Course Design on Emerging Technologies

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Abstract
This paper discusses the design of Emerging Technologies course under the Software Engineering Department at Atilim University. At Atilim University, a visionary course was needed especially for the senior undergraduate students of Information Technology (IT) related departments. At Atilim University, there are 3 IT related departments which are Software Engineering, Computer Engineering, and Information Systems Engineering. This course should have covered all the emerging technologies so that students can decide properly the fields to work after graduation. Moreover, students should have been encouraged for entrepreneurship to develop their own businesses. As a result, a course covering all emerging technologies was designed. First of all, a comprehensive definition is formed for emerging technologies, and they are classified. The important concepts included in the course are active learning, improving the vision, proposing new technologies, and forecasting the future technologies. The course also includes a project which is designed to be a simulation of an important emerging technology. For the simulation project, software development is requested from the students. This provides students to reconcile emerging technologies and software development, which is the most important technology for IT related students. This paper presents instructor experiences, student feedback analysis, lessons learned and recommendations for other instructors.

Keywords: Active learning, emerging technologies, entrepreneurship, forecasting, new technologies, future technologies

Introduction

This paper discusses the experience of the designed Emerging Technologies course. The discussion includes the design of the course, the course project, the assignments, student experience and reactions, and recommendations for maximizing the benefits of the course.

At Atilim University, a visionary course was needed especially for the senior undergraduate students of IT related departments. At Atilim University, there are 3 IT related departments which are Software Engineering, Computer Engineering, and Information Systems Engineering. This course should have covered all the emerging technologies so that students can decide properly the fields to work after graduation. Moreover, students should have been encouraged for entrepreneurship to develop their own businesses. As a result, a course covering all emerging technologies was designed.

In all fields of life, new technologies are being developed. Already, students enrolling the course come from different departments: Software Engineering, Computer Engineering, Information Systems Engineering, Electronics Engineering, and Industrial Engineering. To survive in the fast and turbulent business environment, graduates and firms should be equipped with enough technology concepts and should be able to follow emerging technologies. Students should be able to determine suitable work fields for entrepreneurship after graduation. This course is designed to contribute to these kinds of needs.

In fast changing business environment of today, invention and innovation concepts are very important. These concepts are analyzed in Kaiserfledt (2006). In Arthur (2007), technology is defined as a means to realize a human purpose. In the fast changing business environment, new technologies should be followed, and these technologies should be used to survive in the fast changing environment. If a novel technology is found, it is called invention. If that technology is used in the business, at that time it is called innovation. Emerging technology is defined as a new technology and it would be a building block of the future technologies. Therefore, emerging technology has a dimension related to future. In addition to following emerging technologies, it is aimed to contribute students to propose new technologies and forecast future technologies.

New technologies depend on existing technologies (Arthur, 2009). In other words, new technologies emerge from variation of old technologies. New technologies rely on principles, which are uses of a phenomenon for some purpose, and combination of existing technologies. Most of the new technologies are built from current technologies (Strumsky and Lobo, 2015). In turn, these technologies are used in the construction of other new technologies. This combinatorial pattern has long been used for inventions and innovations. Students should recognize this combinatorial pattern of technology for the success in their career, for entrepreneurship, and for the readiness in the real world industry.

Emerging technologies should be followed. Otherwise, effects of emerging technologies may harm firms. Firms should be competent in the fast changing environment by following emerging technologies (Gotel et al., 2006). Moreover, firms may change these challenges into opportunities by following emerging technologies. Likewise, workers should survive in this

fast changing environment by developing the required skills according to the emerging technologies. They may also convert these difficulties into opportunities for entrepreneurship, and they may establish their own businesses. The similar case is valid for graduating students. They should develop required skills to follow emerging technologies. They should acquire technical knowledge to thrive in the fast-changing environment. They should be well-prepared with their personal and social skills for real world working environments.

The IT industry expects that graduates from IT programs should adapt to the new technologies easily with little or no additional training. In order to meet this expectation, enough knowledge on emerging technologies are essential for undergraduate students.

