy comprehension and overcomes language barriers of rural and weaker students, who respond better to some visualization. Hence students were given images and asked to make inferences with the help of the POGIL questions. The visualizations are shown in figure 1a through 1f.

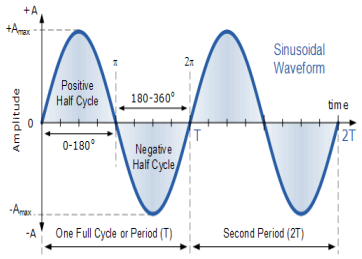

Figure 1a Single tone sine waveform

Figure 1b Collection of small bottles

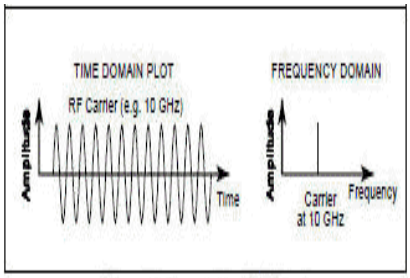

Figure 1. Unmodulated RF Signal

Figure 1c High Frequency sine waveform

Figure 1d- A carry bag

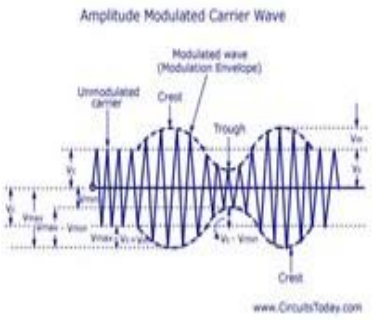

Figure 1e- Modulated waveform

Figure 1f- Carry Bg with collection of bottles

Table 1 Inquiry questions for explaining modulation

Fig No with Question	Inquiry Questions	Expected Answers
1a.	What is the frequency of the waveform shown in figure. Answer can be relative low or high with respect to figure 1c.	Low
1b-1	What is shown in Figure	Small Bottles
1b-2	Can you carry those bottles as it is to short or long ditance?. Why ?	May be for short distance fine, But for long distance we cannot, because they are small individual pieces difficult to carry in hand
1a-2	Realate the collection of small bottles concept with low frequency information for transmission to long distance	As like small bottles, low frequency can be transmitted only for short distance not for long distance
1c-1	Compared to Figure 1a what is the frequency of this waveform?	High frequency

1d-1	What is the figure shown in figure? And its size compared to 1b ?	It is bag, bigger than thoe bottles. Some times we call it as carry bag.
1e-1	Relate the name of the figure 1d-1 with 1c and coin a name for this waveform	Carrier (Multiple answers like carry signal)
1f-1	What is this picture ?	The carry bag with bottles
1f-2	Do you see any change between figure 1d and 1f? If so how ?	Yes there is a change in the shape of the bag due to the bottles
1e-1	Now relate 1f with 1e	When the carrier is carrying the low frequency signal , the amplitude of the carrier is changed with respect to the low frquency signal

III. STUDENTS FEEDBACK AND FINDINGS

POGIL classes were conducted for II-year ECE Vel Tech University students for CE course. The students are from heterogeneous group whose marks range from as low as 50% to as high as 95%. Therefore, the absorbing capability of students is varied. Accordingly, 20% of the students are grouped as more than average 50% students are grouped as average and 30% students are grouped into below average. However, students were not informed about their categorization. A set of questionaries were framed in order to have the formal feedback from the students about the PGOIL classes. There were two types of questions framed objective type and descriptive type. Objective questions were framed in order to guide the students to answer descriptive questions. The questions were given in table 3 & 4. It was not a surprise to see only 70% of the students have answered for the descriptive type due to lack of real interest and the objective questions were answered randomly. The feeedback data analysis showed that the above 60% feedback is either from above average or average students The feedback data was analysed with reference to three points i)group work ii)knowledge construction iii) Final assessment.

Table 2 Descriptive Feedback Questions

S.No	Feedback Questions
1	What do you think about the questions for self-understanding in POGIL classes
2	Do you like to have more questions? If yes or no why?
3	Do you like to have POGIL classes in future? If no state the reason
4	What is the difficulty in recollecting old topics or old concepts studied in the previous semesters?
5	Does POGIL classes reduce your time to review the same topic for exam?
6	What did you like most about the POGIL Classes?
7	What do you think that shouldbe improved in POGIL

	classes
8	Do you like to work in group ?. If no what is the difficulty

Table 3 Objective Feedback Questions and Survey results

S.No	Objective Feedback Questions	Agree %	Undecided/not answered %	Disagree %
1	POGIL activity has helped me learn concepts more effectively than lecture alone would have	70	25	5
2	The POGIL approach has forced me to think more deeply about concepts than the lecture alone would have	65	25	10
3	The POGIL approach has helped me feel more confident about tackling unfamiliar problems	50	30	20
4	The POGIL classes has been effective in improving my problem-solving skills	40	30	30
5	The POGIL classes has helped me improve my communication skills	60	40	0
6	I think the POGIL classes has helped me improve my teamwork skills	60	40	0

