Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 10, October-2020

Curriculum Reform based on Outcome-based Education System-the Case for the Course "Control Systems."

Yohannes Hailemeskel Desta
Tianjin University of Technology and Education

Shi Lianshuan
Tianjin University of Technology and Education

Abstract: **In this paper, based on the implementation framework of outcome-based education (OBE) system, the teaching learning process of the course 'control systems' in our institute is reformed. Three outcomes at the course level has been identified: ability to establish goals and variables to be controlled and specification; ability to define and modeling systems; and ability to design, simulate and analysis a controller. Then all the teaching and learning processes are carried out aiming at the realization of these three learning outcomes to be demonstrated by the students**

Keywords: Learning outcomes; teaching reform; control systems; outcome-based education

INTRODUCTION

Outcome-based education first appeared in basic teaching in the United States in 1970s and got popular in 1990s and getting its way in many countries such as Australia (Kerka, 1998). It is an educational system that primarily focus on the product or result of an education system (Killen, 2001). The most detailed articulation of the theory underpinning OBE is given in Spady (1994). Spady describes OBE as follows: "Outcome-Based Education means clearly focusing and organizing everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences. This means starting with a clear picture of what is important for students to be able to do, then organizing the curriculum, instruction, and assessment to make sure this learning ultimately happens" (Spady, 1994:1). Thus, OBE is used to describe the knowledge, skills, quality and personality that students should have when they graduate, that is, what they know, what they can do, what behaviors and principles they have developed and thus be demonstrated and manifested by them. The main theoretical basis of OBE education mode is Taylor movement, mastery learning theory, competency based vocational education theory and standard reference learning. OBE is a teaching activity with students as the main body and learning output as the center. Through summative and formative evaluation, OBE pays attention to the consistency between students' need and teaching plan. The theory and practice of OBE is basically the center and focus of the Education and Training Policy (MoE,1994) of Ethiopia, which takes education as the basic requirement of education for work and students as the main body.

A country wide movement has been started since the formulation of the policy to carry out teaching reform based on OBE framework in Ethiopia especially in technical and vocational education and training (TVET) institutes. Federal Technical and Vocational Education and Training Institute (FTVETI) was established in 2011 by the Council of Ministers Proclamation 245/2011 to produce highly professional and technically efficient TVET teachers and leaders based on the outcome-based system and occupational standards (FTVETI, web site). Our institute having OBE at its core, thus formulates for TVET teachers the training plan of electrical engineering talents, determines the learning output of electrical engineering talents, optimizes the curriculum settings. Among universities Adama Science and Technology University (ASTU) puts forward the initiative of OBE based engineering education mode, focusing on the cultivation of students' system engineering technology ability, project organization, design, development and implementation ability (Likisa, 2018).

This paper puts forward the viewpoint of paying attention to learning output and students' development in OBE system, and restructure the course "control system" based on OBE theory and practice. On the basis of studying and implementing the OBE concept, taking lessons from the teaching reform experience of colleges and universities at home and abroad, and according to the orientation of control and automation major in our institute, the author studies the teaching reform of "control system" course based on OBE from three aspects: the determination of course learning outcome/objectives (CLO), the development of teaching activities and teaching evaluation. It mainly achieves the following three points: First formulating CLO for the course of "control system" of automation major in our institute. Then according to the expected curriculum output, adopting various teaching methods to carry out the teaching activities of the curriculum, especially pay attention to the application of problem-based teaching method and team work, and let students evaluate their learning output in real time during the implementation of the curriculum, and then adjust the activities of teaching and learning at the student level. Finally evaluating the students' actual CLO by using various evaluation methods. Making the course evaluation both "prospective" and "retrospective", and pays attention to the evaluation of students' understanding and application of methods, domain and cognitive knowledge.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 10, October-2020

