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Research Article

Applying Project Based Learning to Flipped Bloom Taxonomy for Deep Understanding in Control Systems

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Abstract

The peculiar nature of control theory as a course that cut across a lot of major engineering disciplines calls for a look into how its learning can best be done without students feeling like they are wasting their time. This paper takes a look at control theory as subject cut across various engineering field and has a wide background that students must really be comfortable with. Its wide application and background pose a huge challenge to the teaching of control. It goes further to look into traditional method of teaching, Project Based Learning Blooms Taxonomy. It then proposes applying flipped Bloom Taxonomy to Project-based learning for a deep understanding of control systems.

Keywords: Engineering education; Flipped bloom taxonomy; Control sytems; Project based learning

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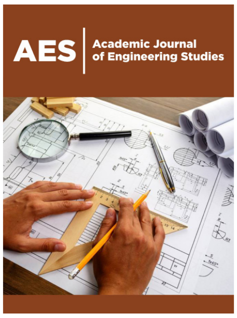

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Introduction

A lot of economies around the world have transited to information and service based on the traditional industry base. Solution to multidisciplinary problems are often responsible for this shift. However, for a seamless transition to happen, there is a high demand for deep learning to happen in university education Goel [1]. While Ahmadi [2] are of the opinion that 21st century competencies are deeply entrenched in creativity, Yasin [3] believes that creativity is better fostered through PBL and POPBL. The learning of important and complex concepts and theories like control system often pose a challenge to students.

Traditional Way of Teaching Control

The traditional way of teaching control is structured as follows:

1) The theoretical part including mathematical modelling, Laplace transform, transfer function, frequency response stability analysis etc. were first covered.

2) The necessary backgrounds were covered, laying the foundation for subsequent more rigorous control topics.

3) Few or no SIMULINK Simulators prepared by instructors are then used by students.

4) It should be noted that the simulators do not give an actual 'live' experience because simulations run in a very short period of time.

5) Laboratory experiments that cover a limited area of study were carried out by students in a laboratory with few stations.

According to the assessment carried out by Haugen [4] they identified the following problems with this traditional approach:

1) The mathematics involved makes the course very demanding.

2) Basic foundational principles are difficult to understand because the theory involved have obscured understanding.

3) Some theoretical topics may not be necessary because they are not applied in practical implementation

4) Few stations available for running multiple laboratory exercises

5) Limited time to exhaust curriculum content.

Other than the problems identified by Haugen [4], Zenger [5] also identified:

1) Lack of motivation

2) Poor background in mathematics and

3) The wide area of application of control systems as shown in (Figure 1).

