Educating for Empathy in Software Engineering Course

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Abstract. The ability to empathize with end-users is an engineering skill that is as necessary as technical expertise and social competency. In particular, empathy is required when embracing the otherness of a group of people and defining their requirements. Empathy is the first step in the design thinking method, which has garnered interest among software development organisations nowadays for leveraging the design and innovation processes and for better realizing the required end-user experience. The design thinking approach places the customer needs up-front, and emphasizes building empathy with users, observing their behavior, and drawing conclusions about what people want and need. This paper presents preliminary findings of a collaboration between design students and engineering students at the Shenkar College of Engineering, Design and Art. The findings show how engineering students, when coping with a serious, human (as opposed to organizational) wicked problem presented to them, practiced empathy and used emotional language when defining requirements for their solutions. The paper posits that the multidisciplinary learning experience of engineering and design students, gained while practicing the design thinking method, can foster empathy and other skills needed in modern digital culture, which exhibits the confluence of technology, knowledge, and culture.

Keywords: Design thinking, software engineering, creativity, emotions, multidisciplinary learning, wicked problem, inclusive requirements engineering.

1 Introduction

When preparing engineers to cope with wicked problems of the 21st century, which are often grand, messy and indeterminate, training should focus on technical as well as social aspects. Engineers must possess not only strong and solid technical expertise but also broader social competencies, such as empathy, communication skills, and the ability to collaborate in multidisciplinary teams [1]. Although many current engineering programs address aspects of communication, teamwork, and multidisciplinary collaboration, empathy training is less commonly incorporated into undergraduate engineering education, partly due to the lack of a "coherent framework" [2].

Design thinking (DT) is being used increasingly in software development, and it is now widely agreed that DT belongs in the curriculum of every leading technical university and that graduates need to be proficient in the method [3]. "It would seem that contemporary, innovative product and service development is hardly conceivable now without some knowledge of design thinking". [ibid, p. ix]. The DT method places the customer needs up-front, and emphasizes building empathy with users, observing their behavior, and drawing conclusions about what people want and need. In addition, it fosters the use of emotional language to describe desires, aspirations, engagement, and experience, as well as products and users [4]. Moreover, in the new global economic era, multidis-

ciplinary knowledge and capabilities are required in order to gain competitive advantages and foster innovation [5,6]. Previous research addressed the need to promote effective collaboration among people from different disciplines, and found that successful multidisciplinary encounters depend on tailoring the selection of a theme, participants, and location to the encounter's particular objectives [7]. In particular, universities are revising their curricula to include disciplines such as social science, humanities, cultural studies, and management studies so that students will be prepared to meet the changing needs of industry and society, which seek to bridge the gap that exists between producers and consumers of technology [8]. For this aim, multidisciplinary learning opportunities are organized in which participants are familiarized with one another's profession and learn to appreciate dissimilar viewpoints [9]. In line with this, innovation can no longer be considered a functional problem since it touches on all aspects of society including cultural and environmental issues [10]. This leads to the perception that research and development (R&D) functions are not enough to drive innovation, and the novel perspective requires involving user experience in the R&D processes [11]. Within this new business environment, design skills have a central role in driving innovation processes and bridging different fields such as engineering, humanities, social science, economics, and production [12]. Such design skills foster design thinking in innovation management, encompassing a creative, proactive, and empathic approach to the connecting of different bodies of knowledge in order to shape innovative solutions [13,14]. Or as Meyer put it: "Combining strategic objectives and technical business requirements with emotions and conceptual thinking, design thinking is used to create interactions between people and systems, products or technology, with a goal of making those interactions simple, intuitive, and empathetic." [4, p. 42]. Although the literature suggests that multidisciplinary programs are beneficial for broadening student perspectives, only a handful of reports describe the multidisciplinary educational experiences and the interactions that occur among their participants.

This paper reports on a multidisciplinary collaboration between a software engineering course given by the School of Industrial Engineering and Management and a design course given by the Department of Interior Building and Environment Design, both at the Shenkar College of Engineering, Design and Art. Preliminary findings show that coping with a human challenge and practicing the DT method during the course fostered empathy among the engineering students. Moreover, the method promotes the use of empathic questions, thus educated the students to use empathic language while presenting their solution requirements. The paper is organized as follows: first, the need for empathy in engineering education is discussed. Next, the DT method is discussed, followed by a presentation of the multidisciplinary learning experience and the preliminary insights gained so far. The paper concludes with a presentation of a vision for empathy education in engineering training through multidisciplinary learning experiences while using the DT method. Finally, future research on this issue is suggested.

2 Empathy and Engineering

Empathy is considered a necessary professional skill for 21st century engineers [1,15]. Hecker [16] noted how soft skills such as active listening skills, the ability to show concern and empathy, and a positive attitude "may have as great an influence over an engineer's overall career success as technical competence" (p. 62). Nowadays, understanding of the importance of educating engineering students to develop empathic skills for coping with the increasingly globalized nature of society is ever increasing [17]. While recognition of the importance of empathy for contemporary engineering practice is growing, the literature on professional skills provides no guidance on how to foster empathy in undergraduate engineering programs [1]. Empathy is one component of emotional intelligence, alongside self-awareness, motivation, self-regulation, and adeptness in relationships [18].

