

AXIOMATIC DESIGN AND IMPLEMENTATION OF SERVICE-ORIENTED UNIVERSITY CLASSES: EMOTIONS AND SENSES

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ABSTRACT

While university education is a part of the service economy, there have been no formal efforts to design university classes as a service. Here we embark upon the Axiomatic Design process to develop university classes with an eye toward including functional requirements found in other services. Drawing inspiration from world renowned university classes and deeply engaging services, we identify functional requirements related to emotions and the senses. Prototype functional requirements and design parameters that can be used to support the design of any service-oriented course are developed. We discuss the application of these prototypes to the design of a university course. The new course is being implemented and evaluated in the Spring 2013 semester at KAIST.

Keywords: Axiomatic Design, university education, service experience, service-oriented university courses.

1 INTRODUCTION

Billions of people have spent decades as the customers of educational services, up to and including university education. Such devotion to education is necessary as it is an essential factor in the success of individuals and nations. As such, there have been decades of research focus on education, and there have been marked improvements; c.f., [Bagchi, 2010]. Yet, despite this focus, and the fact that education is classified as part of the service economy, there have been no efforts to employ formal design methods to create university classes that exploit the fact that they are services. We employ Axiomatic Design [Suh, 1990; 2001] to develop prototype functional requirements (FRs) that focus on cognitive domains, learning styles, emotions and the senses. We hope they can be used to create exceptional service-oriented university classes. We exploit the new FRs to redesign a sophomore general elective class at KAIST entitled Introduction to Operations Research. The new design is being implemented and evaluated in the Spring 2013 semester.

2 RELEVANT LITERATURE & CONTRIBUTION

Much effort has been devoted to the study of education. We next briefly discuss traditional methods, service oriented methods and formal design methods in education. Our goal is to review the major directions and provide perspective that will enable us to clearly distinguish our contribution here.

2.1 TRADITIONAL EDUCATIONAL LITERATURE

There is a vast body of work on education and numerous journals devoted to it. Some of the significant thrusts include the development and application of knowledge taxonomies as exemplified by [Bloom *et al.*, 1956]. In such work, hierarchies of knowledge, starting from rote memorization and culminating in complete mastery of a subject as demonstrated by synthesis, evaluation and creation skills, are developed and exploited in the educational process. Another key development is the study and use of learning styles as in [Davis, 2007]. Each student has their own method or combination of methods for learning that work best for them; these are called learning styles. They include visual, aural, logical, physical and social learning styles, among others. Multiple styles can and should be employed when guiding the learning process for a group of students.

2.2 SERVICE PERSPECTIVES IN EDUCATION

Education is part of the service economy, which broadly speaking, consists of those activities that are neither agriculture nor manufacturing. A host of tools have been developed to guide the creation and management of activities in the service sector. These include service classification models (e.g., the service process matrix of Schmenner [1986]), KANO needs (introduced in [Kano *et al.*, 1984]) and evaluation instruments such as SERVQUAL (suggested in [Parasuraman *et al.*, 1985] and [Parasuraman *et al.*, 1988]). All of these are relevant in the context of education – it is a service – and there have been some efforts to employ such methods. Focusing on basic and performance needs, Cuthbert

[1996], Joseph *et al.*, [1997], Aldridge *et al.*, [1998], Sahney *et al.*, [2004] and Tan *et al.*, [2004] have used methods such as SERVQUAL in efforts to improve the overall university experience. They consider administrative issues such as course scheduling, support facilities and the like, but not individual classes. In [Kim *et al.*, 2011], KANO excitement needs were studied in the context of a university course.

One element of service that has received considerable attention is the application of humor in the classroom. Skinner [2010] provides a brief discussion on the topic and asserts that there are numerous reasons to use humor in the classroom. Berk [2000] suggests that humor on exams can help student performance. These and other efforts of their kind represent what we consider an important perspective. This method is much more common in services such as movies, theatre and television; it has significant value for students. While many have considered humor for education, other facets of service have not been studied.

2.3 FORMAL DESIGN IN EDUCATION

In addition to a service-perspective, we are also concerned with the use of formal design methods in education. There are some papers in this realm. Quality Function Deployment (QFD) has been considered for course design; c.f., [Sahney *et al.*, 2004] and [Bagchi, 2010]. The focus is on ensuring quality in courses with the standard design.

Of particular relevance for our approach are the three papers that, to our knowledge, have discussed the use of Axiomatic Design (AD) for education. The authors of [Tate *et al.*, 2004] address the necessity of teaching Axiomatic Design (AD) and use AD to design such a course. In [Tate, 2005], the design of an internet-based platform for a mechanical design course is discussed. These two papers focused on specific courses. The general use of AD for course design is studied in [Thompson *et al.*, 2009]. Many key issues related to the use of AD for course design are considered. Prototype functional requirements that could be used for any course are developed. As relates to course content, the focus of these AD papers is on incorporating traditional teaching strategies (learning styles and knowledge taxonomies) and organizational methods.

