



Developing Energy Systems Engineering Students' Perceptions of Renewable Energy for Sustainable Future

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ABSTRACT

The main purpose of this study is to describe engineering students' perceptions about renewable energy. The paper focuses what the engineering students' know about renewable energy and developing their understanding on it. To determine students' pre- and post-perceptions about renewable energy, firstly, the questionnaire was developed by the researcher. After conducting the questionnaire, the courses and seminar were prepared. Then, the differences of percentages between pre- and post perceptions were identified. This study found that although the students were in Energy System Engineering Department, they still had many misconceptions about renewable energy. After the course prepared by researcher many students handled their misconceptions and developed their knowledge about renewable energy. This study has demonstrated that as the course took place, the perceptions, and misconceptions of students about renewable energy changed. It also recommended that if the single course can achieve the changes of perceptions and misconceptions of students, consistent changes might be succeeded by curriculum. The learning outcomes of the students showed that the course fits exactly for fulfilling future necessities for the education of students in sustainable topics.

Keywords- Renewable energy, Sustainability, Engineering students, Students' perceptions

INTRODUCTION

Sustainability has actually many aspects such as economic, ecological, and social (Emanuel and Adams, 2010). The "sustainable development" term was originally declared by the United Nations in Agenda 21 (Agenda 21, 1992). Actually, sustainable development term refers "durable development" other than English language and it has "durable", "long-term" or "continued" meanings among others (Leal Filho, 2000). For this development, the qualified people are a necessity. Thus, universities and schools have tried to achieve an embedding sustainability into their education systems. Also, a great number of studies have portrayed a variety of ways to carrying out education for sustainable development by courses or revising curriculum in last decade (Lozano Garcia *et al.*, 2006; Sterling and Thomas, 2006). Especially, the function of universities in this concept is very important not only because they



have conducted many researches about sustainability but also they educate qualified people which contribute to a sustainable future (Barth and Rieckmann, 2012).

In the recent years, Education for Sustainable Development (ESD) has become important in all levels of education. There are strong political and social will to accommodate ESD to education especially in higher education levels. Its severity increases with the declaration of United Nations namely *Decade of Education for Sustainable Development* from 2005 to 2014. Also, the year 2012 was selected as *International Year of Sustainable Energy*. (Pullen and Brinkert, 2014). Internationally, there is a huge attention on renewable energy. Energy is necessity for all basic living needs. However, it is fact that fossil fuels will end in the near future and energy costs increase rapidly. Thus, the solution is that reproductive use of existing sources and recycling energy achieved by the renewable energy.

Engineering professionals are forced to perform engineering more sustainably (WFEO, 1999). Therefore, engineering academics have tried to educate their students about sustainability especially sustainable energy a significant part of sustainable development (Carew and Mitchell, 2002). At this point, the significant question is that how they might achieve to teach their students in this aspect. For this aim, the first thing is what the students know and understand about renewable energy. It is needed to be clear what the renewable energy means or what the students think about it. While the renewable energy receives a lot of attention from the all parts of social life, there is still much confusion on it. Hence, it is important to know and develop engineering students' conceptions about renewable energy. The students' perceptions of sustainability were determined in last decades (Zeegers and Clark, 2014, Emanuel and Adams, 2011, Yumurtaci, 2012). Zeegers and Clark mainly focused on developing students' understanding of sustainability. For this reason, they designed and prepared a tertiary course and seminar in sustainability. The survey was used to determine students' perceptions about sustainability as pre- and post-test in the course. They found that interesting in sustainable development was complex. Also, they showed that if the students can act active role in their learning, they could establish a more balanced view on sustainability. They proof that the change about perspectives needed a longitudinal study.

As to Emanuel and Adams, they compared the college students in Alabama and Hawaii based on three questions: " 1) Are students concerned about the present/future? 2) What do students know about sustainability? 3) Who is responsible for sustainability?" They found that students were interested in wasteful consumption and pollution in two colleges. The students were same in terms of their self-assessed knowledge about sustainability. Also, they were same in their views about who is responsible for sustainability. However, the majority of students in Hawaii declared that they were volunteer to join for sustainable practices.

Numerous studies have been reported about what engineering students know about sustainability and renewable energy (Carew and Mitchell, 2002, Kagawa, 2007, Yumurtaci, 2012, Zeegers and Clark, 2014). However, very little has been prepared courses to train students to deal with their misconceptions. The misconceptions are so important and the first step for achievement an effective concept teaching is to find out students' misconceptions that may differ from the scientific ones (Unal, S., 2010, Taber, K.S., 2011).

