

# Analysis of Student Learning Outcomes in Power Electrical Engineering Courses: A Case Study

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**Abstract.** *Teaching methods have been changed recently to focus on student learning. Various pedagogical methods have been introduced to motivate students to participate activities in classroom. However, the most important thing is student learning outcome. To ensure that new teaching methods are effective and students have accomplished learning goals, appropriate assessments are needed to reflect student learning outcomes. In power electrical engineering program for bachelor's degree, Power System Analysis (PSA) course and Power Plant and Substation (PPS) course are two courses from eight specific engineering courses specified by council of engineering (COE). These two courses should be taken by senior students. At Dhurakij Pundit University, these courses were held at the last semester for the same group of students and taught by the same lecturer. The course contents and teaching materials were different, whereas teaching methods were similar but different in detail. There were significant differences in student scores. Average score from PPS course was 11.62% higher than that from PSA course. The objectives of this paper are to analyze the assessments and student learning outcomes from these two courses. Questionnaires and interviews were carried out. Finally, student feedbacks were analyzed and comparison results were concluded.*

## Keywords:

Assessments, learning outcomes, scores, comparison

## 1. Introduction

Teaching methods have been changed continuously [1]-[3]. Lecturers change their roles to be facilitators whereas student learning outcome is focused. There are many effective learning methods in electrical engineering such as problem-based learning [4], hierarchy of effective learning [5], etc. However, they are implemented with the same goal: to develop students in self learning. To ensure that the learning goals are accomplished, appropriate assessments are needed. They are used to measure learning outcomes and evaluate student knowledge [6]. In addition, facilitators have influenced on student behaviors and learning outcomes [7], [8].

In power electrical engineering program for bachelor's degree, students must learn at least eight specific engineering courses specified by council of engineering (COE). Power System Analysis (PSA) course and Power Plant and Substation (PPS) course are both specific engineering courses. At Dhurakij Pundit University, senior students should learn these two courses in the last semester before they graduate. These courses were taught by the same lecturer in year 2015.

Experience from teaching PSA course more than ten years, the lecturer has learned that students should be evaluated in 3 parts: thinking process, calculation and consideration of feasible solution. Student should study each content carefully, do exercise and homework regularly and seek addition knowledge from other sources. Furthermore, students should analyze and solve problems by integrating their fundamental knowledge.

There are 6 important principles, which must be concreted as basic knowledge in PSA course, as following electrical power system, power directions, economic dispatch, power flow, power system faults and stability. They act as foundation of power system analysis. Therefore, students must understand these principles thoroughly. After that, students should learn how to apply them in various systems. They should study each content carefully, search for relevant knowledge from other sources, do exercises and learn to evaluate the feasible solution. Understand the principle correctly would enable students to utilize them to analyze any power system appropriately. To ensure that students understood correctly, students should perform self tests for each chapter. In addition, primary contents i.e. per unit system, vector, phasor sequence, circuit connection are important as fundamental knowledge which are needed to analyze and solve problems. If students were absent 1-2 classes without learning the missing content, they would not able to follow the subsequent contents.

In PPS course, key contents are electrical power plants, substations, equipment in substation, minimum clearance, substation grounding and lightning protection in substation. The calculation process should follow international standard such as the International Electrotechnical Commission (IEC), the Institute of Electrical and Electronics Engineers (IEEE). The contents

such as design of ground grid, clearance between equipment and lightning protection in substation, are straight forward following standard codes.

Many learning methods have been implemented in PSA course and PPS course in recent years. They include game-based learning, problem-based learning, project assignment, academic trip supporting assignment, etc. However, contents in PSA course are more difficult and more complex. These result in different examination scores.

The objectives of this paper are to compare student scores to analyze student outcomes and to find the appropriate learning methods for each course. It was performed as a small research project in a classroom [9]-[10].

## 2. Methodology

Four methods were used in this paper. First, raw data such as learning goals, assessment methods, student scores, were collected. Learning plan and goals were studied and compared. Learning goals must be specified before selecting assessment tool. Assessments were considered. Student scores were compared and analyzed. Second, questionnaires were distributed to students in PSA and PPS courses. Third, students were interviewed in a small group. Fourth, statistical tool such as t test [11] was used.

### 2.1 Learning goals

Learning goals were knowledge from PSA and PPS courses mentioned in Section I, and other skills i.e. problem solving, working as a team, communication, presentation, etc. Furthermore, students should develop their self-learning skill. Knowledge could be evaluated by examination whereas other skills could be evaluated via assignments and presentations.