OBE SYSTEM CONCEPT AND DESIGN

According to the OBE education concept, the best way to learn is to set goals first, and then carry out various learning activities around to realize the goals (Rahim, 2010). In order to ensure the successful implementation of OBE, OBE can be divided into the following parts: program educational objectives (PEO), program outputs (PO) and course learning objectives/outcomes (CLO). The process of OBE followed a top-down designing process and bottom-up evaluation process (Felder etal., 2003; Dargham etal.,2013) as shown in Figure 1. In the design stage, firstly, the school sets the education goal of PEO according to the school mission and vision, the school characteristics and resources, manpower demand of the industry, engineering talent training standards, etc. PEO should also mapped into the country's educational policy (Kamal 2009). Secondly, the PEO are subdivided into multiple executable POs; finally, the PO are subdivided into CLO of multiple courses, and the CLO-PO matching matrix is designed. In the evaluation process, according to the proportion of required courses in the profession and the CLO-PO matching matrix, the evaluation results of PO are obtained from the program outcome (PO) assessment matrix, and then the evaluation results of PEO are obtained according to the evaluation results of multiple PO. CLO are located at the bottom of the whole OBE system, and the realization of CLO are ultimately attributed to the realization of PLO in many courses. It should be noted that the CLO of each course can realize at least one PO. The more PO the course can realize, the better the effect of the course in the whole OBE, and the higher the importance of the course in the whole education system.

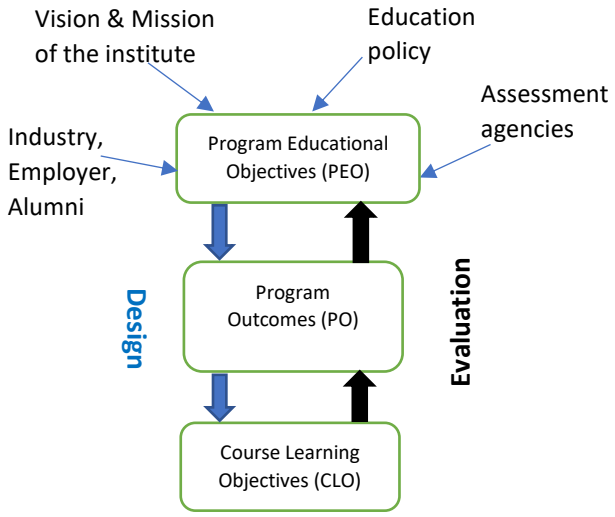

Figure 1 Process of OBE

In OBE system, designing and implementing a course is a dynamic process, as shown in Figure 2 with placing students at the center. The teaching of the course mainly focuses on three aspects: first determining the output of the course, i.e. the expected output to be demonstrated after the completion of the course; second focusing on the realization of the expected output of the course, selecting diversified teaching methods to carry out the teaching activities, i.e. teaching to generate the desired outcome; finally conducting course evaluation to identify the gap between the desired outcome and the actual output of the course and then accordingly improve the desired outcome and made some modification on the methodology. The cycle continues.

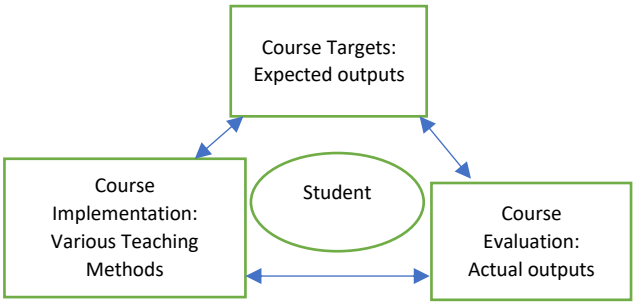

Figure 2 Teaching of automatic control system based on OBE

In Figure 2, there is feedback between every two links. For example, the curriculum goal determines the method of curriculum implementation, which in turn affects the setting of expected output of the curriculum; curriculum evaluation is based on the behavior and performance of students in each link of curriculum implementation, and the evaluation results in turn affect the method of curriculum implementation and students' performance behavior. In the course of teaching, based on the principle of negative feedback, each link tries to reduce the difference between the actual output and the expected output of the course. In this way, the actual output of the students will be close to or equal to the expected output.

