EFFECT OF CONSTRUCTIVE ALIGNMENT IMPLEMENTATION ON CHEMICAL ENGINEERING KINETICS COURSE

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ABSTRACT

Most engineering courses at the undergraduate level are delivered by using a lecture-based teaching approach. In the past, this technique was successful because the students had motivation and passion for learning for improving themselves, but the goal of the study at the university was changed nowadays. In Thailand, some students in the university do not have goals or motivation to improve themselves, so the techniques and the course design need to change to meet the student behaviour. The constructive alignment was chosen to design the course of chemical engineering kinetics and reactor design for third-year students at the department of chemical and materials engineering, faculty of engineering, Rajamangala University of Technology Thanyaburi. There are three parts of the course which need to align together. They are intended learning outcomes (ILOs), teaching and learning activity (T&L), and assessment method (ASM). This action research has studied the alignment of ILOs, T&L, and ASM to increase the engineering skills for chemical engineering students. The intended learning outcomes were the first one, which needs to design according to the course description and the CDIO skills, for example, teamwork, critical thinking, and communication. Then, the assessment methods were selected to measure student skills such as quizzes, assignments, examinations, and rubric for both formative and summative assessments. The last one is teaching and learning activities. T&L needs to design align with ILOs and ASM because they are the indicator of the success of constructive alignment. As mentioned earlier, only lecture techniques are not suitable for present students but still necessary, so we need to add some active learning techniques to combine with short lecture approximately 15 minutes. For example, jigsaw classroom, think pair share, group discussion, etc. The data were collected during the class and after the class. It was found that the behaviour of the students changed with the teaching and learning activities that we used. The students participated actively in the class. Most students said they were excited when the teacher chose their names in a completely random way and asked a question during the lecture and help them always awake. In the past, the number of students who can pass this course was quite low, but when we designed the course with constructive alignment, it can help the teacher to cut off some part that is not important and focus on the important part so the students can understand more about the course.

KEYWORDS

Constructive Alignment, Intended Learning Outcomes, Teaching and Learning Activity, Assessment Methods, Standards 7, 8, 11

INTRODUCTION

In this study, the constructive alignment of the course chemical engineering kinetics and reactor design is presented and discussed. The challenges in higher education today are changes in universities as institutions, and at the level of internal organization, changes in knowledge creation, changes in the educational models, changes aimed at tapping the potential of information and communication technologies, and changes for social responsibility and knowledge transfer (Granados, 2018). So, teaching and learning in higher education need to change as well. CDIO (Conceive-Design-Implement-Operate) framework was used to generate the CDIO skills of the students, such as engineering reasoning and problem-solving, experimentation and knowledge discovery, system thinking, and personal and professional skills (Malmqvist, Enelund, Bingerud, & Almefelt, 2018). In the course level, implementation of CDIO standards 7 and 8 (new methods of teaching and learning) is needed for improving student skills, which are important in the 21st century work society. An innovative course design to transform into an integrated, real-world acoustic context that relates to students' personal experience can help the student to learn advanced mathematical solution methods in a new way (Kari & Högfeldt, 2018).

In chemical engineering, four years of experience in the university consist of many types of courses like other curricula in engineering—for example, lecture, project, cooperative education, laboratory, etc. According to Dale's cone of experience, there are many levels of percentage of people generally remember. The lowest one is reading. Most people can remember only 10% of what they read. The highest percentage goes through real experience, and they will remember 90% of what they do as they perform a task, as shown in Figure 1 (Dale, 1969). The curriculum graduate attributes were specified that the students need to achieve each attribute at the highest level, so the teaching and learning method must match with the cone of experience.

