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REVIEW

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

Gbenga Bankole Folayan* Ibrahim Ademiloye

Department of Electrical Electronic Engineering, The Federal Polytechnic Ado-Ekiti

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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. .

1. Introduction

A lot of economies around the world have transited to information and service based from 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 [1]. While [2] are of the opinion that 21st century competencies are deeply entrenched in creativity, [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.

2. Traditional Way of Teaching Control

The teaching of control is traditionally 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 [4], they identified the following problems with this traditional ap-

**Corresponding Author:*
Gbenga Bankole Folayan,
Department of Electrical Electronic Engineering, The Federal Polytechnic Ado-Ekiti;
Email: nattygbengu@gmail.com

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proach:

(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 [4,5] 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.

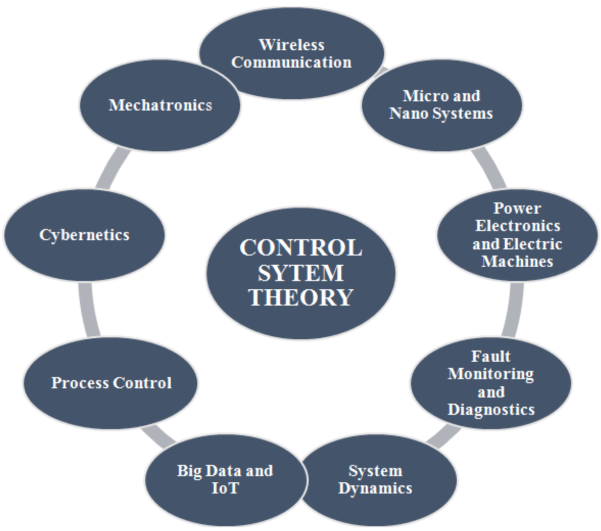

Figure 1. The wide area of application of control systems

3. Teaching Objectives

Deep learning and innovative problem solving skills are required of the 21st century engineers. [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 understand the topics and how they are related, their importance and how they can impact on the development of technology, then students interest in relating to their professional responsibilities increases their motivation for deep understanding in control [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. [7] indicated that their students felt that using real life scenario was not only interesting but also contributed to desire to persevere in learning and also helped in improving their programming skills.

The teaching goals identified by [6] are:

(1) deep background information,

(2) proper theoretical concept understanding,

(3) necessary tools for effecting solutions, and

(4) means of implementing course topics in real-life problems.

4. 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 have to practice with; and later or much later start talking about applications.

The problem with this method of approach is in the fact that it isn't the natural way people attain and retain new knowledge, skills and expertise. Instead, 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 understand that there is an immediate 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 just-in-time learning, problem-based learning, need-to-know learning, discovery learning, and inquiry-based learning. [8]

[9] defines Project Based Learning as "a teaching method that seeks the participation of students in learning necessary and life-improving skills through a broad, student-based inquiry process designed around difficult, authentic questions and carefully designed products and tasks".

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

(1) Problem definition.

(2) Develop hypotheses to start the process of solution.

(3) Identify the known, what to be obtained, and what

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to do.

(4) Come up with various solutions and decide on the best approach.

(5) implement the best solution decided on, test it out, take it or leave it and go back to Step 4.

(6) Reflect on lessons learned.

[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 team work, active participation and collaboration, providing different possibilities for developing technical, contextual and behavioral competences. [11] also concluded that engineering students who were taught using the PjBL approach would have a clearer picture and outlook of what an engineer is supposed to do in the workforce and directly or indirectly motivates them to study, learn and acquire the necessary 21st century skills and expertise that are essential and required by today's industries.

Obviously, straightforward deductive approach to teaching are more comfortable for instructors and student than the deductive presentation of materials. This is so for students who dread problems they have not being taught to deal with before. However, since induction is the natural way people learn, students taught this way have a better chance of mastery of knowledge and skills the instructor wishes to pass across.

5. Bloom Taxonomy

In 1956 Benjamin Bloom classified intellectual behavior in learning into levels. His objective was to advance a framework for presenting educational objectives. Bloom's taxonomy has 11 levels, which are categorized into three domains:

(1) Cognitive - this domain has skills related to how knowledge is recalled, comprehended and critically process a topic. This domain has six levels namely: Knowledge, comprehension, application, analysis, evaluation and synthesis.

(2) Affective - the way people emotionally react to other living being dominates this domain. The five levels include receiving, responding, valuing, organizing and characterizing

(3) Psycho-motor - Skills in this domain are linked to the manner in which people handle tools or appliances (such as screw driver or spanner). There were no levels designed for this level. Some levels were proposed for the domain by some researchers but there is no agreement about their usefulness.