2.4 CONTRIBUTION AND ORGANIZATION

There is considerable evidence to suggest that taking a service orientation in education will improve service quality and educational outcomes. Humor is an element of many services such as comedies, movies, books and theatre. Good presentations are enriched by the use of humor. There is a body of work revealing the value of humor in the educational context; c.f., [Berk, 2000] and [Skinner 2010]. However, delivering humor is not the only service action that one can take. In restaurant service, repeating a customer's order, kneeling next to the table, drawing cute faces on the bill, touching a customer, etc., have statistically significant implications for server tips. Is it possible that other such service oriented actions can improve educational service? In [Kim *et al.*, 2011], experiments were conducted to investigate service actions such as giving candy to students who answer questions in class or calling students by their name. These results suggest, and it is intuitively clear that, designing a

course with a general service orientation may lead to significant improvements in perceived quality and outcomes.

Inspired by the success of humor in education, the monetary value of KANO excitement needs in restaurant service [Lynn, 1996] and experiments to demonstrate that service-oriented actions other than humor can improve education [Kim *et al.*, 2011], we aim to design service-oriented university classes. Following the Axiomatic Design (AD) methodology, we collected hundreds of customer needs for university classes. From these, we extracted prototype functional requirements (FRs) that could be considered for use in the design of any university class. We focus on incorporating functions present in other services; namely, we strive to inspire emotions and stimulate the senses of students in the context of the course material. With these candidate FRs in hand, we proceed to redesign a general elective sophomore-level university course at KAIST in South Korea entitled "Introduction to Operations Research". The resulting design is being used and evaluated in the Spring 2013 offering of the course.

The contributions of this work follow. For what is to our knowledge the first time, we

- Propose the idea of a service perspective in university course education that includes the stimulation of emotions (not only humor) and senses;
- Develop a list of prototype FRs and DPs in an effort to achieve this general service-oriented perspective;
- Design a university course that includes, not only educational functions, but service-oriented ones such as experiencing emotions;
- Discuss the implementation of such a course at KAIST.

It is our hope that the resulting course will provide a truly exceptional experience for the students with the potential to transform their perspective on the world. The inclusion of emotional content has the potential to draw deep connections between the course material and the students' lives. There are a few existing examples of courses that have dramatic influence on students, including Alternatives to Violence [McCarthy, 2013] and a course discussed in [Pausch, 2008]). Such courses were crafted by skilled artisans. By extracting the essence of these experiences, which we believe center on the instilling of emotions related to the course material, the service-orientation may enable the creation of remarkably different educational experiences in a structured manner that can be replicated.

The paper is organized as follows. In Section 3, we review the results of our stakeholder needs evaluation. Prototype FRs and DPs are provided in Section 4. In Sections 5 and 6, we discuss the new course design and implementation, respectively. Concluding remarks are provided in Section 7.

3 STAKEHOLDERS AND BENCHMARKING

Seeking to create service oriented university classes that have the potential to transform students' lives, we pursued the Axiomatic Design process. We began with a consideration of the stakeholder needs and related benchmarking. These needs were extracted from numerous sources, organized and distilled into about 250 Customer Needs (CNs) for use in the design process. The details of the stakeholder concerns evaluation are given next. The CNs are then reviewed. Selected details

about Bloom's Taxonomy of knowledge, learning styles, emotions and senses are then discussed.

3.1 BACKGROUND RESEARCH

To identify a comprehensive list of stakeholder concerns that can then be condensed into our Customer Needs (CNs), we considered ten disparate sources. These were:

- University student surveys;
- Prior course evaluation survey scores and comments;
- Interviews with the KAIST Dean of Education 3.0;
- Interviews with professors who have received excellent teaching awards from KAIST;
- On-line articles and videos about teaching;
- Books on teaching authored by celebrated professors;
- A popular non-fiction Korean television program where lecturing is the format;
- Academic literature on service and education;
- Our own perspectives on what is good about various services; and
- Academic literature on emotions/senses.

Brief details on some of these sources are provided next.

The university student survey was completed by 72 students in June 2012. We sought information on what they perceive as the most important factors for university classes, lectures and professors. We obtained student evaluation results and SERVQUAL surveys conducted in prior offerings of our target course. (These were obtained from the authors of [Kim *et al.*, 2011].) These provided us with potential areas that students might consider as important. The academic literature on service included the seminal papers by [Parasuraman *et al.*, 1985] and [Parasuraman *et al.*, 1988].