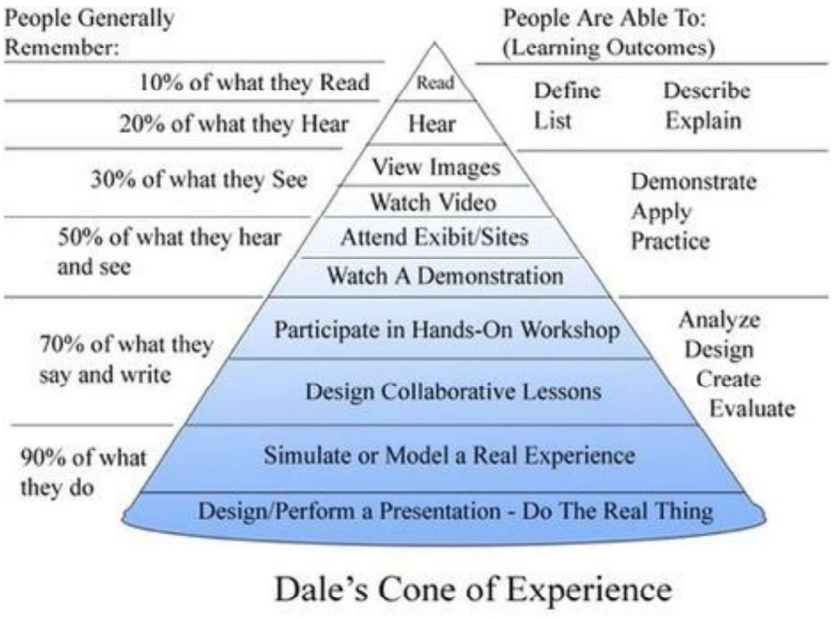

Figure 1. Dale's cone of experience (Dale, 1969)

This paper aimed to implementation of constructive alignment principle on the Chemical Engineering Kinetics and Reactor Design course. This course is the lecture-type course, which has the time to study 3 hours per week and students' self-study 6 hours per week. Therefore, the course was designed by using constructive alignment to help students achieved the learning outcomes of the course. The constructive alignment was born when John Biggs realized how silly it was to give the exam and assignment, which the student told him what he had told them about applying the subject to education. So he asked the students to apply what they knew from the subject and collect their evidence of applying in a portfolio, which is the intended learning outcome of the course (Biggs, 1999). The intended learning outcomes are the first component that we have to consider in constructive alignment. Then, the assessment method and teaching and learning activities designed to align with the intended learning outcomes. The meaning of the intended learning outcome, assessment methods, and teaching and learning activities are shown in Figure 2.