Integration of emerging technologies is expected in the evolving IT curriculum (Knox et al., 2006). The integration positively affects students, increases their interest in emerging technology areas, and may yield superior graduate studies.

Consequently, a course is needed, which teaches emerging technologies, and improves the required skills of students.

The rest of the paper is structured as follows. In the next section, related work is given. Then, emerging technologies and the used methodology are described. In the following section, the course is described. Student awareness on emerging technologies is measured after the description of assignments. Lastly, discussion is made, and conclusions are stated.

Related Work

Students should be ready for real world problems and situations. Therefore, some courses are used to directly prepare students for these purposes. In Nickerson (2006), how to design Information Systems Technologies is taught. In Gotel et al. (2006), how to develop global software is taught. In Meawad (2011), agile practices are embedded in a software engineering course to prepare students to real world working environments. In Todd et al. (1993), an engineering course is designed to satisfy the needs of industrial customers in industrial design and manufacturing projects. In Gorka et al. (2007), a capstone course is designed to meet industry expectations in conjunction with industry. In Coppit and Haddox-Schatz (2005), real software development is experienced by students, which will be useful after graduation. Similarly, this course contributes to prepare students to the real world situations.

Students should be active in the process of learning (Bonwell and Eison, 1991). They should not only listen but should also be engaged in the learning process by reading, writing, and discussing. They should perform analysis, synthesis, and evaluation tasks which are high-level thinking tasks. They should be involved in doing things and thinking about what they are doing. The most common way to engage students in active learning is by stimulating a discussion.

In the course, active learning is applied. In this model, students actively take role in the learning process and interact with other students (Bonwell and Eison, 1991). A good example of active learning is applied in Ludi et al. (2005) on software engineering. In the course, assignments are designed for this purpose especially. The assignments stimulate discussions in the course that support active learning.

The most important property of emerging technologies is novelty (Rotolo et al., 2015). Besides novelty, they show fast growth rates (Small et al., 2014; Cozzens et al., 2010; Srinivasan, 2008). Therefore, they exert a momentous impact on nearly all domains in the economy. In Srinivasan (2008), emerging technologies are examined according to their sources, characteristics, and effects. Emerging technologies dramatically alter industry structures, with significant policy and economic implications. Accordingly, the sources, characteristics, and effects of emerging technologies introduce some threats to firms. Firms should cope with these threats, and they should try to convert them to opportunities to survive in the fast-changing environment.

Emerging technologies have the power to transform a current industry or create a new industry Srinivasan (2008). In Small et al. (2014) and Cozzens et al. (2010), identification of emerging technologies is investigated. Because emerging technologies present both threats and opportunities, they should be identified to achieve competitive advantages in the market. In Cozzens et al. (2010), a quantitative approach is outlined to identify emerging technologies. However, the most prevalent approaches are expert-based or qualitative, and they are prone to errors. Therefore, the quantitative approach based on literature-based data may overcome the errors.

In Hariss and Patten (2015), how emerging technology topics related to security are determined is discussed. Especially, experts determine the topics, and they evaluate them to fix their number and content. Determining the topics is a continuous process because new technologies should be included timely. In [25], areas of emerging technologies related to information technology are determined for civil engineering. The areas are determined by students according to the applicability of them in civil engineering. In Elhouar (2006), a Delphi-based process is applied to meet experts and to reach a consensus on the emerging technology topics related to STEM education.

Emerging technologies are defined and its characteristics are analyzed in Halaweh (2013). In Rotolo et al. (2015), definitions of emerging technologies are listed in a chronological order. Basically, emerging technologies are defined as new technologies in these papers. In Boon and Moors (2008), Hung and Chu (2006) and Gorka et al. (2007), emerging technologies are defined as new technologies which will influence the society especially the economy. In other words, emerging technologies are

related with the future. In Small et al. (2014), emerging technologies are related with the terms novelty and growth. In short, for the definition, the following concepts are needed: novelty, growth, and future. In this paper, these terms are combined to define emerging technologies. The resultant definition is the following: emerging technologies are new technologies which would be building blocks of the future technologies.