This background research revealed that emotions and senses play key roles in good service. Korean Air is a multiple award winner for the best air carrier in the world. They are always kind and helpful and the environment is comfortable; customers feel welcome. Exceptional movies engage our minds and hearts. Popcorn and soda further stimulate our senses at the theatre. The exceptional university classes that we studied included surprise, amazement (e.g., [Pausch, 2008]) and sometimes negative emotions such as horror [McCarthy, 2013]. The stimulation of emotions and senses are essential in extraordinary services that we remember. So too may these be helpful in engaging students.

3.2 CUSTOMER NEEDS

We organized and condensed the stakeholder requirements obtained from these disparate sources into 259 customer needs (CNs). These were categorized into three main classes of needs: teaching staff, lecture/discussions and students. The teaching staff category contains 79 CNs associated with the staff's knowledge of the material, attitude toward the material and the students, and their preparedness for class meetings. The lecture category contains 160 CNs associated with the contents of class meetings, lectures and discussions. Lecture delivery methods, the exhibition of attitudes (such as kindness and respect toward the students), exhibition of emotions, stimulation of the senses and classroom environment were included. There were 20 CNs in the third category of student. These CNs related to the

student's response to the class and included such needs as student ability, attitude and preparation. They focused not only on themselves, but on the attitudes of the other students. This third category reflects the fact that classroom learning occurs in a social environment. Participation by students can improve the experience.

From these CNs, several other broad categories were also observed. These included content, delivery, evaluation and overall course experience. Content refers to the knowledge gained by the students in the course. (We consider knowledge about the structure of the course itself in this category.) Delivery relates to how the knowledge is transmitted or communicated. Evaluation refers to the manner in which the student absorption of the knowledge is measured. The overall class experience relates to the manner in which the connections between the knowledge and the students' lives are established. These categories will form the basis of our FRs.

3.3 COGNITIVE DOMAINS FOR LEARNING

The authors of [Bloom *et al.*, 1956] identified six cognitive domains of learning objectives: knowledge, comprehension, application, analysis, synthesis, and evaluation. They are briefly described next:

- The knowledge domain refers to the act of remembering data or information. The recall of basic concepts such as definitions and theorems are included.
- The comprehension domain refers to the act of understanding a topic as opposed to just remembering the facts. It implies an understanding of how the topics relate to each other and intuition of their implications.
- The application domain refers to the capability to apply knowledge from the first two domains. Solving example problems using the topics is included.
- The analysis domain is a more advanced application domain. This domain can be satisfied studying situations and determining how the topics can be used in that context. Real life applications are at the highest level in this domain.
- The synthesis domain involves creative problem solving in which seemingly disparate concept or ideas within the material are employed together.
- The evaluation domain includes making judgements about the value of ideas or materials.

These six domains can be considered when developing course material. Different types of learning activities may be employed for each. Bloom's taxonomy is typically depicted as a pyramid (Figure 1). This suggests a hierarchy of domains. Lower level domains form a base for the development of higher ones.

We will explicitly include these learning domains in our prototype functional requirements. The course designer should select which of the domains they wish to target for each particular learning module.

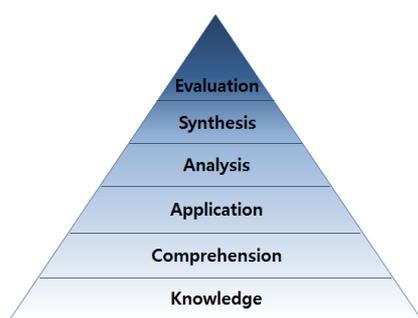


Figure 1. Bloom's Taxonomy in the cognitive domain.

3.4 LEARNING STYLES

A service-oriented educational experience should be student-centric. The focus for the delivery of knowledge will be on how students learn rather than on how the instructor teaches. Since every student is different, and they can have dramatically different preferences in the manner in which they learn, the learning experience should consider methods to satisfy potentially diverse needs.

In [Davis, 2007], the literature on learning styles was organized into seven convenient categories. Students may prefer more than one of these styles.

- Visual learners receive information best via images, pictures, and colours. Material organized and delivered with visual aids can be effective when targeting these students.
- Aural learners prefer sound and music. Material presented via music, songs or rhythm is preferred.
- Verbal learners best receive material via words. Written or spoken words help them to absorb material.
- Physical learners prefer action. They use their body and senses, so that touch, action, and movement support their learning process.
- Logical learners thrive with a logical and stepwise approach. They may have an advantage in understanding mathematics and sequential contents.
- Social learners prefer to learn via communicating with each other. Group tasks are good ways to engage them.
- Solitary learners tend to study alone. Individual homework or activities may be helpful to them.

It can be difficult to address the specific needs of all students in a university class simultaneously. Creating subgroups of students and providing them with customized learning material is typically infeasible. One option is to attempt to deliver each topic using several interleaved styles. An issue that may arise is that some material may not be suitable for all styles. For examples, the rigorous proof of vector calculus theories may not be easily delivered with aural styles (music, song, etc.).