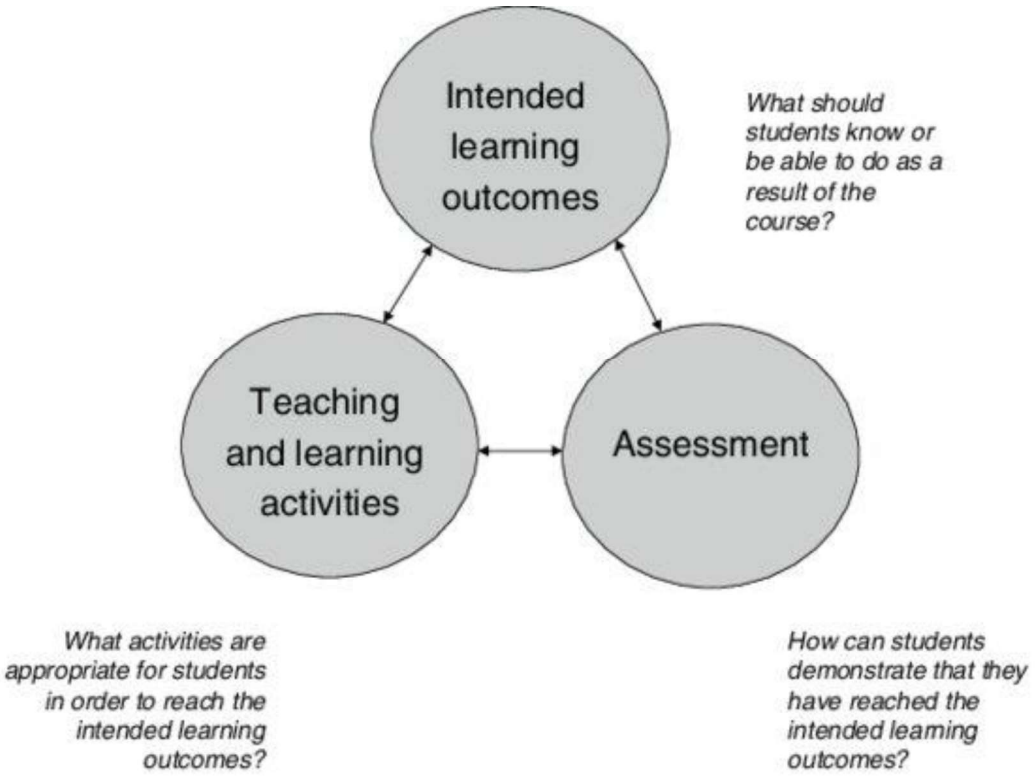

Figure 2. Diagram of constructive alignment (Edström et al., 2007)

COURSE INFORMATION

Chemical Engineering Kinetics and Reactor Design or Chemical Reaction Engineering is the course for third-year chemical engineering students. The course description is the application of thermodynamic and kinetic fundamentals to the analysis and design of chemical reactors, type of reactors, single reactor and multiple reactor systems, isothermal and non-isothermal operation, homogeneous reactors and introduction to heterogeneous reactors. As it is the course for third-year students, so this course needs background knowledge from the first and second years. The fundamental knowledge of the students before registered to this course are basic mathematics such as calculus, basic science such as chemistry and physics, basic

knowledge of chemical engineering such as the principle of chemical engineering (mole and energy balances), chemical engineering thermodynamics, and applied mathematics for chemical engineering, etc. So, this is an integrated course that the third-year students of chemical engineering need to practice. Especially, this course like the heart of chemical engineering because how to design the chemical reactor is the skill of a chemical engineer, which is different from another engineer.

INTENDED LEARNING OUTCOMES

From the constructive alignment principle, the intended learning outcomes of the course is the most important thing which we need to consider first. In the curriculum of chemical engineering, there are two pieces of information on the course for the lecturer. The first one is the course description, as mentioned earlier. The second one is curriculum mapping, which is informed about the scope of graduate attributes of the course. From this information, the teacher has to generate the intended learning outcomes of the course. Bloom's taxonomy was used to identify the intended learning outcomes of this course (Bloom B.S., Engelhart M.D., Furst E.J., W.H., & D.R, 1956). There are three domains of learning objective in Bloom's taxonomy. They are cognitive domain (mental skills), affective domain (attitude), and psychomotor (physical skills). In 2002, Krathwohi revised Bloom's taxonomy of the cognitive domain, as shown in Figure 3 (Krathwohl, 2002).