### 2.2 Assessment methods

Learning outcomes were evaluated from their assignments, tests, exercises, presentations, examinations. To assess student learning outcomes, students were evaluated in three processes: i) project assignments to evaluate student self-learning, ii) participation and responsibility to evaluate skills in communication and team work iii) tests, midterm and final examinations to evaluate knowledge in each course.

Assessments for these two courses were quite similar. However, the questions in examinations for PSA course were more complex. Students should use 3-7 relevant processes, to solve problems. In addition, they must have fundamental knowledge such as circuit analysis theory, mathematics, complex number, phasor sequences etc. To solve problems, students needed to integrate knowledge from many areas. Whereas, questions in PPS course were quite straight forward i.e. to examine the design whether it

complied standard codes and guidelines. Thus, examinations of PSA course were more difficult than those of PPS course.

### 2.3 Comparison student scores

Student scores from these two courses were collected, compared and analyzed. Mid-term and final examination scores were focused.

### 2.4 Questionnaires

There were 37 and 34 students for PSA course and PPS course respectively. Students were asked to answer questionnaires. Questionnaires were distributed to 25 students (13 students from 4 year program, 12 students from 3 year program). Note that the 3 year program is set for students who graduated from high vocational certificate level.

### 2.5 Student feedbacks

After final examination, four students were interviewed in a small group in the meeting room at electrical engineering department.

### 2.6 Statistical tool

The statistical tool for data analysis procedure such as t-test was used for hypothesis testing. It was used to test the difference of average scores from midterm and final examination, from PPS and PSA courses.

## 3. Results

Scores of 31 students who took both courses were compared. Student scores, evaluations and feedbacks were considered. Student scores and feedbacks from PSA and PPS courses were considered.

### 3.1 Student scores

Their scores are shown in Fig. 1-3 and Table 1. The scores from two courses for each student are compared. Most of students got higher scores from PPS course than those from PSA course.

In midterm examination, the scores were quite similar. There was no big difference, 10.50/20 for PSA course and 11.84/20 for PPS course. In PSA course, the key contents in first half course were power development plan in Thailand, economic dispatch and power flow. Economic dispatch was not too complicated. Teaching materials were power point files, seven short video clips, eight exercises and solutions. Power flow was quite difficult due to numerical calculation which was performed in several iterations until the solution converges to the final value.

Thus, students should learn this content via project assignment. In the first half term, contents and midterm examination in PSA were not too complex. Whereas, in PPS course, the contents were power plant, equipment in substation, substation type and switching order. They needed less calculation. However, students needed to understand the principle and logical control. Two students got zero scores in PSA course because they lacked problem solving skill and calculation skill and they could not raise process/methodology. In Table 1, the average midterm examination score in PPS course was 12.76% higher than that in PSA course. Note that the scores of student in 4 year program were higher than those of student in 3 year program.

In final examination, the scores of most students in PPS course were higher than those in PSA course except one student who was good at calculation. She liked to learn by reading from text books at home. Her skills for doing assignment, working as a team and presentation were less than her reading skill. Her learning from assignment was much less than learning by self-reading.

In Table 1, the average final examination score in PPS course (28.83/50) was 60% higher than that in PSA course (18.02/50). Note that the scores of students in 4 year program were still higher than those of students in 3 year program. The contents in PSA course in the second half term were power system fault, stability and protection which were much more complex. Whereas, learning contents in PPS course were solar power plant, minimum clearance, substation grounding and lightning protection in substation. The process of calculation was quite long but direct forward. Students learned them through many assignments. They took longer time in class in learning by doing. These developed the ability of problem solving to perform in steps and in sequences of calculation.

The total scores of most students in PPS course shown in Fig. 3 were higher than those in PSA course except one student who did not submit some assignments. There was one student who got the lowest mark in PSA course. He was absented class many times due to his private reasons. The continuously absent made him confuse. He could not follow the subsequent contents in class. He should have learned from teaching material and video clips, but he did not pay any attention. In Table 1, the total score in PPS course (60.96/100) was 11.62% higher than that in PSA course (54.61/100). Note that the scores of students in 4 year program were still higher than those of students in 3 year program.