Emerging Technologies

Emerging technologies are new technologies which would be building blocks of the future technologies. In other words, emerging technologies are new for today and will survive in the future. To collect examples of emerging technologies, internet is scanned for the news of emerging technologies. Approximately 3000 news related with emerging technologies are reviewed.

For the efficiency of teaching, examples of emerging technologies should have been classified. Therefore, suitable classifications are searched. Except Gartner Hype Cycle, no classification is found for emerging technologies. In the Gartner Hype Cycle for emerging technologies (Research, 2017), there are only specific technologies. These are not suitable for technology grouping. Also, nearly all of them are related with future technologies. Since there is no applicable classification, the required classification is formed.

The Methodology

First of all, technology news is collected. For the collection of technology news, Google Alerts (2017) is used. Google Alerts is a mail notification service according to the search terms. Summaries of search results are sent to subscribers to the service. Subscribers create alerts, and take mails periodically.

For the creation of alerts, firstly well-known new technology areas are selected. These are robots, drones, energy, 3D printing, health, agriculture, virtual reality, augmented reality, transportation, space, nanotechnology, internet of things, defense, security, smart devices, wearable devices, and artificial intelligence. For each of these determined groups, an alert is created. Also, some other alerts are created to capture news about other technology groups and future technologies. The following shows the search terms of these additional alerts one by one in the google search format:

- "emerging technology"
- “new technology”
- innovation OR invention
- "future trend" OR futurology OR "futures study"
- ("science fiction" OR "Sci-Fi") technology
- futurologist OR futurist
- patent

Daily, the alert mails are scanned for news about technologies. Found technologies are reviewed one by one. If a found technology is a new technology and it is also an invention or an innovation, it is classified according the aim of the new technology. If the new technology is fit to a determined group, then it is attributed with the determined group. Some new technologies are not suitable for determined groups. Because they have different dimension as technology and their counts are increased. For those, new grouping with a related name is formed. At the end, all groupings are reviewed, and final 33 groupings are formed. These are named as emerging technology classification groups. The following shows the steps of the methodology:

- Take a technology
- If it is a new technology, and it is also an invention or an innovation, separate it as an emerging technology
- Consider the aim of the emerging technology, if it is fit to an existing determined group, attribute it with that group
- If it is not suitable to an existing group because its count is increased and it has different dimension, then create a new group for it and attribute it with the new group
- Apply these steps until enough number of emerging technologies is considered
- At the end, review all the groups and their related technologies, make them consistent and finalize the groups

The described methodology is applied to the technologies. Consequently, final groupings are formed. Table 1 shows formed classification groups, their related contents and their news counts.

The Course

This course is named as SE426 Emerging Technologies which is taught in the Software Engineering Department at Atilim University. This course is designed for senior undergraduate students.

The course is organized with a theory part followed by discussion part. Both parts are covered every week. In the first part, the technology as a science is taught. For the theory part, the following topics are selected. Each topic is detailed mainly from the book Arthur (2009). The topics are:

- Emerging Technology
- Disruptive Technologies
- The 3D Printing Revolution
- The Evolution of Technology
- Innovation
- Combination and Structure
- Phenomena
- Problem Solving
- Origin of Technologies
- Technological Revolution
- Economic Revolution

- Forecasting

Table 2 shows the curriculum of the course. In the first column, the weeks of the course are seen. In the second column, there are the topics which are covered in the corresponding weeks. In the third column, assignment topics are placed. In the last column, emerging technology classification groups are shown. In the discussion part of the course, some examples from these groups are presented and discussed.

The course is designed with two exams as a midterm and a final. The contribution of the midterm is 20%, whereas the contribution of final is 30% to the total grade. The remaining 50% is divided for assignments and a project. 10 small assignments are prepared nearly for each week of education time. Each takes 2% and totally 20% is allocated for them. The project is scored with 30.