This present study will thus focuses on perceptions of students about renewable energy. An enough understanding of the concept of renewable energy is a first and vital step for educating qualified engineering people for sustainable future.

The study

The main purpose of this study was to describe engineering students' perceptions about renewable energy. It was planned to contribute to literature that has some deficiency about research related to students' perceptions about sustainability and particularly renewable

energy (Carew and Mitchell, 2002, Kagawa, 2007, Yumurtaci, 2012, Zeegers and Clark, 2014).

The paper focuses what the engineering students' know about renewable energy and developing their understanding on it. For this reason, the questionnaire was developed to determine their initial perceptions of renewable energy. Then, the courses and seminar were prepared to improve their perceptions of renewable energy.

Research Questions

The main research questions were about students' conceptions about renewable energy before and after attending courses. The questions were below as:

Q1: What do the students know about renewable energy?

Q2: Did students' perceptions about renewable energy change by the courses?

METHODS

To determine students' pre- and post-perceptions about renewable energy, firstly, the questionnaire was developed by the researcher. After conducting the questionnaire, the courses and seminar were prepared. Then, the differences of percentages between pre- and post perceptions were identified.

Questionnaire

The 20-item Renewable Energy Awareness Questionnaire was developed based on (1) the literature on misconceptions of renewable energy, (2) interviews with students that include misconceptions about renewable energy.

The items included *knowledge about renewable energy* (items 1,2,4,6, 8 and 10), *knowledge about solar energy* (items 3,7,11,13, and 16), *renewable energy in Turkey* (items 5,9,12,14, and 15), and *perceptions about their department and themselves* (items 17,18,19, and 20). The Cronbach coefficient alpha was 0.62.

The students responded on a Likert-type scale from (1) strongly agree, (2) agree, (3) undecided (4) disagree, and (5) strongly disagree options. Before the conducting study, the questionnaire was piloted with 102 engineering students in state university. With the pilot study, some corrections to the questionnaire were made based on these insights and students' responses. It was carried out before and after the course and took nearly 20 minutes.

Samples

The Questionnaire was applied to undergraduate energy systems engineering students' during fall semester of 2014. The Questionnaire was distributed all freshmen and juniors students in this department. Data were observed from a total of 89 students in a state university in Giresun. Participants were volunteers. The majority of the students were freshmen (%82) and 18 percent of the students were juniors. The greater number of students (79.8%) was male and the rest of the students (20.2%) were female. The participants' ages ranged from 18 to 22 years old.

The course

The Renewable Energy with All Aspects is an undergraduate course, which focuses on renewable energy in terms of basic knowledge about it and energy policy in Turkey and world. It includes lectures that namely as follows:

1. Renewable Energy and its sources in Turkey and the world
2. The benefits of Renewable Energy?

- 3 Solar energy and the researches and applications of solar energy in Turkey
4. The renewable energy and climate change
5. The policy of Renewable Energy in Turkey and the world
6. Movie about climate change and Renewable Energy
7. Discussion seminar on Renewable Energy

The course was developed and carried out by the researcher in collaboration with the Department of Energy Systems Engineering in Giresun University, Turkey. The purpose was to arrange an undergraduate course that included teaching methods to give knowledge about renewable energy and policy to engineering students.

The course was implemented as an intensive one-week course. The fundamental elements of the course were lectures given by academicians from the Department of Energy Systems Engineering. The lecturers explained their topics in a greater detailed and got and answered students' questions about this topic. After ending lectures, the movie about climate change and Renewable Energy was watched by the students. Then, discussion seminar was organized and implemented by the researcher. In this discussion seminar, students not only share their knowledge about renewable energy but also discuss their ideas about energy policy of Turkey.

Course Evaluation

The course was evaluated on two standards as follows:

1. The perceptions of the students were evaluated by the Renewable Energy Awareness Questionnaire, which was implemented as a pre-, and post-test.
2. Students' ideas and satisfaction were determined by the interviews that were carried out after the questionnaire and include concepts of course and their learning outcomes.

Interviews

Semi-structured individual interviews were conducted to make sure of satisfaction of the students about the course. During the interviews, students were asked to explain what they think about the course. In the study, 10 students were interviewed after the questionnaire in the class environment. These students were selected randomly. Each interview continued for approximately 10 minutes and all interviews were recorded on audiotape. The questions were presented as follows:

1. What do you think about the course?
2. Did you believe whether the course is well design or it has some deficiencies?

RESULTS

Perceptions of the Students

Renewable Energy Awareness Questionnaire was carried out to determine the perceptions of the students as a pre and post-test. The percentages of the questions in the pre-test were given in Table 1.

