A PROBLEM-BASED LEARNING APPROACH IN TEACHING MASK DESIGN FOR MOSFET FABRICATION

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Abstract

Problem-based learning (PBL) has been introduced at Universiti Tun Hussein Onn Malaysia (UTHM) for almost two years as a new innovative teaching method for engineering education. This paper highlights an alternative way of teaching mask design for MOSFET fabrication using PBL approach as a student centered-learning approach. The learning process has been successful using the Facts-Ideas-Learning Issues-Action Plans (FILA) chart as a PBL technique. Four groups of students have been assigned a project topic which meets the curriculum objectives and have industrial relevance. In this project, the students work independently; learning new Computer Aided Design (CAD) tools to create their own mask design using contact printing method. It is said to be a cost effective and simple technique for mask design. The students also have the opportunity to be involved "hands-on" in fabrication process of MOSFET (Metal-Oxide-Semiconductor Field Effect Transistor) where they perform the photolithography technique in order to transfer the pattern from the masks onto the wafer and hence complete the fabrication process. The fabrication process was done in UTHM Microelectronics Cleanroom. In addition, the students also prepare the presentation and the documentation of the project. The paper concludes by discussing the benefits and advantages to the students after completing the project.

Keywords: PBL; FILA chart; mask design; MOSFET fabrication

1. Introduction

Problem based learning (PBL) method has been applied widely by the higher learning institutions all over the world such as McMaster University, Harvard University, University of Manchester, National University of Singapore and Aalborg University. In Malaysia, Universiti Malaya, Universiti Islam Antarabangsa Malaysia, Universiti Sains Malaysia and Universiti Teknologi MARA have used this method especially in medical field. As for Universiti Tun Hussein Onn Malaysia (UTHM), this method has been applied in teaching and learning in the field of engineering and technology.

PBL already widely known may be defined differently. However, it is basically a problem solving skill which requires students to do and be active [1]. It is a learning approach that is most commonly constructed around a series of problems selected by a lecturer [2]. At UTHM, PBL was successfully introduced two years ago as a new innovative approach to teaching and learning and it has been widely applied in various disciplines, including engineering and technology. The PBL approaches to teaching in the engineering discipline include, but are not limited to, the following characteristics [2]:

i. Using stimulus material to help students discuss an important engineering problem, design task or issue,
ii. Presenting the problem as a simulation of professional industry practice or a real life workplace situation,
iii. Guiding engineering students to utilize critical thinking and direct and/or providing limited resources to help them solve the problem,
iv. Getting students to cooperatively work in a team to complement each others work, not compete with one another, in an environment where they have access to a lecturer who facilitates the groups learning process,
v. Getting students to identify their own learning needs and developing their information literacy skills to locate, evaluate and manage resources that are useful to help them solve engineering problems,
vi. Self-assessment to evaluate their learning process

In Microelectronics, subject teaching mask design for MOSFET fabrication is quite a challenge. The students have to master the fundamental theories before they get personally involve in a laboratory session where they are working on fabrication

process of MOSFET via UTHM Microelectronics Cleanroom.

In this paper, the authors highlight an alternative way of teaching mask design for MOSFET fabrication using PBL approach as students centered-learning.

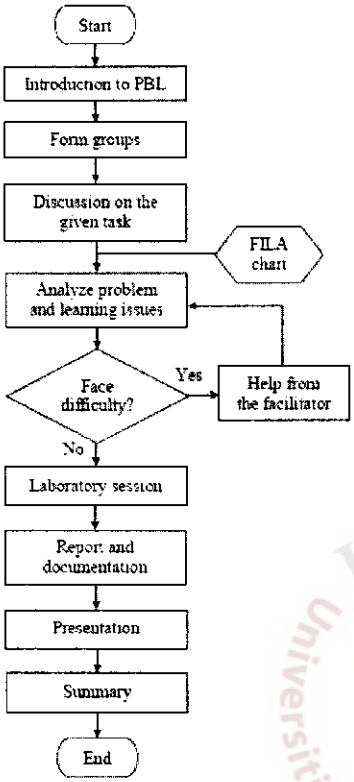

Fig. 1. The process of PBL.