To include these learning styles in our prototype FRs, we will include all of them. The course designer should then select those styles that they want to exploit.

3.5 EMOTIONS

A fundamental feature of other services, particularly in the entertainment category as well as the extraordinary classes

studied during our benchmarking, is the stimulation of emotions. Humor, empathy, excitement and many others are common. Humor is well known to improve learning experiences. In [Kim, 2011], various service activities were conducted and connected with a perception of the instructor's compassion or caring (termed kindness in their study). We believe that establishing emotional connections between the students and the course material may significantly improve their retention and overall satisfaction with the experience.

In [Parrott, 2011], emotions are organized in a hierarchy (Table 1). While what is possible will depend on the course topics, emotions can be used in many ways in a university course. Joy is an important emotion that can be employed. Humor is a type of joy that has been shown effective in educational contexts. Pride is also in the class of joy. It can be instilled in students by impressing upon them the importance of the material or helping them to understand how challenging the material that they are mastering is. Students can be filled with surprise via demonstration. Chemistry classes often use exploding chemicals.

In [Pausch, 2008], it is described how a class professor destroys a fax machine with a sledge hammer. Unexpected and lively demonstrations in class can serve to instill surprise. Though it may be less clear initially, negative emotions such as anger, sadness, or fear can be exploited as well. Pity or horror have been used to demonstrate the suffering of animals in [McCarthy, 2013]. Pity for persons who suffer can be used to inspire students to care about a particular problem. Solving the problem via the course material may then show them the value of the material and encourage them to care about the power or possession of that knowledge.

A key here is not only to inspire emotions, but to inspire them in the context of the course material. It is through that link that will we hope to build deep connections between the student and the course material.

There are numerous methods that can be used to inspire emotions in others. These include providing knowledge that may inspire the emotion, demonstrating an emotion oneself (via voice timbre and body language), stating that a particular emotion should be felt and appealing to the senses.

3.6 SENSES

The stimulation of the senses can be helpful to improve the perception of service quality in university education. There are five human senses: sight, touch, smell, taste and hearing. To this we add the logical sense, which is the perception that an argument "makes sense". Note that senses can be exploited in support of the various learning styles.

In our surveys, many sensory needs were uncovered. Clearly visible teaching materials and the neat appearance of the teaching staff were mentioned. Touch, as in a comfortable temperature, and smell, as in clean fresh air, were mentioned in relation to the classroom. In [Kim, 2011], candy and treats were given to the students; this stimulates the taste sense. This is perhaps related to the sale of refreshments at movie theatres. Students were also concerned about the appropriate volume and clarity of an instructor's voice. Logically clear course materials were also a concern.

Table 1. Parrott’s hierarch of human emotions.

First level	Second level	Third level
Love	Affection	Adoration, affection, love, fondness, liking, attraction, caring, tenderness, compassion, sentimentality
	Lust	Arousal, desire, lust, passion, infatuation
	Longing	Longing
Joy	Cheerfulness	Amusement, bliss, cheerfulness, gaiety, glee, jolliness, joviality, joy, delight, enjoyment, gladness, happiness, jubilation, elation, satisfaction, ecstasy, euphoria
	Zest	Enthusiasm, zeal, zest, excitement, thrill, exhilaration
	Contentment	Contentment, pleasure
	Pride	Pride, triumph
	Optimum	Eagerness, hope, optimism
	Enthrallment	Enthrallment, rapture
	Relief	Relief
Surprise	Surprise	Amazement, surprise, astonishment
Anger	Irritation	Aggravation, irritation, agitation, annoyance, grouchiness, grumpiness
	Exasperation	Exasperation, frustration
	Rage	Anger, rage, outrage, fury, wrath, hostility, ferocity, bitterness, hate, loathing, scorn, spite, vengefulness, dislike, resentment
	Disgust	Disgust, revulsion, contempt
	Envy	Envy, jealousy
	Torment	Torment
Sadness	Suffering	Agony, suffering, hurt, anguish
	Sadness	Depression, despair, hopelessness, gloom, glumness, sadness, unhappiness, grief, sorrow, woe, misery, melancholy
	Disappointment	Dismay, disappointment, displeasure
	Shame	Guilt, shame, regret, remorse
	Neglect	Alienation, isolation, neglect, loneliness, rejection, homesickness, defeat, dejection, insecurity, embarrassment, humiliation, insult
	Sympathy	Pity, sympathy
Fear	Horror	Alarm, shock, fear, fright, horror, terror, panic, hysteria, mortification
	Nervousness	Anxiety, nervousness, tenseness, uneasiness, apprehension, worry, distress, dread

By taking a step back from these specific concerns and considering the larger context, the senses, one can consider methods to stimulate the senses that are not commonly used in this context and perhaps novel. The sense stimulating element need not be part of the course material. For example, one could spray air freshener or clean the desks prior to class with lemon scented cleaner. Sparkling clean chairs, desks and floor or soothing (learning friendly) colors might support the learning experience. Candy, doughnuts or pizza could bring joy to the student via the satisfaction of their taste sense. (Note here that the goal would not be to “bribe” the students to give a better course evaluation just prior to the survey, but to generally provide them with a pleasing sensory input through the learning experience. Although, it is possible the “bribe” approach is effective in increasing the course evaluation scores.)