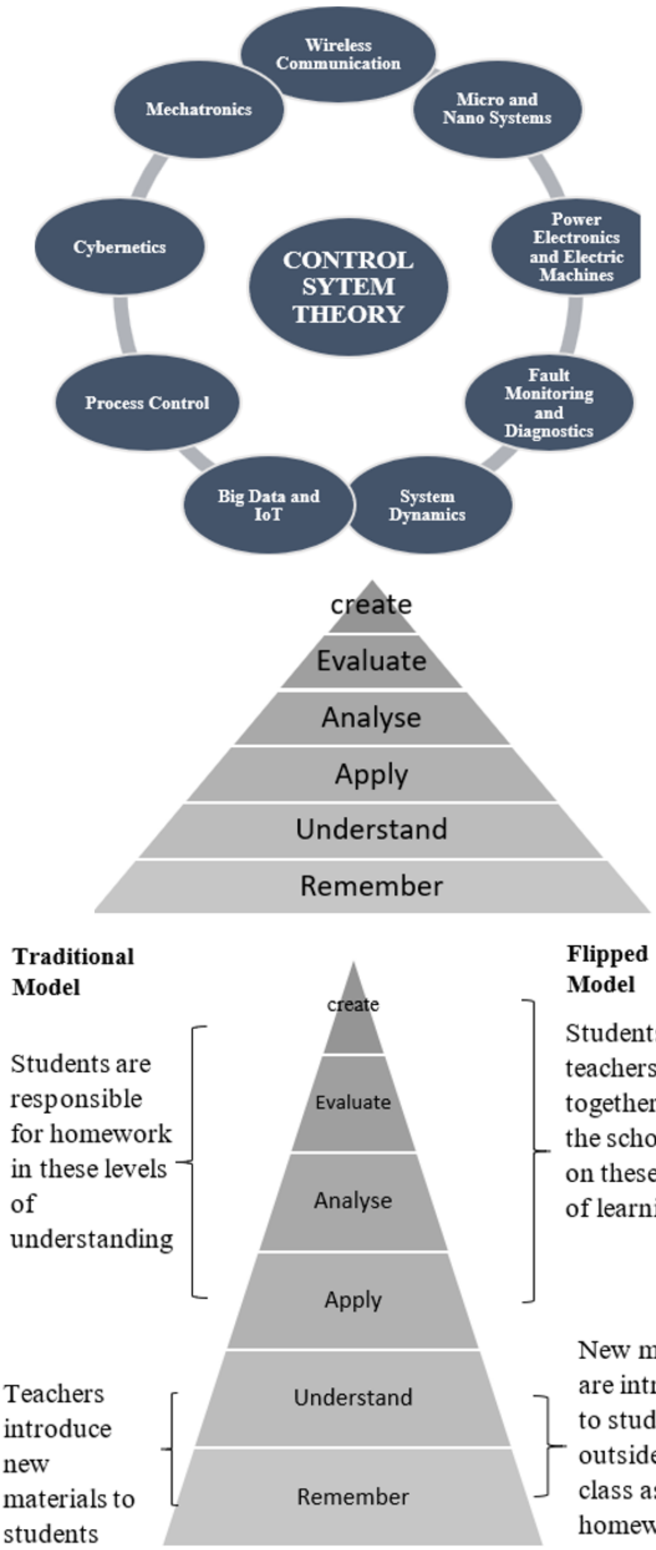

Figure1: Hierarchical relationship among levels.

Teaching Objectives

Deep learning and innovative problem-solving skills are required of the 21st century engineers Juuso [6]. listed three key areas that would make this possible: theory, implementation and application. While a strong theoretical understanding gives a firm foundation for the other two fields, if students know the context of the topics and the connections to other engineering topics. In other words, if students recognize what they are studying, why they are studying and the significance of the course, then students' need for relatedness to their professional community increase their intrinsic motivation to study. Gero [7] Implementation is another key area beside theoretical concepts. Implementation is mostly done by computers these days which make coding language vital. The last essential part of knowledge is the proper application of learnt concepts in real-life problems. Gero et al. [7] indicated that their students felt that the use of real-life scenario was interesting and contributed to desire to persevere in learning and also helped in improving their programming skills.

The teaching goals identified by Juuso [6] are:

1) profound background information,

2) deep understanding of theoretical concepts, tools for implementing the solutions, and

3) tools for applying course topics to real-life problems.

Project Based Learning and Other Inductive Approaches

The approach normally used for instructing engineering students is mostly deductive. It graduates from general principle to specific applications. The instructor would start by teaching students the foundational materials that has to do with principles, theories, mathematical methods, and historical approaches. He later gives assignments which students must practice with; and later or much later start talking about applications. The problem with this approach is that it is not the natural way people attain and retain new knowledge and skills. Rather, people face the problem head on using residual knowledge; acknowledging more knowledge is needed, they acquire by reading, enquiring or observing the solution of similar problems and then practicing the newly acquired knowledge or skill repeatedly on the problem. People are more motivated to learn most effectively when they there is a clear need to know rather than having the need to know after four or five years. Thus, teaching students inductively is a better alternative deductive approach. A lot of variations to this approach have emerged over the years, these include problem-based learning, inquiry-based learning, discovery learning, need-to-know learning, and just-in-time learning. Felder [8]. PBL works [9] define Project Based Learning as ''a systematic teaching method that engages students in learning essential knowledge and life-enhancing skills through an extended, student-influenced inquiry process structured around complex, authentic questions and carefully designed products and tasks".

This definition is in agreement with the steps listed by Felder [8] in the following order:

1) Define the problem.

2) Build hypotheses to initiate the solution process.

3) Identify what is known, what must be determined, and what to do.

4) Generate possible solutions and decide on the best one.

5) Complete the best solution, test it, and either accept it or reject it and go back to Step 4.

6) Reflect on lessons learned.

Ríos [10] describe PBL as the most suitable approach to engineering education. It develops competencies, linked teaching with specialized practice. The learning scheme is based on teamwork, active participation and collaboration, providing different possibilities for developing technical, contextual and behavioral competences. Noordin [11] also concluded that engineering students who undergo the PjBL approach will have a clear picture of what an engineer does in the workforce and directly motivates them to learn 21st century skills that are required by today's industries. These methods are initially less comfortable for instructors than straightforward deductive presentation of material, and they can at first be distressing to students, who may not appreciate having to deal with problems they have not been taught to solve beforehand. Since induction is how people learn, however, the students taught this way are likely to end up with a much greater mastery of the knowledge and skills the instructor wishes to impart.

Bloom Taxonomy

In 1956 Benjamin Bloom classified levels of intellectual behavior in learning. His intent was to develop a framework for writing educational objectives.

Bloom's taxonomy has 11 levels, which are categorized in the following three different domains:

1) Cognitive - Skills in this domain are related to the way people recall knowledge, comprehend, and critically think about a particular topic. The six levels of this domain are knowledge, comprehension, application, analysis, evaluation, and synthesis.

2) Affective - Skills in this domain are related to the way people emotionally react about another living been pain or joy. The five levels of this domain are receiving, responding, valuing, organizing, and characterizing

3) Psycho-motor - Skills in this domain are related to the way people manipulate tools or instruments (such as hand or hammer). Benjamin Bloom never designed levels for this category. Some researchers have proposed levels for such domain, but there is no consensus about the usefulness of their proposed levels.