Group Work

With respect to group work students were more interested in learning in group, but it is mostly because there is no higher authority there to direct them or they are comfortable in their mother tongue as the instructor language and the students language were different. The main motivation for group learning is the language fear initially and slowly they learnt to like at the end. Group learning is a good sign but it was not reflected in the assessment results. However the above average students were keen in giving their answers before anyone else rather than engage in discussion with their group members. It shows that students have to be practiced for group work from the beginning.

Assessment

The university conducts four internal assessment tests and one end semester exam. The evaluation questions were prepared by the course handling teachers for the internal assessment tests, whereas it was prepared by the externals from other university with the help of the outcomes given in the syllabus. The internal assessment results were always

good with the students who followed POGIL classes compared to the students without POGIL. The end semester exams also had a similar statistics. However it is quite different i.e. the expected result was more due to the practices they already had during their all four internal tests. The declinining result was because in most of the cases the evaluation questions were not based on the outcome i.e. in some cases it was understood in a differet context. For example In CE course the modulation can be dealt only with respect to mathematical equations which describes the modulation in black box level or the electronics involved in modulation. The exact assessment is possible only when the course syllabus, course outcome and evaluation questions prepared by the course instructor who follows the innovative teaching learning. Hence it is very difficult to practice any kind of innovative learning in a system heavily oriented towards textbooks driven examinations.

Knowledge **Construction**

Most of the objective as well as descriptive questions were based on the knowledge construction. The statistics from the above table shows that, though it was easy for most of the students to understand the concept, applying the same to higher level was very dificult. Even within the above average class of students, they expect the instructor to feed the knowledge to them. This is only because of the attitude of the students to change from the exam pattern they were trained so far. Hence it is highly essential that, the memebrs of the education system i.e. from the management, higher level authorities, instructor to students in inquiry-based courses must show some charecteristics for the success of any innovative teaching practices including POGIL classes.

The collective students feedback can be grouped into three different categories i.e. Assessment, Group work and Knowledge construction. Always the higher learners made sure their presence by answering before their discussion with their peers. In a country like India, where the competition culture is deep rooted the idea of team work has to be improved a little bit. Knowledge construction has definitely happened and is reflected in their grades in internal assessment. Students ususally confuse between the frequency of the carrier and the imformation signal. Here they had very good long lasting effect that at any time they compared the carry bag with the carrier used in modulation. The end semester exams also had a similar statistics. However it is quite different i.e. the expected result was more due to the practices they already had during their all four internal tests. The declinining result was because in most of the cases the evaluation questions were not based on the outcome i.e. in some cases it was understood in a differet context. For example In CE course the modulation can be dealt only with respect to mathematical equations which describes the modulation in black box level or the electronics involved in modulation. The exact assessment is possible only when the course syllabus, course outcome and evaluation questions prepared by the course instructor who follows the innovative teaching learning. Hence it is very difficult to practice any kind of innovative learning in an independent assessment system.

IV. CDIO CONNECTION

In the context of this paper it is customary to describe the connection between the innovative pedagogy followed i.e. POGIL and CDIO standard. It is very simple to establish the connection with OBE as the pedagogy is the medium to achieve only the course learning outcomes. However, CDIO needs a practice based learning, which means a realistic scenario at the work place needs to be emulated. Practice does not mean P_2BL as does not involve the students in the process followed in Industries. Experiential learning can always be used to achieve this and its connectivity is established by Claire (2014) for polytechnic education. In the current Indian scenario in private universities and colleges it is very tough to follow experiential learning due to two factors i) System has not yet been matured in terms of assessment and evaluation ii) Non-availability of experienced faculty. As a complete CDIO syllabus cannot be designed in short time, it is the self-interest of the author to frame a CDIO project with the motivation from higher management, for interested students to test on pilot basis. By designing the project a part of the CDIO syllabus (standard 3) has been arrived and this CDIO project has been discussed with respect to conceive design and implement (CDI) phase.