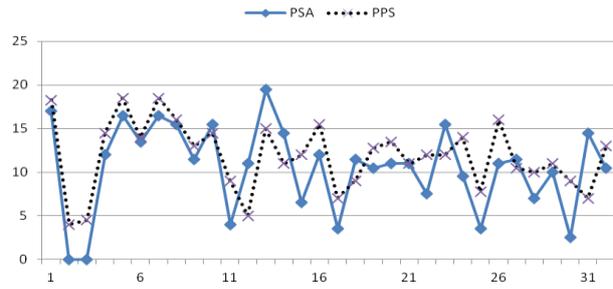


Fig. 1: Mid-term exam score comparison

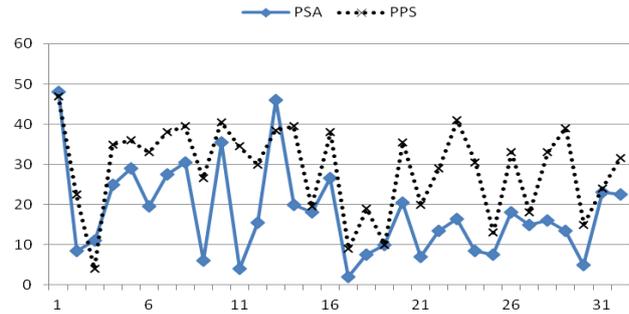


Fig. 2: Final exam score comparison

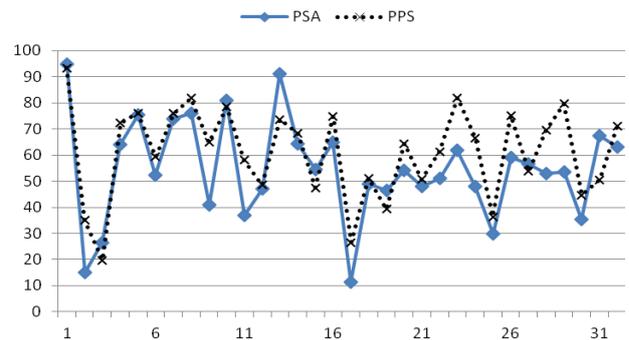


Fig. 3: Total score comparison

Table 1: Average scores

Course		Average Scores		
		Mid-term examination	Final examination	Total
PSA	4 year program	11.11	21.18	56.99
	3 year program	9.62	13.39	51.12
	Total	10.50	18.02	54.61
PPS	4 year program	12.22	30.61	61.93
	3 year program	11.27	26.23	59.55
	Total	11.84	28.83	60.96

For other learning outcomes, the evaluations of project assignments from two courses were compared and shown in Fig. 4. There were three project assignments in PPS course whereas there was only one in PSA course. In PPS course, some students could not find the actual data in practical use for some assignments. Some students did not submit assignments in time. However, students had developed skills in problem solving, working as a team, communication and presentation.

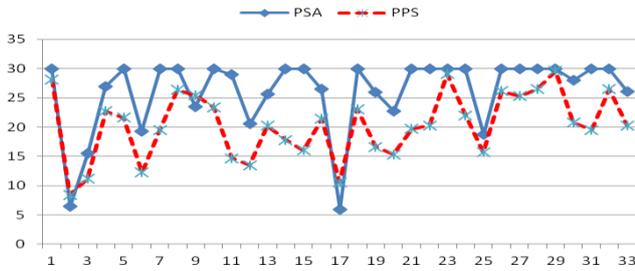


Fig. 4: Comparison of project assignment evaluations

### 3.2 Comparison student scores across years

Student scores from PSA and PPS courses were compared across consecutive years. Student scores from PSA course in 2013, 2014 and 2015 are shown in Fig. 5. The related average scores were 13.95, 18.02 and 38.67, respectively. Actually, they could not be compared directly. It was the same content, the same lecturer but different students. Student behaviors and learning skill were different. Students in 2015 learned together as a strong team. They had very close relationship and participated in many activities. However, lecturer has used lessons learned from year 2014 to improve her teaching method. In addition, video clips were put on YouTube, teaching material and assignments were put on Google Classroom. Whereas, student scores from PPS courses in 2013 and 2014 are shown in Fig. 6. The related scores were 17.44

and 28.83, respectively. PPS course was first taught in 2013. There were a few students who were in 3 year program. Thus, student scores from different year should not be compared directly. Student scores in 2015 were not taken to comparison since another lecturer was assigned to teach this course.

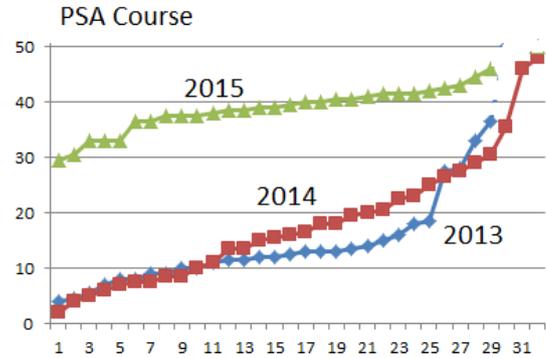


Fig. 5: Comparison of final examination scores from PSA course in 2013, 2014 and 2015.