Of all the domains, the cognitive domain received more devotion from Benjamin Bloom. It is therefore no surprise that it is the one applied the most by educators. The description of the revised model given by [12] is shown in table 1

Table 1. Revised Bloom Taxonomy levels and description [12]

Levels	Description
Remember	Relevant knowledge are recognized, retrieved and recalled from long term memory
Understand	Significant meaning from written oral and graphic messages are created through exemplifying interpreting, classifying and explaining.
Apply	Procedures are carried out by implementing or executing. Information gathered is used in another similar scenario.
Analyze	Materials are being broken into parts, how the broken parts relate to each other as well as the overall structure and purpose by differentiating, attributing and organizing is understood.
Evaluate	Judgements are made based on standards and criteria by checking and appraising. This involves justifying a decision or course of action.
Create	Assembling components together in order to form a coherent or working whole; putting elements into a new structure and pattern by through creating, planning or constructing. This involves coming up with new ideas, products and various ways of seeing things

The relationship between these levels are hierarchical in nature as shown in Figure 2. Higher levels are linked to higher complexity. Therefore, the learning process should proceed from the first (remember) level and gradually progress to the create level.

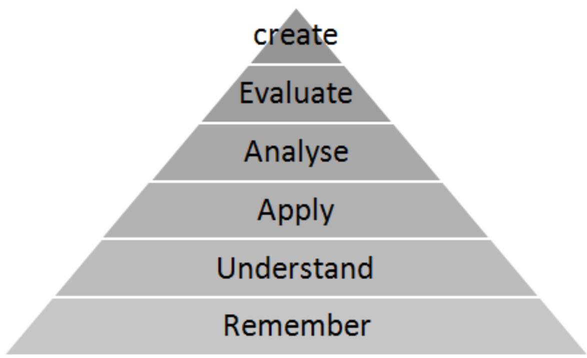

Figure 2. Hierarchical relationship among levels

6. Flipped Bloom Taxonomy

A usual engineering curriculum is dedicated to giving more time and practice in the lower levels of "remember", "understand" and "apply". Less time is giving to students to practice in the higher levels of "analyze", "evaluate" and "create". Not much is required as far as thinking skills are concerned in the lower level. However as one moves higher in the hierarchy, higher thinking skills are required in the activities involved. Higher thinking skills provide students with the arsenal to succeed in demanding and in-

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ternational engineering environment. More so, if students cannot be brought to higher levels of "analyze", "evaluate" and "create" it is very likely they will not be able to transfer what they have learnt to other situation presented in school talk less of real life scenarios. When open ended designs are presented to students, their inability to transfer classroom learning becomes evident. If student do not know in advance which set of algorithms and formulas to use and what set of assumptions could 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 [13].

Flipped learning is another method of blended learning that use technology to stimulate learning in a classroom, this is to enable the teacher 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 don't yet understand [14]. Flipped learning uses a different approach of carrying out a learning process in which a student's homework is the customary practice that is worked on in class. Class time will basically be dedicated to inquiry-based learning which actually comprise what would normally be seen as a student's homework task. When the students go through the work they've done before, he looks at other areas than those worked on in class. So, with the preliminary work done at home, he would have worked on the first three levels (remember, understand, apply), meanwhile in the classroom, the more difficult levels would be practiced (analyze, evaluate and create). For teachers, using on bloom taxonomy permits them to create specific objectives in relation to which areas they want addressed or enhanced, as well as stating a learning organization that help each student to progress - from the bottom to the top of the pyramid. The instructor merely becomes a guide in the learning process while the student becomes the focus of attention, necessarily taking an active role [15].

Applying Bloom's revised taxonomy to flipped learning, students majorly work on the lower levels of cognitive work (remembering and understanding) on their own, and concentrating on the upper levels of cognitive work (applying, analyzing, evaluating, and creating) in the classroom, where they can be encouraged by their classmates and teachers [16]. The flipped idea allows a student to attain or understand the essential part 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 is comparable to the traditional method of teaching where the lower level skills are often the center of attention of classroom activities while students are left to work on the higher levels skills in their own time with homework and additional exercises [14].

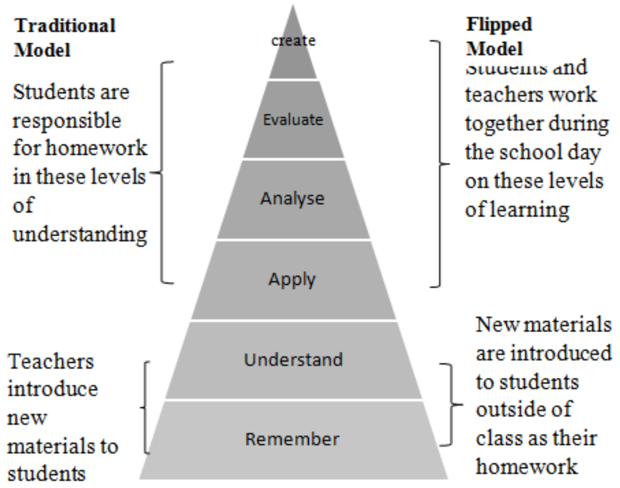

Figure 3. Flipped Blooms taxonomy model

7. 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 [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 testament to the ubiquitous nature of control system. many years of several successful applications have hardly drained the potential or importance 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 seen as useful for evolutionary advances in today's good, products, systems and solutions; 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 [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

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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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