1. Designing Courses

There are many text books and reference materials that set the purpose of control system theory and practice in general. Chen (1993), in his book, said that the ultimate goal of control engineering is to design and build real physical systems to perform given tasks. The purpose of the course "control systems" is to train students to think about problems from the perspective of system and overall situation, so that students can master the essence of control theory and the methods of system analysis and research. "Control systems" is also a course based on methodology, which teaches a set of methodology involving information circulation, system theory and control thought, and can train students in logical thinking. The main task of the course is to focus on the three aspects: establishment of system mathematical model, analysis of system performance index and modification of the system. The course learning outcomes (CLO) of the course "control systems" is shown in Table 1. Different types of systems have different mathematical models. For example, the mathematical model of SISO (single input single output) continuous system has differential equation, transfer function, structure diagram and signal flow diagram, while the mathematical model of multi input multi output continuous system is state space expression. The performance index of the system includes stability, accuracy and rapidity. The performance index analysis methods of different types of systems are also different. For SISO continuous system, the time domain method, root locus method and frequency method are used, while for MIMO continuous system, the state space method is used. When the

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 10, October-2020

system is calibrated, if the system is SISO system, the output feedback is used, and for MIMO system, the state feedback method is used.

Table 1 Course learning outcome of "control systems"

Course learning output	Specific description
CLO1 Establishing of goals & variables to be controlled and write specifications	- Establishing the control goals - Identifying the variables to be controlled - Writing specifications
CLO2 Defining and modeling systems	- Establish system configuration - Model the process, actuator & sensor
CLO3 Design a controller, simulate and analyze	- Describe a controller and select key parameters - Optimize the parameters & analyze the performance

2. INSTRUCTIONAL METHODS

OBE teaching mode emphasizes the abilities that students should have when they graduate. For example, ABET accreditation system of American engineering education has formulated 11 abilities or learning outcomes for engineering graduates. Therefore, the teaching activities should focus on the realization of these specified learning outcomes by making students to actively engaged in the teaching and learning activities (Felder & Brent, 2003). According to Edgar Dale's "learning pyramid" theory, the more students participate in teaching activities and practice, the deeper their memory and understanding of knowledge will be (Master, 2013). In teaching activities, according to the different characteristics of students, we choose various teaching methods, especially the application of problem-based learning (PBL) and cooperative learning (CL) (Felder & Brent, 2003). For example, the PBL teaching method is adopted around the problems of different levels of "disk drive reading system": qualitative analysis, modeling and quantitative analysis (Dorf & Bishop, 2011). It takes solving real-world problems as the learning activity, pays attention to the training of students' thinking methods and abilities, and emphasizes the ability of students' independent learning and problem solving. In CL teaching method, students are required to complete a task or product in the way of team or group cooperation with the completion of real projects as the learning activity, emphasizing student-centered, interdisciplinary, collaborative learning and independent learning.

Lemu & etal. (2012) in their study on need assessment of mechatronics education they identified that companies, in general, seem to underestimate theoretical knowledge and give less emphasis on skills in application of mathematical tools and laws of physics, while concurrently they demand the innovative approach and skills that need training. To train these skills they suggested a project-based teaching and problem solving in a team with clear distribution of tasks and responsibility.

The teaching content of the course is organized based on methodology that is suitable for the implementation of PBL and CL. The main contents of the course are "qualitative analysis of the system - quantitative analysis of the system - redesign of the system". The bridge between qualitative analysis and quantitative analysis of the system is built with the help of mathematical model. Four methods of system performance analysis are given through comparison and analogy, namely, immediate domain method, root locus method, frequency domain method and state space analysis method. From the relationship between system performance and system parameters, the measures to improve system performance are analyzed, and then the transition from system performance analysis to system redesign is completed (Dorf & Bishop, 2011).

In the first teaching of the course, introduce to the students the three course learning outputs of the course, the matching matrix between the course learning outputs and the professional or the program outputs, and the logical relationship between the teaching contents, so that the students can carry out the course learning around the outputs in the whole course learning process. If students know really the learning output or outcome, they work hard for the realization of the outputs and actively participate in learning for the implementation the learning outcomes and extending the depth and width of the course in general. In this way, in the process of teaching activities, students always evaluate their own learning, and compare with the expected output. According to the comparison results, students can adjust their learning methods or make suggestions on the teaching process of the course, forming a good dynamic adjustment process.