Sensory stimulus directly related to the course material or the inspiration of emotions is also possible. Clear visual aids or physical objects may support learning objectives and the sense that the course is logically clear. (This relates to the learning styles.) When making efforts to inspire emotions, it is well known that even instrumental music can magnify feelings. Visual images of people displaying an emotion will often result in a related feeling in the viewer.

The senses can be used to improve student satisfaction.

4 PROTOTYPE FRs AND DPs

Based on the insights gleaned from the customer needs development in conjunction with a careful consideration of the existing literature on AD for education ([Tate *et al.*, 2004; Tate, 2005; Thompson *et al.*, 2009]), we developed prototype functional requirements (FRs) and design parameters (DPs). The idea of prototype FRs is that, while they are not particularly detailed, they can be used for any course design at the level of the course, chapter or lecture. They are intentionally generic. The designer simply selects those FR/DP pairs they wish to employ at a particular time in the class. Specific FR topics must be selected and DPs created. This concept coincides with the perspective in [Thompson *et al.*, 2009] regarding course design: “In a flexible system, only a subset of all FRs must be satisfied at any given time. For each FR, there may be several candidate DPs to choose from.”

Our high level prototype FRs are as follows:

- FR0: Establish student understanding of course knowledge (content) map;
- FRi: Establish cognitive domains for course topic i in students;
- FRA: Evaluate course quality;
- FRB: Establish connections between course topics and students concerns; and
- FRC: Magnify intensity of emotion the student associates with selected ideas.

Each of these is discussed briefly next. The detailed prototype FR and DP decomposition is provided in Appendix I. There, the prototype DPs are simply stated as “method to provide” the FR. Depending on the course topic and applications, the course designer will select DPs appropriate to their context. In

Section 5, examples of DPs for a particular course are provided.

FR0 seeks to develop an understanding of the overall structure of knowledge for the topics in the course. This function is essentially the same as FRi22 in [Thompson *et al.*, 2009]. Each FRi seeks to teach the students the material for each topic i. Here, as children of each of these FRs, we will place the cognitive domains of [Bloom *et al.*, 1956]. Beneath each of the cognitive domains, we will place children FRs for the various learning styles. We consider that this structure contains FRi3, FRi4 and FRi5 from [Thompson *et al.*, 2009]. FRA will assess the quality of the course; this is FRi6 of [Thompson *et al.*, 2009]. This FR could certainly be investigated in more detail, but our focus here is on the creation of emotions the stimulation of the senses. FRB and FRC largely venture into new territory. FRB seeks to connect the course material with things that the students care about. These may be everyday elements of their life, as in [Thompson *et al.*, 2009]’s FRi23. They may be broader. This breadth enables one to select from a vast array of potential target life elements. Examples will be provided in our design. FRC seeks to establish deep meaning for a particular idea via the magnification of emotions associated with it. Under FRC, as children, the stimulation of emotions and senses will appear. One example in this broad class of functions is FRi21 of [Thompson *et al.*, 2009]. There, emotions are connected with a particular course administration component (grades). Other topics can have deep emotions associated with them; these can then be exploited for many course objectives. We will demonstrate how this can be used in the context of a course in our course design discussion.

It is important to note that the prototype FRs and DPs should be considered as generic guidance and structural placeholders. Specific DPs and topics should be selected when creating a specific course. In addition, these FRs and DPs must be distributed across time (e.g, throughout each lecture or throughout the semester).

5 APPLICATION TO A UNIVERSITY COURSE

We elected to apply these prototype FRs and DPs to the redesign of the sophomore level general elective course entitled Introduction to Operation Research (IE 200) at KAIST. Many students who take the course have not yet chosen a major. They are at a ‘crossroads’ in their life. As such, a course intending to provide strong guidance to them may be appropriate. Moreover, as this is a basic elective course, many motivating examples should be included. We will discuss the design of this course and provide examples of the course material developed for the chapter on Optimization of Network Models.

5.1 SELECTED FRs AND SPECIFIED DPs

FRs must be selected for the course. While broad course level FRs such as FR0 and FRA must be selected, we do not discuss them here. We instead focus on the development of lecture material for an illustrative topic in our target course. We make particular efforts to include functions FRB and FRC. We primarily include these in the first or last lecture of a chapter, and focus on DPs including motivating examples and practical cases.