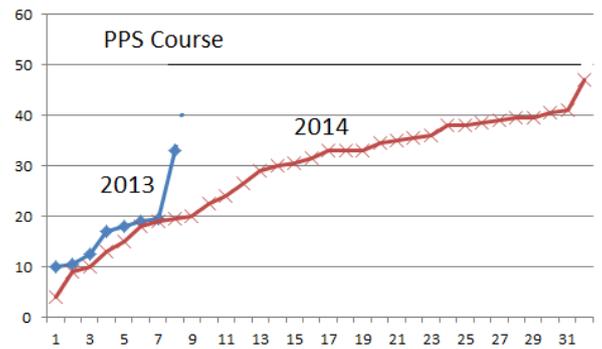


Fig. 6: Comparison of final examination scores from PPS course in 2013 and 2014.

Table 2: Evaluation from student obtained by survey questionnaires. Rating scale is in interval 0-5, where 5 is the highest scale.

Item	Description	4 year Program		3 year Program		Average	
		PSA	PPS	PSA	PPS	PSA	PPS
1	Availability of text, teaching material, multimedia	4.54	4.00	4.17	4.17	4.36	4.08
2	Complexity of contents	4.39	3.12	4.58	3.67	4.48	3.38
3	Satisfying of learning method	4.58	3.92	4.42	4.83	4.5	4.36
4	Knowledge obtained	3.96	4.04	3.83	4.25	3.9	4.14
5	Appropriation of assignment	3.85	3.62	4.42	4.67	4.12	4.12
6	Benefit from accomplish assignment	4.08	4.15	4.08	4.50	4.08	4.32
7	Difficulty of examinations	4.23	3.31	4.58	3.67	4.4	3.48
8	Clarity of examinations	3.92	4.23	3.5	4.00	3.72	4.12
9	Subject favourable	4.31	4.23	4.00	4.58	4.16	4.40
10	Subject benefit	4.31	4.31	4.00	4.33	4.16	4.32
11	Appropriation of Lecturer	4.62	4.69	4.58	4.67	4.6	4.68

### 3.3 Evaluations from student

The evaluations from survey questionnaires shown in Table 2, illustrated that the contents in PSA course were more difficult than those in PPS course (item 7). In PSA course, the contents were complex and difficult to understand, unclear questions in examinations (item 2 and 8).

Students from 3 year program liked learning by practice via project assignments (item 3, 5, 6 and 9). In other words, in PSA course, contents were more complex, examinations were more difficult, questions were unclear and there was only one assignment. In PPS course, contents were less complex, students could learn through project assignments. These resulted in less knowledge and benefit obtained from PSA course (item 4 and 10) though more teaching material, text book, video clips were provided in PSA courses (item 1). Students from 3 year program who had background in practice, enjoyed learning via project assignments whereas student from 4 year program preferred to learn in class, do some exercises and concentrate in calculation.

### 3.4 Student Feedbacks

Most of students had positive feedbacks. They could understand the contents in PPS course more clearly than those in PSA course. Student feedbacks were obtained through many questions as shown below.

#### 3.4.1 The reason why students could get higher scores in PPS course:

- The contents in PSA course were more difficult than those in PPS course.
- The principle, equations in PPS course were direct forward and easy to understand.
- In PPS course, there were fewer contents.
- In PPS course, most of contents were based on design calculations with easier formulas.
- In PPS course, I have learned from doing and I could touch real-world tasks.
- PPS final examination was the last examination on the last day, I could prepare myself perfectly.
- I could understand contents in PPS course more clearly.
- I lacked calculation skill.
- I was absented in PSA course in some classes which I could not understand thoroughly by self learning.

- I have prepared myself for examination and selected contents relevant.

#### 3.4.2 The reason why some students could get higher scores in PSA course:

- In PSA course, contents were easier than those in PPS course (only one feedback).
- I preferred PSA course since I had fun, more calculation, less memory needed.
- I was sick so that I could not prepare myself good enough and I missed one chapter in PPS course.