Conceive

The conceive phase from the Instructor perspective is to design the curriculum for engineering education by engineering practice context. With respect to this, with the existing curriculum and syllabus, the number of design experiences in the complete ECE curriculum can be divided into 4 each one in the following field

- Communication Engineering
- Embedded systems
- Signal Processing
- VLSI design

The students who would like to get into research can opt for theory based courses with at least two projects during the entire program. In communication engineering field, the design project considered is “Design and implementation of community based low power FM radio Transmitter and Receiver” for Veltech University. This project can be taken by any students after completing Analog Electronics (AE), Circuit Theory (CT), CE and Antenna course. In an era of software defined radio, doing the hardware based FM Transmitter/Receiver will seems to be trivial. But in the author, point of view, if the students are strong in basics they can apply to any advanced technology that will come in future. Also, as CE course falls in the early semester not all the students will be comfortable with using the software application package or using the microprocessor for designing the radio receiver. The aim of the project is to promote the ability of the students to describe, anticipate and plan for some of the realistic factors that are encountered in an engineering project. In students point of view the project requirement or the context is to come up with the good broadcasting system for any immediate university message when there are no other advanced technologies are existing like network down time. The goals or Learning outcomes of the CDI project are derived

according to the specific objectives (standard 2) of the CDIO syllabus given by Edward (2001) and is given in table 4.

Table 4 FM Transmitter Design Learning Outcomes:

S.No	Learning Outcomes	Skills Acquired and CDIO syllabus outcomes
1	Recognize the application of the disciplinary knowledge in action	Technical (2.1)
2	Design and develop the electronics circuit and understand how the different parts of this electronics circuit function together to make an FM transmitter	Technical (4.2,4.3 and 4.4)
3	Explain ways in which critical thinking, creativity, problem-solving and experimentation are required in designing and implementing the proposed FM Transmitter/Receiver Project	Technical (2.1,2.2,2.3 and 2.4)
4	Describe the need for modules based design and hence the importance of team work	Interpersonal (3.1 and 3.2)
5	Explain the challenges faced during the design and implementation	Technical (2.4, 4.4 and 4.5)
6	Anticipate and plan for factors that are encountered in an engineering project	Team Work and Technical (3.1.3.2, 4.3 and 4.4)
7	Describe need for good documentation of designs and implementation processes	Personal (3.2 and 3.3)
8	Explain the FCC regulations for getting licensed spectrum	Interpersonal (3.2 and 3.3)
9	Realise importance of designing with quality and inherent safety with the public in mind	Interpersonal (4.1)

Design and Implement Experience (standard 5)

The team must work with realistic factors like customer requirements, government regulations on spectrum allocations and power transmission. Investigations on the customer requirement should be made by the team to arrive at the design and engineering considerations. FM transmitter Receiver is a very basic project with multiples of design availability and hence the students are encouraged to learn the design through multiple trial process. In each of the phases a set of inquiry questions in three phases as in POGIL were developed to guide the students. Conceive phase questions will make the students to critically analyse the customer requirement to go for design in abstract level. Design phase questions will make them to analyse the current design and go for a specific design in implementation phase.

Framing CDIO syllabus

The syllabus has been framed for the objectives listed in table 1. As students fail to apply the concepts they already learnt and performed well in another context, it has been decided to include part of the contents from AE, CE, and CT i.e. whichever is directly applicable in designing FM transmitter. As the Antenna course is already in 5th semester it is not repeated in the syllabus specific to CDIO. While it is necessary to give design and practice experience as per CDIO standard it is also essential to provide research based knowledge which will come only through much of theoretical understanding. Hence the outcome of the basic core courses like CE are not very much towards practice and is given below in table 3 unit wise

Table 5 Learning outcomes of CE course

1.1	Compare the performance characteristics of different amplitude modulation techniques
1.2	Derive the AM expression for the given AM transmitter and receiver system block diagram
1.3	Explain how AM superhetrodyne receiver performance is better than Tuned Radio Frequency receiver
2.1	Compare the performance characteristics of different angle modulation techniques
2.2	Derive the AM expression for the given AM s transmitter and receiver system block diagram
2.3	Explain how FM superhetrodyne receiver performance different from AM receiver
3.1	Discuss different types of noise present in the communication receivers
4.1	Compare the noise figures in different modulation system
5.1	Solve problems on source coding

V. CONCLUSION

In the first part of this paper a systematic way of developing POGIL worksheet has been addressed and its impact on students grade also has been analysed. It is found that the average and below average students were not happy with the new pedagogy followed because despite their hard work the independent examination system did not give them expected grades. In the second part a CDI project has been designed to attain specific CDI goals. CDIO syllabus has been framed through the CDI project. A similar approach can be followed to design other CDIO projects in the remaining fields like embedded system in the higher semester. Framing the syllabus is not the end; an excellent assessment process also needs to be evolved. If the assessment system for the project is also an independent evaluation system, then total CDIO process will be a catastrophic failure.

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BIOGRAPHICAL INFORMATION

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