For our Optimization of Network Models chapter, we select FRs and DPs that include a surprising performance, strong emotional content and connecting examples. Naturally, course topics are covered. A typical high FRB and FRC content lecture is described next.

The primary FRBs and FRCs selected seek to surprise the students with a topic related performance in which the teaching team dresses as the Red Cross, enters to dynamic music and delivers “course survival kits” including candy and the assignment hand out for the day’s activities. Content connecting real world Red Cross food distribution to the course network models are discussed. Topics related to linear programming models for such networks are integrated throughout. The students solve a simple problem in class and try their hand at a more realistic one. Finally, an emotionally moving slide show including music, startling facts and pictures of huger stricken children is provided. The connection between an optimized food distribution network that provides more food and relief for these suffering children is established. The summary FRs and DPs used for this lecture design are provided in the lower half of Figure 2.

This kind of lecture will occur about one out of three lectures. The others are less dynamic, but still have FRB and FRC content. The lecture described is intended as the first class of the topic. It starts with a joyful surprise that also introduces the contents to be covered for that topic. It finally establishes a connection between the knowledge and the students’ emotional lives.

Time Line	Functional Requirements	Design Parameters
0~5	FRC.Ln.1: Magnify the intensity of student surprise associated with life topic 'class'	Sudden appearance of professor
5~10	FRC.Ln.1: Magnify the intensity of student fun associated with life topic 'class'	Candies distributed during performance
10~15	FRC.Ln.1: Magnify the intensity of student sadness associated with extra-life topic	Video about poor children
15~30	FRB.j.k: Establish connection between course topic 'Network Modelling' and students	Food distribution examples
30~35	FRC.Cm.1: Magnify the intensity of student curiosity associated with course topic 'Network'	Network examples which cannot be solved
35~50	FR1i.1: Establish knowledge domain for topic 'Network Modelling'	Introduction to Network Modelling

Time Line	Functional Requirements	Design Parameters
0~5	FRC.Ln.1: Magnify the intensity of student surprise associated with life topic 'class'	Sudden appearance of professor
5~10	FRC.Ln.1: Magnify the intensity of student fun associated with life topic 'class'	Candies distribute performance
10~25	FRB.j.k: Establish connection between course topic 'Network Modelling' and students	Food distribution examples
25~30	FRC.Cm.1: Magnify the intensity of student curiosity associated with course topic 'Network'	Network examples which cannot be solved
30~45	FR1i.1: Establish knowledge domain for topic 'Network Modelling'	Introduction to Network Modelling
45~50	FRC.Ln.1: Magnify the intensity of student sadness associated with extra-life topic	Video about poor children

Figure 2. FRs and DPs for our example lecture.

5.2 ORDERING AND TIME DEPENDENCY

The selected FRs and specific DPs must be ordered within each lecture. Wise time ordering, especially for content, is essential. This is demonstrated via the decoupled design matrix in [Thompson *et al.*, 2009]’s Figure 1b. The issue of coupling, addressed via AD’s Axiom I, arises in the context of emotional content as well. Consider again the design for the Optimization of Network Models lecture described in the prequel. Consider the case where the two emotional functions of FRC used follow the chronological order of fun surprise, sadness and then topic content, as given in the top of Figure 2. While the FRC functions can be independent, in this case, there is a dependency associated with the time sequencing. Refer to the upper design matrix (DM) of Figure 3.

FR1	=	X	0	0	0	0	0	DP1
FR2		X	X	0	0	0	0	DP2
FR3		X	X	X	0	0	0	DP3
FR4		0	0	0	X	0	0	DP4
FR5		0	0	0	X	X	0	DP5
FR6		0	0	0	0	0	X	DP6
FR1		X	0	0	0	0	0	DP1
FR2		X	X	0	0	0	0	DP2
FR3		0	0	X	0	0	0	DP3
FR4		0	0	X	X	0	0	DP4
FR5		0	0	0	0	X	0	DP5
FR6		0	0	0	0	0	X	DP6

Figure 3. Design matrices for candidate lectures.

If the sad emotions are simulated immediately after the joyful surprise, the impact of sadness will be significantly reduced (or even thought of as absurd). Using the chronology of the lower half of Figure 2 resolves the dependence. Refer to the lower DM of Figure 3; two X’s have been removed. There is sufficient distance between the emotional FRCs. These issues must be considered when designing with FRC.