Table 1: Classification Groups

Classification Group	Content	News Count
Robots	technologies related with robots	169
Autonomous Movable Devices	drones, autonomous vehicles, unmanned aerial vehicles, self-driving cars, etc.	96
Energy	technologies related to energy, battery technologies, solar energy, wind energy, wave energy, etc.	249
Light	technologies related with light, optic technologies, laser, etc.	48
Electromagnetics	technologies related to electromagnetics, radio wave technologies, microwave technologies, etc.	34
3D Printing	technologies related with 3D printing	187
Health	technologies related with health, surgery technologies, genetics, drugs, biotechnology, hygiene technologies, artificial organs, etc.	314
Food	technologies related with food, technologies related with nutrition, new foods, etc.	135
Agriculture	technologies related with agriculture	99
Sports	technologies related with sports, sportswear, new sports tools, etc.	72
Virtual Reality	technologies related with virtual reality	37
Augmented Reality	technologies related with augmented reality	31
Transportation	technologies related with transportation	161
Communication	technologies related with communication	118
Space	technologies related with space	107
New Materials	technologies related with new materials, graphene, perovskite, etc.	62
Nanotechnology	technologies related with nanotechnology	71
Internet of Things	technologies related with internet of things (IoT), smart home technologies, sensor technologies, etc.	106
Camera	technologies related to sight sense, camera technologies, etc.	221
Presentation	technologies related with presentation, screens, displays, LED screens, etc.	72
Perception	technologies related with perception, technologies used to perceive objects especially humans, retina scan, palm scan, etc.	24
Sound	technologies related with sound, voice technologies, ultrasound technologies, hearing technologies, etc.	45
Defense	technologies related to war and defense, etc.	109
Security	technologies related with security, digital security, cyber security, physical security, etc.	27
Cryptography	technologies related with cryptography, blockchain, bitcoin, cryptocurrencies, etc.	53
Wearable Devices	technologies related with wearable devices, smart rings, smart watches, smart glasses, etc.	79
Smart Devices	technologies related with smart devices, mobile phones, etc.	51
Computing	technologies related with computing, computers, memory technologies, quantum computing, etc.	78
Artificial Intelligence	technologies related with artificial intelligence	99
Data	technologies related with data, big data, data preservation, etc.	32
Social Media	technologies related with social media, facebook, twitter, instagram, etc.	98
Software	technologies related with software, software development technologies, etc.	28
Common	common technologies, technologies used in cities by governments, technologies related with education, recycling technologies, prevalently used technologies, etc	67
TOTAL		3179

Table 2: Curriculum

WEEK #	TOPIC	ASSIGNMENT TOPIC	EMERGING TECHNOLOGY CLASSIFICATION GROUPS
1	Emerging Technology		
2	Disruptive Technologies	Robots	Robots, Autonomous Movable Devices
3	The 3D Printing Revolution	Energy	Energy, Light
4	The Evolution of Technology	3D Printing	3D Printing
5	Innovation	Health	Health, Food, Agriculture, Sports
6	Combination and Structure	Virtual Reality	Virtual Reality, Augmented Reality
7	Midterm		
8	Phenomena	Transportation	Transportation, Communication, Space, New Materials, Nanotechnology
9	Problem Solving	Internet of Things (IoT)	Internet of Things, Camera, Presentation, Perception
10	Origin of Technologies	Security	Defense, Security, Cryptography
11	Technological Revolution	Wearable Technologies	Wearable Devices, Smart Devices, Computing
12	Economic Revolution	Artificial Intelligence (AI)	Artificial Intelligence, Data, Social Media, Software
13	Forecasting		Sound, Electromagnetics, Common
14	Review		

For the project, a simulation of an important emerging technology is designed. As an important technology, 3D printing simulation project is assigned. This project is a software development project. Through this project, students realize the effects of the related emerging technology. Moreover, software development is already an important technology. It is used in the project, and students realize its importance also. In addition, the course is designed for especially IT related departments so that the project is well-matched with the departments. In short, students apply practical reflection of an important emerging technology in the course project.