#### 3.4.3 Learning methods that students liked:

- Assignments helped me in self-learning.
- Exercises in class.
- Games: bidding, matching equipment name.
- Quiz/test after learning.
- Brief lecture and assignments.
- I liked every learning method provided.
- Lecture from teacher and then doing case study under teacher coaching.
- Exercises after class to ensure my understanding.

#### 3.4.4 Learning methods that students did not like:

- Lecture in whole class and memory needed.
- Lecture too much, calculation too fast.
- Presentation of my assignment without knowing the practical data.
- Teaching without paying attention for students.
- Too much lecture, practice or learning by doing would make us learn to think.
- Self learning and answer questions from the lecturer during presentation.

#### 3.4.5 Other feedbacks:

- The complex process of calculation should be taught slowly.
- The complex contents should be emphasized.
- The clarity of contents should be improved.

- It should be emphasized for students to watch the video clips before class.
- There should be more tests.
- Specify the contents in final examination clearly.
- We should make a learning trip to get some experience before we do our assignment because it is needed for design.
- We should make a learning trip in real site or real power plant.
- There should be more learning activities.
- There were too many contents in PSA course.
- The examinations in PSA course were too difficult.
- There should be more exercises in PSA course.
- I wanted to learn so that I can picture it clearly in PSA course.
- Learning time in class was too short for contents in PSA course. It was too fast in learning class.
- Contents should be repeated and there should be more time for PPS class.
- Text book should be provided for PPS course.
- I liked these learning methods. I learned from my assignments and presentations. I learned mistakes from my presentations.
- I liked assignment for working in a team. We could learn from each other.
- I liked bidding game. It made me thinking and learning to think.
- More problems or exercises to make me understand the questions in PSA course.
- Too many assignments.
- Teaching too fast.

### 3.5 Comparison

The comparison was performed in course contents, clarity of examinations, learning methods, and teaching material, assignments.

The examination scores were divided into three parts: process of calculation or solving methodology, correctness of calculation and feasibility of solutions. The assessments were midterm and final examinations, tests and project assignments. They were compared between those assignments in PSA course and PPS course. Students have obtained higher scores, knowledge

and benefit from PPS course in which students could learn via project assignments.

Statistical tool, t-test was used for hypothesis testing. Student scores, midterm and final examination, from PPS and PSA courses, were used as input data. The results showed that the average mid-term scores from PPS and PSA courses were not different with confidential 95%, p value-0.089. Whereas, the average final scores from PPS were different from those of PSA with confidential 95%, p-value 0.00005.

### 4. Lesson Learned

Lesson learned from these two courses is described below:

- The contents in PSA course were more complex. Students must analyze many thinking process. More exercises and activities were needed. Learning by doing in class with coaching was necessary. The key principles should be learned slowly. Since time in classroom was too short, students did not have sufficient time to learn each content in detail slowly. Thus, students should be encouraged to study video clips before attending class room. Then, activities to support learning contents in classroom should be performed. Flipped classroom should be employed. It must be ensured that students understand key principles correctly. In addition, questions in examination should be reviewed carefully.
- The contents in PPS course were direct forward. Each design was based on international standard. It was a step by step calculation process. It was easy to understand. Design process was followed standard guidelines. In addition, questions in examinations were clear.
- More education trips to power plants and substations were necessary before the beginning of design in project assignment. Questions should be prepared for students for each trip to stimulate them and make them more interested. Students should be eager to notice, analyze and integrate knowledge from each trip.
- There should be an appropriate treatment for each student group. Facilitator should notice and analyze the learning progress and team work of each group. Additional classes for explaining in detail should be set for students who need more time to develop thinking and calculation process.
- Student should be motivated to do self-test for each content.

- Lecturer had experience in PSA course for many years. Text book was written and published in 2014. Whereas, the lecturer has just been assigned to teach PPS course for two years. Lecturer was keener in PSA course. Coaching for assignment in PSA course was better than that in PPS course. Thus, learning contents were much deeper in detail. Questions in examinations were more complex.

## 5. Conclusions

Assessments and learning outcomes of senior students from PSA course and PPS course were compared and analyzed. Student scores for both midterm and final examinations in PPS course were higher than those in PSA course. The reasons were the complexity of contents, assignments, clarity of questions in examinations and learning methods. More learning activities and exercises in classroom were needed. Student's favorite learning methods are game based learning, learning via project assignments, doing exercises in classroom under coaching.

The survey and interview results showed that students were more eager to learn through activities than listening. Some improvement for learning methods should be further developed. Students should watch video clips before attending classroom. Activities in classroom under coaching could support student learning to make them understand correctly and more clearly. Flipped class room should be employed.

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