6 IMPLEMENTATION OF THE NEW DESIGN

The redesigned course is being implemented currently (Spring 2013 semester) at KAIST. Each chapter (as before the redesign) consumes about one week of class time. Typically, one of the three lectures has very strong emotional content focus as described above. The others have been enhanced for emotions and the senses, but spend more time on enhanced content material. It is our plan to measure the results using the SERVQUAL [Parasuraman *et al.*, 1985; Parasuraman *et al.*, 1985] instrument. Statistical hypothesis testing will be used on the normal course evaluations to assess if the student satisfaction has increased. We will make efforts to determine if there is an increase in learning outcomes, but the measure will be muddled since different exams will be used than in previous offerings of the course.

7 CONCLUDING REMARKS

Education is an essential element of our modern society. As such, there has been much focus on improving and understanding the educational process. Most efforts have focused on knowledge taxonomies and learning styles. In the macroscopic view, however, the purpose of education is not only academic development but improving the students’ lives. Here, we have made efforts to develop an educational design process rooted in a service-orientation. We strive to enable deep connections between university course content and ideas that students care about.

To provide guidance to educators seeking service-oriented educational experiences, we first collected hundreds of customer needs. From these we developed prototype FRs and DPs that can be used to guide course design. The key point of differentiation from prior efforts is our focus on emotions and the senses. We employed the prototypes to redesign a sophomore level general elective Introduction to Operations Research course at KAIST. Some details of a typical lecture were discussed. The issue of emotional coupling arose and was addressed. The course is being implemented in the Spring 2013 semester at KAIST. We plan to evaluate the performance of the new design.

The methods developed here can be used to support the design of any course to include a service orientation. We hope that such approaches can be employed to develop transformative and dramatic learning experiences that improve both satisfaction and learning outcomes.

8 REFERENCES

- [1] Suh N.P., *The Principles of Design*, New York: Oxford University Press, 1990. ISBN 0-19-504345-6
- [2] Suh, Nam P, *Axiomatic Design: Advances and Applications*, Oxford University Press, 2001.
- [3] Bagchi, U., “Delivering Student Satisfaction in Higher Education: A QFD Approach”, *7th International Conference on Service Systems and Service Management, ICSSSM 2010*, Tokyo, Japan, pp.1-4, June 28-30, 2010.
- [4] Bloom B. S., Engelhart M. D., Furst E. J., Hill W. H., Krathwohl D. R., *Taxonomy of educational objectives: The classification of educational goals; Handbook I: Cognitive Domain*, New York: Longmans, Green, 1956.
- [5] Davis S. E., “Learning styles and memory”, *Institute for Learning Styles Journal*, Vol. 1, Fall, pp. 46-51, 2007.
- [6] Schmenner R. W., “How Can Service Businesses Survive and Prosper?”, *Sloan Management Review*, Vol. 27, No. 3, 1986, p. 21-32.
- [7] Kano N., Seraku N., Takahashi F., Tsuji S., “Attractive quality and must-be quality”, (in Japanese), *Journal of the Japanese Society for Quality Control*, Vol. 14, No. 2, pp. 39-48, 1984.
- [8] A. Parasuraman, Zeithaml V. A., Berry L. L., "A conceptual model of service quality and its implications for future research", *Journal of Marketing*, Vol. 49, No. 4, pp. 41-50, 1985.
- [9] Parasuraman A., Zeithaml V. A. and Berry L. L., “SERVQUAL: A Multiple Item Scale for Measuring

- Consumer Perceptions of Service Quality”, *Journal of Retailing*, Vol. 64, No. 1, pp. 14-40, 1988.
- [10] Cuthbert P. F., “Managing service quality in HE: IsSERVQUAL the answer? Part 1”, *Managing Service Quality*, Vol. 6, No. 2, pp. 11-16, 1996.
- [11] Joseph M., Joseph B., “Service quality in education: A student perspective”, *Quality Assurance in Education*, Vol. 5 No. 1, pp.15 – 21, 1997.
- [12] Susan Aldridge, Jennifer Rowley, “Measuring customer satisfaction in higher education”, *Quality Assurance in Education*, Vol. 6, No. 4, pp.197-204, 1998.
- [13] Sahney S., Banwet D. K., Karunes S., “A SERVQUAL and QFD approach to total quality education: A student perspective”, *International Journal of Productivity and Performance Management*, Vol. 53, No. 2, pp.143-166, 2004.
- [14] Tan K. C., Kek S. W., “Service Quality in Higher Education Using an enhanced SERVQUAL approach”, *Quality in Higher Education*, Vol. 10, No. 1, pp. 17-24, 2004.
- [15] Kim H., Morrison J. R., “Experiments on education as a service”, *8th International Conference on Service Systems and Service Management, ICSSSM'11*, Tianjin, China, pp. 166-172, June 2011.
- [16] Skinner M. E., “All Joking Aside: Five Reasons to Use Humor in the Classroom”, *Education Digest: Essential Readings Condensed for Quick Review*, Vol. 76, No. 2, pp. 19-21, 2010.
- [17] Berk R. A., “Does Humor in Course Tests Reduce Anxiety and Improve Performance?”, *College Teaching*, Vol. 48, No. 4, pp. 151-158, 2000.
- [18] Tate D., Lu, Y. “Strategies for Axiomatic Design Education”, *3rd International Conference on Axiomatic Design, ICAD2004*, Seoul, Korea, June 21-24, 2004.
- [19] Tate D., “Design and Creation of Web-based Educational Materials for Teaching Axiomatic Design”, *8th World Conference on Integrated Design and Process Technology, Society for Design and Process Science*, Beijing, China, June 13-17, 2005.
- [20] Thompson M.K., “Applying Axiomatic Design to the Educational Process”, *5th Fijih International Conference on Axiomatic Design, ICAD2009*, Campus de Caparica – March 25-27, 2009.
- [21] Lynn M., “Seven Ways to Increase Servers’ Tips”, *Cornell Hotel and Restaurant Administration Quarterly*, Vol. 37, No. 3, pg. 24, 1996.
- [22] McCarthy, C., “HONR 359B Alternatives to Violence”, University of Maryland Honors Program, available from <http://www.universityhonors.umd.edu/359B1001.php>, accessed March 12, 2013.
- [23] Pausch, R., *The Last Lecture: The Legacy Education*, Hyperion Press, 2008.
- [24] Parrott, W. *Emotions in Social Psychology*, Psychology Press, 2001.