Table 1. *The percentages of pre- Renewable Energy Awareness Questionnaire*

	Percentages (%)				
	1	2	3	4	5
1.They always involve energy sources whose availability is unlimited	34.8	43.8	12.4	5.6	3.4
2.The renewable energy means energy that does not increase pollution and that does not deplete resources	38.2	42.7	9.0	7.9	2.2
3.Solar energy is only applied in warm regions	4.5	15.7	11.2	40.4	28.1
4.The technology of renewable energy does not work unless it reaches sources of energy	20.2	42.7	24.7	10.1	2.2
5.Turkey is a rich country about renewable energy sources	32.6	38.2	21.3	6.7	1.1
6.The renewable energy is always cheaper than non-sustainable energy sources	20.2	28.1	23.6	21.3	6.7
7.Solar energy is too expensive and is not technologically ready to mass use	16.9	25.8	23.6	22.5	11.2
8.When the renewable energy is used, it never produces environmental pollution	19.1	22.5	29.2	24.7	4.5
9.Turkey uses renewable energy sources to meet its necessity for energy	3.4	14.6	19.1	38.2	24.7
10.Renewable energy sources will replace non- renewable energy sources in the future	38.2	36.0	18.0	6.7	1.1
11.Solar energy panels are not actually environmentally friendly because energy consumed during manufacturing is larger than energy generated	3.4	4.5	23.6	44.9	23.6
12.Turkey uses technologies of renewable energy effectively	2.2	10.1	23.6	44.9	19.1
13.After installing solar energy panels, you will still need fossil fuel as a back-up energy source in cloudy and rainy days.	1.1	25.8	31.5	33.7	7.9
14.Turkey is at the top of Europe rankings with respect to solar energy sources	20.2	43.8	22.5	12.4	1.1
15.Turkey should give great importance on renewable energy technologies and use	69.7	22.5	3.4	3.4	1.1
16.When only solar energy is used at home, our life quality can decrease due to necessity of huge power for modern instruments	13.5	28.1	19.1	25.8	13.5
17.I believe that I have enough information on renewable energy	3.4	13.5	37.1	41.6	4.5
18.I think that there are no adequate courses about renewable energy	3.4	15.7	21.3	30.3	29.2
19.I think that there should be more courses about renewable energy in our curriculum	57.3	27.0	10.1	3.4	2.2
20.I want to work on renewable energy field in the future	67.4	25.8	3.4	1.1	2.2

Table 2. *The percentages of post- Renewable Energy Awareness Questionnaire*

	Percentages (%)				
	1	2	3	4	5
1. They always involve energy sources whose availability is unlimited	1.1	3.4	2.2	57.3	36.0
2. The renewable energy means energy that does not increase pollution and that does not deplete resources	51.7	43.8	0	4.5	0
3. Solar energy is only applied in warm regions	1.1	0	3.4	58.4	37.1
4. The technology of renewable energy does not work unless it reaches sources of energy	4.5	9.0	10.1	57.3	18.0
5. Turkey is a rich country about renewable energy sources	40.4	37.1	2.2	13.5	6.7
6. The renewable energy is always cheaper than non-	4.5	3.4	3.4	51.7	37.1

sustainable energy sources					
7. Solar energy is too expensive and is not technologically ready to mass use	4.5	4.5	9.0	60.7	21.3
8. When the renewable energy is used, it never produces environmental pollution	4.5	12.4	6.7	53.9	22.5
9. Turkey uses renewable energy sources to meet its necessity for energy	3.4	2.2	5.6	51.7	37.1
10. Renewable energy sources will replace non-renewable energy sources in the future	16.9	31.5	15.7	28.1	7.9
11. Solar energy panels are not actually environmentally friendly because energy consumed during manufacturing is larger than energy generated	1.1	6.7	15.7	52.8	23.6
12. Turkey uses technologies of renewable energy effectively	0	6.7	14.6	43.8	34.8
13. After installing solar energy panels, you will still need fossil fuel as a back-up energy source in cloudy and rainy days.	5.6	42.7	11.2	31.5	9.0
14. Turkey is at the top of Europe rankings with respect to solar energy sources	30.3	46.1	5.6	14.6	3.4
15. Turkey should give great importance on renewable energy technologies and use	75.3	21.3	1.1	1.1	1.1
16. When only solar energy is used at home, our life quality can decrease due to necessity of huge power for modern instruments	13.5	21.3	19.1	34.8	11.2
17. I believe that I have enough information on renewable energy	12.4	44.9	22.5	19.1	1.1
18. I think that there are no adequate courses about renewable energy	6.7	15.7	16.9	37.1	23.6
19. I think that there should be more courses about renewable energy in our curriculum	64.0	30.3	2.2	3.4	0
20. I want to work on renewable energy field in the future	73.0	23.6	1.1	2.2	0

Renewable Energy

Renewable energy was investigated in items 1,2,4,6,8, and 10. In these statements, the general knowledge and misconceptions about renewable energy were stated and expected students to know these information.