3. INSTRUCTIONAL ASSESSMENT

Assessment is required to help universities and educational faculties to identify and verify whether they met or not their educational objectives.

In OBE system, in order to achieve the continuous improvement of teaching quality, it is necessary to evaluate the implementation effect of the course. At the end of the course, it is necessary to use a variety of evaluation methods to assess the actual course output of students. The more the methods of curriculum evaluation, the more the evaluation results can truly reflect the actual output of students.

For the course of "control system", formative evaluation and summative evaluation are used to evaluate students' course output. The proportion of formative evaluation is 40%, the proportion of summative evaluation is 60%. The evaluation goal of the course is that at least 50% of students complete the course with the lowest score of 65 (Kamal, 2009).

Formative evaluation focuses on the evaluation of students' learning process, which is a "forward-looking" evaluation. In the course of curriculum implementation, according to the completion of students' homework, group learning effect, classroom performance, experiment development and experiment report completion, formative evaluation is carried out for students, and the course teaching is constantly improved and improved according to the evaluation results.

The summative evaluation is a "retrospective" evaluation, which is used to evaluate the degree and ability level of students' mastering knowledge and skills after the end of the course, and is carried out through the final examination.

Krathwohl (2002) divides learning into six categories in his revised Bloom’s Taxonomy: remember (C1), understanding

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 10, October-2020

(C2), apply (C3), analyze (C4), evaluate (C5) and create (C6), and divides knowledge into four categories: factual knowledge, conceptual knowledge, procedural knowledge and metacognitive knowledge according to knowledge dimensions. The education mode based on OBE emphasizes the abilities that students should have and the skill that demonstrate when they graduate, the ways and means that students solve problems, not the simple recollection or memory of the factual knowledge, but the understanding, application and analysis of the methods, criteria and cognitive knowledge, and the higher level is the evaluation and creation of them.

Table 2 shows the score distribution of the final examination of the course "control system" in our institute. The row represents the course learning output (CLO), the list shows the cognitive process, and "√" represents the assessment of the corresponding knowledge or ability in this row. It can be seen from table 2 that in the summary evaluation of the course, students' understanding (C2) and application (C3) of knowledge and analysis (C4) should be evaluated more, while memory / recall (C1), evaluation (C5) and creation (C6) only account for a small part of the whole evaluation, and more attention should be paid to the evaluation of learning to produce CLO2, because the analysis of system performance is the core content of the course, which provide the basis and method for system modification. Modifying Kamal's (2009) exam percentage for the cognitive process as: Low (C1) from 10 to 20 %, medium (C2, C3, C4) from 60 to 70 %, and high (C5 and C6) from 10 to 20 % will give much portion to the understanding and analysis of control systems.

Table 2 Score distribution of final examination of the course "control system"

	C1	C2	C3	C4	C5	C6	Total score
CLO1	√	√	√				10-20
CLO2	√	√	√	√	√		60-70
CLO3			√	√	√	√	20-30
Total score	5-10	70-80		10-20			

In addition to assessment of the course learning outcomes, an evaluation of the process of OBE evaluation and program outcomes should be carried out at faculty and institute level. Mohamed & etal. (2012) provided a tool for such evaluation of outcome-based education. Dargham (2013) also, with indicating that the achievement of program outcomes is very important for engineering higher education institutes who have adopted OBE, informed that a direct assessment method of the achievement of the program outcomes from the course learning outcomes based on the marks obtained in the final exam.

After the final exam assessment of the course is performed, the evaluation of the course in addressing the program outcomes be carried out according to the course assessment matrix shown in Table 3.