Assignments

Nearly for each week of the education period, an assignment is given. Totally, there are 10 assignments. After the first week, assignments are started. The assignments and the emerging technology classification groups are aligned. The assignment topics are synchronized with a classification group that is discussed in the class.

The assignments are designed as simple to involve the students into the class commitments. The active learning component of the course is assignments (Bonwell and Eison, 1991). The format of the 10 assignments are the same. The students are asked to search a new technology about the given topic. That technology should be different from the new technologies found by other students. Otherwise, the grade will be divided by the count of the same new technologies. In addition, students are asked also to propose a new technology depending on the found new technology. In other words, students propose a new technology which uses the new technology they searched. Also, the proposed new technologies should be different from the other proposed new technologies of the students. Weekly assignments increase the contribution of students to the class works. At the end of the semester, some students thanked for the course especially for the assignments and discussions because the course fostered them to follow emerging technologies.

Awareness on Emerging Technologies

A simple survey is constructed to measure the awareness of students about emerging technology topics. The survey has only one open-ended question which is "Write down all new technologies you know." This survey is conducted at the beginning of the course. Table 3 shows the results of the 13 enrolled students.

On average, students know 3 classification groups at the beginning. In other words, they know 9% of emerging technologies.

At the end of the course, the same survey is conducted again. The results are shown in Table 4. Table 4 shows that nearly 14 classification groups are covered on the average. Consequently, approximately 43% of emerging technologies are known by students. This means that students learned approximately 5 times more new technologies and they followed nearly half of the emerging technologies. This shows that vision of the students is improved, and can be used for potential entrepreneurship.

Discussion

The designed course is unique in the sense that both theory and practice parts have nearly equal importance. Usually, in emerging technologies courses, some emerging technology topics related to a specific field are selected and covered. In other similar courses, only one emerging technology is embedded in curriculum in addition to the theory part. In the opposite direction, and it is rarely applied, only technology as a science is covered.

In the theory part of the course, technology is covered without concrete applications. Evolution of technology is discussed, and interesting features of technologies are examined. Especially, disruptive technologies topic is enjoyed by the students. Moreover, innovation and phenomena topics are appreciated by the students.

The course tries to cover all the emerging technologies. Therefore, a general classification is

formed about emerging technologies. All the emerging technology topics are distributed in the curriculum.

Table 3: First Survey about Emerging Technologies

Classification Group	Student Numbers													Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Robots	1		1		1					2			2	7
Autonomous Movable Devices		1				1	1			1			1	5
Energy								1						1
Light														0
Electromagnetics														0
3D Printing									1		1			2
Health	1							2	1			2		6
Food														0
Agriculture														0
Sports														0
Virtual Reality						1								1
Augmented Reality														0
Transportation		1			1									2
Communication									1					1
Space				1										1
New Materials														0
Nanotechnology														0
Internet of Things							1							1
Camera														0
Presentation														0
Perception						1		1						2
Sound														0
Defense	1			2			2					1		6
Security												1		1
Cryptography													1	1
Wearable Devices										1			2	3
Smart Devices		1						2			1			4
Computing														0
Artificial Intelligence		1												1
Data														0
Social Media														0
Software														0
Common														0
TOTAL	3	4	1	3	2	3	4	6	3	4	2	4	6	45
# of Classification Groups	3	4	1	2	2	3	3	4	3	3	2	3	4	3
Percentage of Coverage	9	12	3	6	6	9	9	12	9	9	6	9	12	9

From these emerging technology topics, good technology examples are explained to the students. Future potentials of these technologies are discussed with the students.

As an instructor, it is experienced that some proposed technologies and predictions about future technologies become superficial. Therefore, assignments may be improved via a former check and feedback before class. According to feedback of students, the course fosters learning. Students indicate a positive learning experience.