2. PBL Implementation

2.1. PBL Process

The idea of PBL in this particular topic is the concept of student centered-learning where they personally perform the self directed-learning for a given task. The process of PBL applied in this topic is shown in Fig. 1.

The process starts with an explanation about PBL itself from the facilitator. Then, students are instructed to form group of six with a total of four groups all together. Once they are in one group, self directed-learning begins. They themselves will conduct the discussions on the given task, analyze problems and issues, and here they will fill up the Facts-Ideas-Learning Issues-Action Plan (FILA) chart in order to get to the solutions.

If they face any difficulty along the process, they are very much welcome to ask any questions to the facilitator. Then, they will continue to start the laboratory session where they are involved hands-on directly. The laboratory took place at UTHM Microelectronics Cleanroom. After they run the session, they will prepare the report and document the project. At the end, the group will present their findings and work where it should comprise of all subject's requirement as stated in the syllabus. Lastly, the facilitator will come out with the summary, give feedback on the PBL process, request the students to reflect on their solution, explain the problem, and assess their work and commitment throughout the learning process.

2.1. PBL Technique

The technique used in this PBL process is the FILA chart. It has been introduced by the National University of Singapore to facilitate students in teaching and teaming sessions. It is used widely in all field to generate students skill in effective communication, creative and analytical thinking, deep understanding, leadership and teamwork or independently.

Table 1 shows the standard FILA chart that is used in the PBL session especially during group discussions. It is created to list out all the facts in the problem, ideas to manage the problem, learning issues in order to manage the problem and action plan in seeking information.

Table 1. Standard FILA chart

Facts	Ideas	Learning Issues	Action Plan
Facts in the problems	Ideas to manage problem	Learning issues in order to manage problems	Action in seeking information

As guidelines for facilitators, they have to fill up the FILA chart and discuss among themselves before giving out the project to the students. These will help the facilitators while conducting the PBL sessions. The FILA chart does not end here; it will fill up again as regular discussions are made along the PBL process.

3. The development of mask design for MOSFET fabrication - An example of PBL

The goal of the project was the development of a mask design for MOSFET fabrication. Such masks are required in order to form a certain pattern on the wafer surface in the fabrication process. Masks are used to protect parts of the wafer from the high intensity UV light that will remove the photoresist coated earlier. Different masks are used when creating each of the different structures on the wafer.

It was designed and created using an AutoCAD software and printed onto the transparency films. There are four masks used in the fabrication process; diffusion mask to define source and drain region, gate mask to define gate region, contact mask for creating contact hole ,and metal mask to create the metal contact.

The student groups started the project with basic knowledge in MOS transistor theory, CMOS processing technology, Lithography technique, Modu-Lab Trainer series of semiconductor processing modules and had to study the AutoCAD software to create their own mask design using contact printing method. Accompanying courses were on IC Design, Cleanroom Technology, Electrical Characterization and Performance Estimation. One of the students served as a group leader and another as a secretary and is responsible for scheduling, reporting project progress, presentating, and organizing regular project meetings with the facilitators. In addition, the student team gained valuable experience in project management and teamwork, acquiring technical knowledge in microelectronics.

The project is completed in ten three-hour laboratory periods by students working in groups of six with high motivation and improvement in their performance. It involved "hands-on" fabrication process of MOSFET where the students perform the photolithography technique in order to transfer the pattern from the masks onto the wafer and hence complete the fabrication process. It is said to be a cost effective and simple technique for mask design. The project topic that has been assigned meets the curriculum objectives and has industrial relevance.

4. Conclusion

Throughout the learning process of PBL, the students learn how to handle problems found in real-world projects via UTHM Microelectronics Cleanroom that is equipped with semiconductor processing modules that similar to "real" semiconductor fab lab in the industry. Thus, this gives the students a greater appreciation for the delicacy, precision, and complexity of the process. In addition to the technical skills learned in the process of completing the project, students learn how to work as a team, develop self-directed learning strategies, manage time and resources, and present the results of their work in oral and written form.

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