In the first statement, the students' perceptions were investigated whether they know the renewable energy sources are limited or not. Before the courses, 78.7% percent of students believed that the sources are unlimited. However, 93.4% percent selected that they don't agree with this statement after the course.

The second statement explained what the definition of renewable energy is. There is no big difference between before and after the course based on students' perceptions. Before the course 80.9 % percent and after the course 95.5% percent chose that they agree with this sentence. That is, they generally know the definition.

In the fourth statement, one of the biggest misconceptions about renewable energy is whether renewable energy sources are always working or not. Actually, 62.9 % percent of the students believe that it does not work if there is no source of energy before the course. Yet, 24.7% percent of students selected that they are undecided and 13.3% percent selected that they are not agree with this statement. After the course, 75.3% percent think that they agree with this sentence. In fact, it is not a constant source and it works when it reaches sources. May be, technologically some solar cells or wind-tribunes can stock the source and use it when necessary.

Six statement presents that renewable energy sources are always cheaper than other fossil fuels. Before the course, 48.3% percent of the students strongly agree and agree with

this statement while this percent is 7.9% after the course. Indeed, the sources of renewable energy could pay for themselves. But, there are many factors for cost of energy such as its technology, amount of energy necessity. For example, the construction of solar panels is not cheap and it takes decades that compensate for its initial cost.

Regard to eight statement, it was stated that renewable energy never produces environmental pollution. Before the course, 41.6% percent of the student selected “agree” and “strongly agree” with this statement. But, after the course this proportion decreased 16.9. The students consider that environmental pollution is never generated by renewable energy. Actually, during the construction of renewable energy technologies, it can be some environmental pollution.

The last statement about renewable energy was whether the renewable energy would replace non-renewable energy exactly or not. Whereas 74.2% percent of the students believe that it would replace completely before the course, 48.3% percent think like that after the course. Actually, the students believe that renewable energy is good thing, thus it should replace in full. However, the fact is that the technology could not meet its demand.

Solar Energy

Solar energy, which is the most common and used renewable energy source in Turkey, was explored in items 3, 7, 11,13, and 16. As renewable energy items, these items included some misconceptions and knowledge about solar energy.

With regard to solar energy, the third statement told that solar energy could be used in warm regions. While 20.2 % percent thinks that they agree with this statement before the course, only 1.1% percent selected that they agree with this statement after the course. Before the course, they consider that the temperature of area affects the performance of solar cells. However, in the course, it was explained that solar cells could be used effectively under lower temperature and the enough sunlight for solar cells can be observed in cold regions.

In the seventh statement, it was asked whether solar energy is suitable for mass consumption or not. Before the course, 42.7 % percent of the students believe that solar energy is not suitable for mass use because of cost and deficiency of technologies. 82% percent of the students did not agree with this statement. They think that it can be used for mass use. It is fact that after decades of solar energy research and technological progress, pricing decreased and it caused reliable mass use.

The eleventh statement stated that the use of solar panels is environmentally unfriendly because of consuming energy during manufacturing. There are no big differences, which disagree with this statement, between before (68.5%) and after (76.4%) the course. National Renewable Energy reported that panels are paid back within 1 to 4 years based on type of the cell. The solar energy panels continue to function nearly 30 years thus it results in 26 to 29 years of zero- emission electricity.

The necessity of fossil fuels as a back-up energy source in cloudy and rainy days was presented in the thirteen statement. The percentages of students who disagree with this statement are nearly same in before (41.6%) and after (40.5%) the course. The students may think that fossil fuels are obligation in cloudy and rainy days. However, there is no necessity for back-up generator as long as your home is connected to grid.

The last statement about solar energy was that the life quality could be decreased because of necessity of huge power at home when using solar energy. While 39.3% percent of the students disagree with this statement before the course, 46.0 % percent disagree after the course. Actually, again there is no big difference between before and after the course. As mentioned above, homes still stay on grid after installing solar panels, power supply can support energy demand thus the life quality could not be decreased.

Perceptions about their departments and themselves

The perceptions about their departments and themselves were investigated in items 17, 18, 19, and 20.