For active learning of students, a simple assignment format is prepared. 10 assignments are given to the students. For each assignment, students find a new technology about the emerging technology topic of the week. Also, they should propose a new technology based upon their found new technology. Consequently, they search emerging technologies, and think on them to propose new technologies. Students explain their found new technologies in the class. Other students comment about that technology whether it is an emerging technology or not. Moreover, new technology proposals are explained by the students,

and discussed every week. As the students learn about different emerging technologies, they begin to produce interesting predictions about the future and their participations to the discussions are increased. From the technology examples, their relation to the science of technology is associated. Especially, these relations increase competence about prediction of future technologies.

Table 4: Second Survey about Emerging Technologies

Classification Group	Student Number													Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	
Robots	1	1		3		1	1	1	1	2	1	1	5	18
Autonomous Movable Devices	2	1		1		1	2			3			3	13
Energy	5		1	1	1	2	2	1	1		1	3		18
Light	1			1	1	1						1		5
Electromagnetics		1				2		2		1			2	8
3D Printing	1	1	1	2	1	1	1	1	1	3	1	2	2	18
Health	2	1	1	3	4		3	2	1		4	5	3	29
Food			1				1					1		3
Agriculture										1				1
Sports							1							1
Virtual Reality					1	1	1				1		1	5
Augmented Reality	1													1
Transportation	1	1			1	6	1			1	1	2	1	15
Communication					1			1	1					3
Space				3	2	1						1		7
New Materials	1	1												2
Nanotechnology	2	1	1		2									6
Internet of Things		1	2			1	4		2		2	1	1	14
Camera				1									1	2
Presentation	2				1							1	1	5
Perception	1			3		1	2	1		2		1		11
Sound							1					1		2
Defense	2	1		5	1		2			1			1	13
Security	1	1		1			2	1		1	1	1	1	10
Cryptography							2						1	3
Wearable Devices	1	2				2	3	1		1	3	1	5	19
Smart Devices	2	2				1	2	5			3	1	3	19
Computing			1		1	2	1	2			3	1		11
Artificial Intelligence	1	1		1		2	2		1	1	1	1	2	13
Data							1	3				1		5
Social Media								2						2
Software				2			4			2		1	2	11
Common		1		1			1				1			4
TOTAL	27	17	8	28	17	25	40	23	8	19	23	27	35	297
# of Classification Groups	17	15	7	14	12	15	22	13	7	12	13	19	17	14
Percentage of Coverage	52	45	21	42	36	45	67	39	21	36	39	58	52	43

Conclusion

In this paper, the design of Emerging Technologies course is described. This visionary course is divided into two parts: theory and practice. In the theory part, technology is taught as a science. In the practice part, examples from the classified emerging technologies are discussed with students. Students are encouraged to propose new technologies, and to forecast future technologies in order to easily follow emerging technologies. This course contributes students to improve their invention and innovation skills.

A comprehensive definition is constructed for emerging technologies. Active learning is applied via designed weekly assignments. Students analyze, synthesize and evaluate current emerging technologies

through assignments. They propose new technologies and predict future technologies based on current emerging technologies. They try to find different technology from the technologies found by other students for all of these current, proposed and future technologies. Therefore, they do high level thinking tasks, and they discuss whether the technologies are emerging technologies or not based on the constructed definition.

To this course, students are enrolled from different engineering departments, who are interested in IT. This course fulfills a vision which should have been owned by senior level technical students. It is suggested that this kind of visionary course is valuable for students of IT related departments. This course contributes students to select appropriate work fields after graduation. Moreover, students are encouraged for entrepreneurship.

The works related to the assignments are designed to provide active learning. Especially, the assignments about emerging technologies and their discussions are valuable and high satisfactory for students and instructors.

For this course, two surveys were established to measure the awareness of students on emerging technologies. According to the results, students become to comprehend nearly half of the emerging technologies at the end of the course.

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