Table 3: Course Assessment Matrix

Course learning objectives (CLO)	Program outcomes (PO)						
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**
CLO 1	3	1		1			
CLO 2	2			1		1	
CLO 3	2	3	3	2	2	2	2

1= objective address outcome slightly, 2 = moderately, 3 = substantively

PO1: (3a) an ability to apply knowledge of mathematics, science and engineering
PO2: (3b) an ability to design and conduct, as well as analyze and interpret data
PO3: (3c) an ability to design a system, component or process to meet desired needs
PO4: (3h) the broad education necessary to understand the impact of engineering solution in a global and social context
PO5: (3g) an ability to communicate effectively
PO6: (3d) an ability to function on a multidisciplinary team
PO7: (3i) a recognition of the need for an ability to engage in lifelong learning

CONCLUSION

Under the background of paying attention to students' learning output, an outcome-based curriculum of "control system" course for control system major in our institute is designed, and the teaching and learning process of the course is carried out around students' learning output. In the whole teaching process, a dynamic cycle of continuous improvement of teaching quality has been formed. There is feedback between the formulation of curriculum output, the implementation of curriculum and the evaluation of curriculum, so as to ensure that the actual output of students tends to the expected output. Further studies will be carried out to investigate the effectiveness of the OBE system in this regard.

REFERENCE:

[1] Chen, C. (1993). Analogue and Digital Control System Design. Transfer-function, State-space and Algebraic Methods. Saunders College Publishing

[2] Dargham, J A., Chekima, A., Yin, R. C. K., & Wong, F. (2013). A direct assessment method of the achievement of the program outcomes from the course outcomes. *IEEE 5th Conference on Engineering Education (ICEED)*, Kuala Lumpur, Malaysia: IEEE

[3] Dorf, R.C. & Bishop, R.H. (2011). Modern Control Systems. 12th ed. Prentice Hall: Pearson Education, Inc., Upper Saddle River, New Jersey 07458

[4] Felder, R.M., & Brent, R. (2003). Designing and teaching courses to satisfy the ABET engineering criteria. *Journal of Engineering Education*, 92 (1), 7-25.

[5] FTVETI. Background of the institute. https://www.ftveti.edu.et/about

[6] Kamal, M.M. & Latip, H.H.M.F. (2009). Examinable Course Assessment Tool Based on Outcome Based Education. *International Conference on Engineering Education* (ICEED 2009), Dec 7-8, Kuala Lumpur, Malaysia.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 10, October-2020

[7] Kerka, S. (1998). Competency based education and training myths and realities. *ERIC Clearinghouse on Adult, Career, and Vocational Education.* The Ohio State University

[8] Killen, R. (2001). Outcomes-based education: principles and possibilities. Unpublished manuscript, University of Newcastle, Faculty of Education.

[9] Krathwohl, D.R. (2002). A Revision of Bloom's taxonomy: an overview. *THEORY INTO PRACTICE*, Volume 41, Number 4, Autumn 2002 Copyright © 2002 College of Education, The Ohio State University

[10] Likisa, K.D. (2018). Challenges and prospects of competency-based education: The case of Adama science and technology university alumni students and Hawas TVET college, Adama, Ethiopia. *Competency-based Education*, 2018;3: e01163. Wiley

[11] Lemu, H.G., Frick, J., Uhl, T., Lisowski, W., & Piwowarczyk, P. (2012). Study on Need Assessment of Mechatronics Education in Norway and Poland. ©IFIP *International Fedration for Information Processing 2012*

[12] Master, K. (2013). Edgar Dale's Pyramid of Learning in medical education: A literature review. *Medical teacher WEB paper*, 2013; 35: e1584–e1593

[13] Ministry of Education (MoE). (1994). *Education and training policy*. Addis Ababa. Federal democratic republic government of Ethiopia. E.E.P-86. St. George printing press.

[14] Mohamed, S., Tukiran, Z., Hanifa, R.M., Ahmad, A., Md Som, M. (2012). An evaluation assessment tools in outcome-based education: a way forward. *Journal of education and vocational research.* Ol.3, No. 11,pp. 336-343, Nov 2012 (ISSN 2221-2590.

[15] Rahim, A.A.Ab., Thamrin, N. M., Abdullah, N. E., & Hashim, H. (2010). Modem control systems in electrical engineering course assessment using the outcome-based education approach. *2nd International Congress on Engineering Education, Kuala Lumpur, Malaysia*

[16] Spady, W. (1994). *Outcome-based education: Critical issues and answers.* Arlington, VA: American Association of School Administrators.