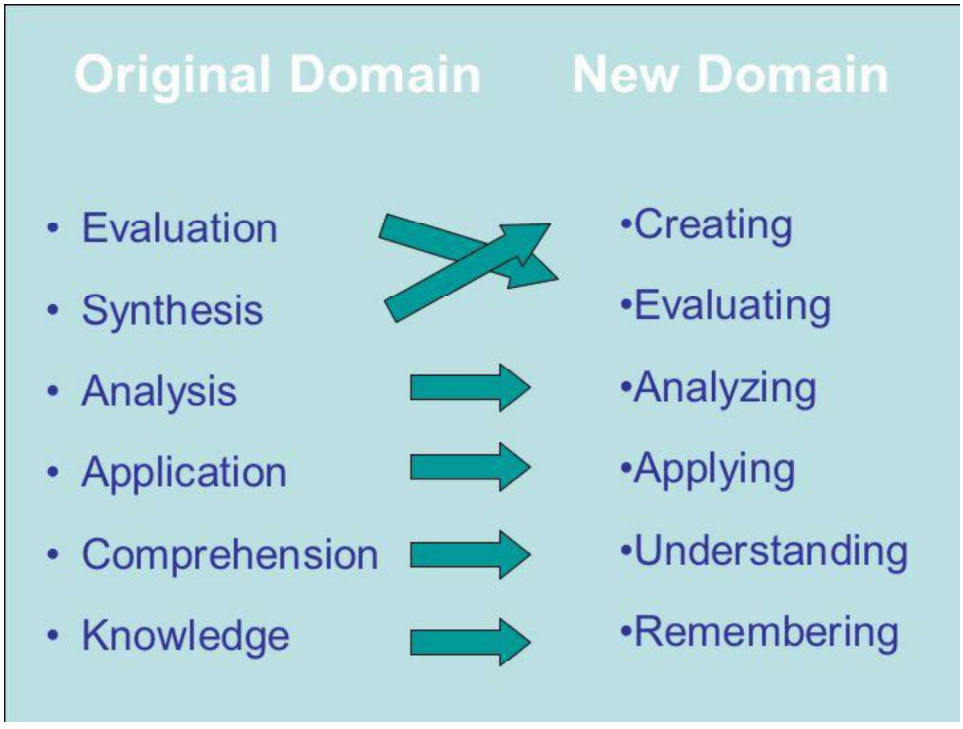

Figure 3. Revised Bloom's taxonomy by Krathwohi (Krathwohl, 2002)

According to revised Bloom's taxonomy, the intended learning outcomes of this course were modified. It is expected that by the end of the course student should be able to:

1. Understand the dependence of temperature, pressure and/or concentration on rate laws
2. Analyse rate data using an integral and differential method

3. Apply the basic principles involved in the analysis of experimental data to derive rate laws
4. Analyse how selectivity and yields are affected in series and parallel reactions
5. Differentiate the type of reactor between batch, semi-continuous and continuous reactors
6. Derive general mole balance equations for batch, semi-continuous and continuous reactors from first principles
7. Develop stoichiometric tables for batch, semi-continuous and flow reactors
8. Analyse basics energy balance of a reacting system
9. Apply energy balance equation to flow and batch reactor systems operating with and without heat exchange
10. Apply energy balance equation to describe equilibrium conversions
11. Evaluate the requirement of thermodynamic consistency of a rate law for reversible reactions
12. Understand the fundamentals of heterogeneous reactor design

ASSESSMENT METHODS

After the design of intended learning outcomes, the assessment method is the next component, which we have to consider because an assessment is a tool that we can use to check the achievement of the intended learning outcomes. The first alignment between intended learning outcomes and assessment method is very important because many times, the lecturer analyses the results of the class incorrectly. For example, the intended learning outcome is the student can apply the basic principle of the subject, but in the assessment, the lecturer asked the student to explain or to analyze the basic principle of the subject. So, the results from the assessment showed a very low score, or the conclusion is the student can explain, but they cannot apply the knowledge. Graduate attributes such as teamwork skills, communication skills are the most difficult attribute to assess (Falls, 2015). Falls proposed peer assessment and/or evaluation surveys to assess team dynamics.

There are three purposes of assessment in pedagogy. They are assessment for learning, assessment as learning, and assessment of learning. The assessment for learning and assessment of learning assess by the teacher, but an assessment as learning was done by the student (Bennett, 2017). The design of the assessment method to align with the intended learning outcomes needs to understand the purpose of the assessment. If we need to assess for learning, we can use both formative and summative assessment. If we need to assess as learning to help the student in the class or during the learning activity, we can use formative assessment. What are the formative and summative assessments? Formative assessment performed during the teaching and learning process to monitor student learning and to improve teaching and learning activity for the teacher. Summative assessment performed at the end of the course to judge the student after the course such as a midterm exam, final project, or final report, etc. (Hanna & Dettmer, 2004)

From intended learning outcomes, there are many levels of learning, such as understanding, applying, analyzing, and creating. Table 1 presents examples of activities that can be used to assess the different types of intended learning outcomes.