The cognitive domain has received more attention from Benjamin Bloom and consequently it has been applied the most by educators. The description of the revised model given by bloom's taxonomy revised [12] is shown in [Table 1]. There is a hierarchical relationship between the above- discussed levels (Figure 1); the higher the level, the bigger is the complexity inherent to the level. Thus, the learning process must start from the remember level and incrementally progress to the create level.

Table 1: Revised Bloom Taxonomy levels and description.

Levels	Description
Remember	Retrieving recognizing and recalling relevant knowledge from long term memory
Understand	Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying and explaining.
Apply	Carrying out or using a procedure through executing or implementing. Using information in another familiar situation
Analyze	Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose trough differentiating, organizing and attributing
Evaluate	Making judgements based on criteria and standards through checking and critiquing. This includes justifying a decision or course of action.
Create	Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning or producing. This includes generating new ideas, products and ways of viewing thing

Flipped Bloom Taxonomy

A typical engineering curriculum gives the student much practice in the lower levels of 'remember', 'understand' and 'apply'. Students receive less practice in the higher levels of 'analyze', 'evaluate' and 'create'. The lower levels require less in the way of thinking skills. As one moves down the hierarchy, the activities require higher level thinking skills. The higher-level thinking skills will enable the students to succeed in the competitive, international, engineering environment. Moreover, unless students can be brought to the higher levels of analysis, synthesis, and evaluation, it is unlikely that most students will be able to transfer material learned in the classroom to real life situations. They may not even be able to apply it to school situations other than the one in which it was "learned." The inability to transfer classroom learning to real situations is most apparent when students are confronted by an open ended design. If they do not know in advance which set of formulas or algorithm to apply and what assumptions should be made, even high achieving students struggle to create realistic models of the situation. Often students attempt to force fit any given data into dimly remembered equations. Reality learning can change this situation. Farris [13].

Flipped learning is another method of blended learning that use technology to stimulate learning in a classroom, this is to enable the teacher to have more time to interact with students rather than lecture them on theories. In addition to this, further support is received from their peers about the activities that they are performing and what they do not yet understand. Ouda [14]. Flipped learning is a new approach of conducting learning process in which a student's homework is the customary practice that is viewed in class. Class time will now be dedicated for inquiry-based learning which would comprise what would usually be viewed as a student's homework assignment. When the student revises previously done work, he broaches different areas than those approached in class. So, with that preparatory work at home, he would work the first three areas (remember, understand, apply), while in the classroom more complex levels would be exercised (analyze, evaluate and create). For teachers, relying on bloom taxonomy allows them to establish specific targets according to which areas they wish to address or enhance, as well as outlining a learning plan that allows each student to move forward from the base to the top of the pyramid. The teacher becomes a guide in the learning process while the student becomes the center of it, necessarily taking an active role. Real influencers [15].

Applying Bloom's revised taxonomy to flipped learning, students are doing the lower levels of cognitive work (remembering and understanding) outside of class, and focusing on the higher types of cognitive work (applying, analyzing, evaluating, and creating) in class, where they have the encouragement of their peers and instructor Brame [16]. The flipped sitting permits a student to attain a substantial basis of a topic, the understanding, before a session, in order that other activities, assessments and consolidation activities can build on the developing the higher skills when a teacher is present to support the student. This can be compared to the traditional method of teaching where the basic level skills are often the center of attention of classroom sessions and students are left to work on the higher levels skills in their own time with homework and additional exercises Ouda [14].

Conclusion

The importance of control system is so diverse that it cannot be limited to engineering. For instance, it is profoundly fundamental in nature, human social and political organization as well as in science and philosophy of science Suryadi [17]. If we limit our focus to within engineering, it is everywhere as far as technology is concerned. Aircraft and spacecraft, process plants and factories, homes and buildings, automobiles and trains, cellular telephones and networks all these lay testaments to the ubiquitous nature of control system. Several years of successful applications have hardly exhausted the potential or vitality of the field. The number and size of control conferences and journals continue to grow, new societal imperatives highlight the importance of control, and investments in control technology and technologists are taking place in old and new industrial sectors.

Control is not only considered instrumental for evolutionary improvements in today's products, solutions, and systems; it is also considered a fundamental enabling technology for realizing future visions and ambitions in emerging areas such as biomedicine, renewable energy, and critical infrastructures. Samad [18]. If we are to produce 21st solution providers, students of control theory must be properly thought. They must be motivated as well as know what to expect in the industry. They should be able to tackle challenges with creativity and ingenuity. Teaching control systems has to evolve and must not be left to ineffective teaching methods. For these to happen, students have to spend more time in the first four levels of the flipped bloom taxonomy. The 'create', 'evaluate' 'analyze' and 'apply' present the proper platform for the use of PBL. When a problem is presented, teachers can help breakdown the project into modules and theories student need to learn to solve the problem. This way students do not only learn the necessary theories needed but also come up with ways of solving similar problems and projects creatively.

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