APPENDIX I – DECOMPOSITION OF PROTOTYPE FRs AND DPs

FR0: Establish students understanding of course knowledge (content) map (MKT FRI22) FR0.1: Create student concept of course knowledge (content) map FR0.2: Populate the map with the course ideas and connection	DP0: Methods to establish students understanding of course knowledge (content) map (MKT DPi22) DP0.1: Methods to create student concept of course knowledge (content) map DP0.2: Methods to populate the map with the course ideas and connection
FR1: Establish cognitive domain for course FR1i: Establish cognitive domain for topic i FR1i.1: Establish knowledge domain for topic i FR1i.1.1: Enable visual learning of knowledge domain for topic i FR1i.1.2: Enable aural learning of knowledge domain for topic i FR1i.2: Establish comprehension domain for topic i	DPi: Methods to establish cognitive domain for course DP1i: Methods to establish cognitive domain for topic i DP1i.1: Methods to teach knowledge of topic I exploiting learning style DP1i.1.1: Visual aids on knowledge of topic i DP1i.1.2: Aural aids on knowledge of topic i DP1i.2: Methods to make students understand knowledge of topic i exploiting learning style
FRA: Evaluate course quality FRA.1: Evaluate students learning FRA.2: Evaluate students satisfaction	DPA: Methods to evaluate quality DPA.1: Methods to evaluate students learning DPA.2: Methods to evaluate students satisfaction
FRB,j,k: Establish connection between course topic j and student concerns topic k	DPB,j,k: Methods to establish connection between course topic j and students concerns topic k
FRC: Magnify the intensity of student emotions associated with specific ideas FRC.C0: Magnify the intensity of student emotions associated with ideas related to the overall course FRC.C0.1: Magnify the intensity of the student emotion (fear) associated with the possibility of a poor evaluation in the course (MKT FRI21) FRC.C0.2: FRC.Cm: Magnify the intensity of student emotions associated with course topic m FRC.Cm.1: Magnify the intensity of student joy associated with course topic m FRC.Cm.1.1: Magnify the intensity of student joy associated with course topic m via sight FRC.Cm.1.6: Magnify the intensity of student joy associated with course topic m via logic/data FRC.Cm.2: Magnify the intensity of student sadness associated with course topic m FRC.Ln: Magnify the intensity of student emotions associated with life topic n FRC.Ln.1: Magnify the intensity of student joy associated with life topic n FRC.Ln.2: Magnify the intensity of student sadness associated with life topic n	DPC: Methods to magnify the intensity of student emotions associated with specific ideas DPC.C0: Methods to magnify the intensity of student emotions associated with ideas related to the overall course DPC.C0.1: Provide penalties for failure to learn (MKT DPi21) DPC.C0.2: DPC.Cm: Methods to magnify the intensity of student emotions associated with course topic m DPC.Cm.1: Sense based methods to magnify the intensity of student joy associated with course topic m DPC.Cm.1.1: Vision based methods to magnify the intensity of student joy associated with course topic m DPC.Cm.1.6: Logic/data based methods to magnify the intensity of student joy associated with course topic m DPC.Cm.2: Methods to magnify the intensity of student sadness associated with course topic m DPC.Ln: Methods to magnify the intensity of student emotions associated with life topic n DPC.Ln.1: Methods to magnify the intensity of student joy associated with life topic n DPC.Ln.2: Methods to magnify the intensity of student sadness associated with life topic n