Table 1. Examples of assessment method for different intended learning outcomes

Type of intended learning outcomes	Examples of appropriate assessments
Understand	These are the verbs which we can use for understanding in intended learning outcome Interpret, Classify, Summarize, Compare, Explain To assess the understanding level of learning, we can use the activities like papers, exams, problem sets, class discussions, or concept maps.
Apply	The verbs for this type of intended learning outcomes are applied, execute, and implement To assess the applying skill, we can use activities like problem sets, performances, labs, prototyping, or simulations. In this course, the quizzes (short paper exam) were used to assess the understanding and applying of the student.
Analyze	We can use these verbs to explain about analyzing. Analyze, Differentiate, Organize, Attribute To assess the analyzing skill, these are activities that suitable case studies, critiques, labs, papers, projects, debates, or concept maps
Evaluate	Evaluate, Check, Critique, Assess are the verb that can use to identify the intended learning outcome To assess the evaluating skill, we can use the activities like journals, diaries, critiques, problem sets, product reviews, or studies
Create	The highest level of the cognitive domain, we can use these verbs to create, generate, plan, produce, design. To assess the creativity of the student, the activities are research projects, musical compositions, performances, essays, business plans, website designs, or set designs In this course, the students have to design a chemical reactor to show their ability of this level.

TEACHING AND LEARNING ACTIVITIES

The last part of the constructive alignment design of the course is to align teaching and learning activity with intended learning outcomes and assessment methods. Before the alignment, we have to understand the principle of teaching approaches and modes of delivery. There are a lot of teaching approaches which we can use to design the teaching and learning activity. For example, project-based learning, problem-based learning, case-based learning, challenge-based learning, experiential-based learning, studio-based learning, scenario/story-based

learning, and gamification/simulation. In each teaching approach, we can use many types of modes of delivery to transfer knowledge to the students. Examples of delivery modes are jigsaw classroom, flipped classroom, team teaching, mini-lecture, think-pair-share, debate, concept questions, role play, and fishbowl class discussion, which we know as active learning. There is research on removing lectures from the course. They found that the results not only increased student satisfaction but also bolstered the intended learning outcomes (Christian Thode Larsen, Gross, & Bærentzen, 2015).

This course has three hours per week of contact sessions. There are fifth teen contact sessions in one semester. In each week, the class was design for one major intended learning outcome. So the teaching approach each week was changed depending on the intended learning outcome and the assessment method of that week. For example, the intended learning outcome is to understand the dependence of temperature, pressure, and/or concentration on rate laws, and the assessment method of formative assessment is the quiz of explaining the dependence of temperature, pressure, and concentration on rate law. The teaching and learning activities are assessment as learning, mini-lecture for 15 minutes, concept questions during the lecture, an example of calculations about the topic, and the last one is an assignment for practicing. Figure 4 shows the teaching and learning activities in the classroom.

Figure 4. Classroom activities

After the implementation of constructive alignment, the first advantage is for the teacher. When we get the class information during the teaching and learning process, and at the end of the course, it is easier to analyze the results because we will see the alignment of each component (intended learning outcome, assessment method, and teaching and learning activities). So if we want to use the information to improve the next class, we will know where the weak point of the class is, and we can fix it effectively. The second advantage is for the student. From constructive alignment, the students need to know the intended learning outcomes. Therefore they can assess themselves about the achievement of the course so the student can improve themselves by this method.

This course also uses educational technology to motivate the student in the classroom, such as www.mycourseville.com, Facebook, and line application. These websites can use to random the student name during the discussion, which makes the student always excited. The

communication between teachers and students is very easy via these technologies as well. For example, the students can submit their assignments online by using the internet, and the students can check their scores on the website so they can monitor their progress of learning. Figure 5 shows the improvement of student outcomes after the implementation of the constructive alignment principle as you can see in Figure, the average scores increased significantly.

Figure 5. Student score after implementation of constructive alignment

CONCLUSIONS

The constructive alignment principle was implemented in the chemical engineering kinetics and reactor design course. The intended learning outcomes were changed to follow the revised Bloom's taxonomy. The assessment methods were designed to align with intended learning outcomes. The teaching and learning activities also aligned with intended learning outcomes and assessment methods. The results after implementation of the constructive alignment principle help the teacher to analyze the course easily and know how to improve the course and help the students to improve themselves follow the intended learning outcomes through teaching and learning activities that align with assessment methods. Therefore, the achievement of the course is better than the unaligned course.

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