Before the course, 16.9% percent of the students believe that they have enough information about renewable energy whereas 57.3% percent of the students believe like that after the course. In addition, approximately 60% percent of the students think that there is not enough courses in their departments and 94.4% percent of the students think that there should be more courses about renewable energy in their curriculum. Furthermore; nearly 95.0% percent of the students want to work on renewable energy field in their careers.

Interviews

The success of the course was not evaluated by questionnaire scores but also by interviews. Semi-structured interviews were conducted with 10 students. Some of their comments were presented below:

- I enjoy the course. It gives opportunity for us to learn deep information about renewable energy.
- The course is useful for us. I learn many things and in the discussion seminar I aware different perspective of my friends
- I really like the course. It provides us think in new about renewable energy that is already our subject.
- It is really great course. I learn much new information about renewable energy that is the main subject of my academic career.

Generally, they think that the course increase their awareness about renewable energy. They believe that they should be qualified person about renewable energy because their academic career is already interested in energy systems.

DISCUSSION

Necessity of energy, one of the most important challenges for the entire world, increases from day to day with population and industrialization. It is fact that in order to meet and handle these challenges, qualified people and consciousness of renewable energy are required. This requirement can be achieved by education. With an education, we tried to train and increase students' awareness to meet our future challenges. For this reason, we developed the course and investigated students' perceptions before and after the course by Renewable Energy Awareness Questionnaire.

Before the course, many students had some misconceptions about renewable energy. These misconceptions may cause from students' daily lives. They read and listen a lot of things about sustainability and renewable energy from newspaper, magazines, and TV. The most common misconception is that the availability of renewable energy sources is unlimited. It may cause of the meaning of renewable that refers "inexhaustible" in Turkish language. Another common misconception is about the cost of renewable energy. Majority of the students believe that renewable energy always is cheaper than other energy sources. They think that renewable energy sources are observed from nature thus money is not paid for them. Besides, several students think that renewable energy will replace with non-renewable energy in full. They think that renewable energy is good for nature and it can meet necessity of energy. Thus, they think that only renewable energy should be used in future.

With regard to solar energy, there are two common misconceptions that about its cost and its deficiency for mass use. Students believe that solar energy is too expensive and not

suitable for mass consumption due to technology deficiency. They consider that there is a huge demand for energy at home and solar energy cannot meet this necessity.

As for perceptions about their departments and themselves, they generally think that they are not qualified about renewable energy and there should be more courses about it. Although they are students in Energy System Engineering Department, they even think that they do not have enough information about renewable energy. On the contrary, the large majority, that is nearly all, considers that they want and hope career in renewable energy field. As reported in Emanuel, R and Adams, J.N (2011), students honestly give answers about their self-assessment of their knowledge about renewable energy.

With the course, the students are trained about the renewable energy. The course provides them to think in new and handle their misconceptions. Also, it gives an opportunity to increase their awareness in their own subjects. Thus, after the course, it is observed that there is a decrease in the percent of misconceptions.

As regard to evaluation of students on course, students believe that the course was the great and useful for them. They declared that explanations were deep and clear. The course showed them the different aspects of renewable energy and they learned them.

In this study, it was found that students in Energy System Engineering Department have many misconceptions about renewable energy as reported by Leal Filho (2000). Leal Filho reported that there were many sources of these misconceptions such as knowledge, background, experience, perception, values and context. We think that the main source of these misconceptions arise from daily experiences same as Leal Filho.

To sum up, this study found that although the students were in Energy System Engineering Department, they still had many misconceptions about renewable energy. After the course prepared by researcher many students handled their misconceptions and developed their knowledge about renewable energy.

CONCLUSION

To achieve sustainable future will need the development of awareness and knowledge of engineering students especially energy system engineering students about renewable energy. Mainly, in developing countries such as Turkey, developing renewable energy requires qualified people and consciousness of renewable energy.

Unfortunately, even Energy System Engineering students have many misconceptions about renewable energy. Although, there are many sources of these misconceptions, it should be overcome these misconceptions with education for welfare future.

Thus, in this study, we tried to train energy system engineering students about renewable energy. With this article, we would like to increase perceptions of engineering students on renewable energy and help them overcome their misconceptions about it. Affirmative evaluation of students on the whole learning outcomes show that the course meets the requirements of qualified people about renewable energy.

This study has demonstrated that as the course took place, the perceptions, and misconceptions of students about renewable energy changed. It also recommended that if the single course can achieve the changes of perceptions and misconceptions of students, consistent changes might be succeeded by curriculum. We hope that we could affect teachers and educators with our course to change and develop curriculum about renewable energy for sustainable future.

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