The literature provides various activities, such as role play and peer reviews, that can support the development of emotional intelligence, and so empathy is, so it seems, a teachable and learnable skill [19]. This paper focuses on developing empathy in a design context that requires combining empathic and analytical thinking. Previous research identified a reciprocal inhibitory relationship between social cognition (i.e., reasoning about the mental states of other persons) and physical cognition (i.e., reasoning about the causal/mechanical properties of the system) [20]. A follow-up study illustrated the inverse relationship between empathic, social and non-technical concerns and analytical thought that is relevant to the engineering work [21]. These studies show the importance of including empathy development in engineering programs, in particular in the context of DT and multidisciplinary learning experiences. However, according to Walter et al. [1], engineering educators who wish to integrate such skill training into undergraduate programs are still challenged in doing so due to a lack of conceptual clarity regarding the nature and purpose of empathy. To close this gap, Walter et al. developed a model of empathy for engineering that conceptualizes empathy as a skill, a practice orientation, and a professional way of being. The skill dimension focuses on enhancing empathic communication, relationship building, and decision making (e.g. self- and other-awareness, emotional regulation, moving from empathic to analytic thinking modes and more). The orientation dimension captures a range of mental dispositions, assumptions, and personal values that influence the way engineers empathically engage with others (e.g. micro to macro focus, reflective-value awareness, and value pluralism). Finally, the being dimension situates empathic skills and practices within a contextualizing framework of broader values (e.g. service to society, dignity and worth of all stakeholders, and integrating personal values and beliefs with professional goals and actions) [1]. This model served in analyzing the findings of the multidisciplinary learning experience presented in Section 4.

3 The DT Method

DT has three perspectives: (1) mindset, (2) process, and (3) toolbox [22]. As a mindset, it exhibits three key principles: (1) a combination of divergent and convergent thinking,

(2) a strong orientation towards both explicit and implicit needs of customers and users, and (3) prototyping. As a process it combines a micro- and a macro-process. The micro-process—as an innovation process per se—consists of five steps: (1) define the problem; (2) find needs and synthesize; (3) ideate; (4) create prototype; and (5) test. The macro-process consists of managing milestones while developing prototypes that must fulfill defined requirements. As a toolbox, DT refers to the application of numerous methods and techniques taken from various disciplines: design, engineering, informatics, and psychology [22]. DT includes well-known practices such as brainstorming [23], which is implemented during the "ideate" step. Indeed, allowing divergent and convergent thinking during the "ideate" step, motivates team members to suggest many ideas without considering whether they are feasible or not, hence reducing criticism and encouraging associative thinking that may lead to innovation.

DT places empathy with the end-users up-front. Empathy design differs from other user-centered design techniques in the way users and other stakeholders are conceived: "More recently, however, there has been a shift toward empathic design as a way to genuinely engage with and involve users (and other stakeholders) in the development of solutions that best fit their needs and life circumstances, rather than simply the economic bottom line of designers" [1, p.132]. To better realize end-user needs, an empathy map is often used to analyze conversations and interviews with stakeholders, especially end customers. These conversations are categorized into four categories: "Say" (quotations and central terms), "Do" (observed behaviors), "Think" (assumptions of thoughts) and "Feel" (emotions) [22]. This method was practiced by the engineering students in their learning experience, presented next.

4 The Multidisciplinary Learning Experience and Preliminary Findings

This paper reports on a multidisciplinary collaboration between two courses given by two different schools at Shenkar, College of Engineering, Design and Art. The first course–"Software Analysis and Design 1"–was a 3rd year course given by the author at the School of Industrial Engineering and Management, and deals with information system (IS) analysis and design. During the course students learned about the IS development cycle, and practiced IS requirement analysis and design using entity-relationships diagrams (ERDs) as well as data flow diagrams (DFDs). The students proposed and designed ISs in three stages: requirements analysis, functional system design (using DFDs) and data base design (using ERDs). The second course–"Special Project – Attention Movement 1"– was given by the Department of Interior Building and Environment Design. The two courses were taught in parallel, and each course was taught by an instructor from its owning faculty and was attended by students from this owning faculty. In total, 150 engineering students and 22 design students participated in the two courses.

In former years, the engineering students were required to identify an IS need in an organizational context and provide the requirements as well as a system analysis and design to meet the identified need. This year, students could choose whether to develop an organizational IS or to collaborate with the design students and develop an IS for an

object the design students were designing in the context of attention disordered children. Developing an IS for such an object was considered to be a serious challenge, since the engineering students were familiar neither with the scientific understanding of children with attention disorder, nor with the relevant IS that may be applicable to the designed object. Nevertheless, most of the engineering students (117) chose to develop an IS for the designed object, which implies that they were interested in collaborating with the design students, although that required additional coordination among team members. Since the number of engineering students exceeded the number of design students, we divided the two classes into 21 teams of 4-6 engineers and one designer each. Each class had its own lessons with the relevant teaching materials. In addition, each lecturer presented the other class with an overview of her domain during the first lesson so that students from both classes would have the perspective of the other domain, in addition to their own.

Moreover, in order to initiate a common language among the students, the lecturers developed a mutual questionnaire designed to lead to common understanding between members of the multidisciplinary teams. For example, the engineering students asked about the design language of the design object while the designers asked about the purpose of IS and the benefit it could bring to the project.

In addition to the traditional learning materials in each course, the DT method was discussed in both classes, and emphasis was placed on three major steps: (1) define the problem, (2) find needs and synthesize and (3) ideate. The purpose of these steps was to better study the end-users and foster empathy and creativity.

Our preliminary findings relate to the "define the problem" and "find needs and synthesize" steps, which required the engineering students to learn a new domain and a new kind of user, while collaborating with design students who were used to different developing phases and looser timetables. The engineers had to familiarize themselves with the context of children with attention disorder, which was new for them. They could not jump immediately to a solution, as they often do when creating solutions in an organizational context. The designers served as their clients, which differed completely from past, familiar client. To facilitate empathy, the engineering students had to address the four questions of the empathy map tool, which is part of the DT method [22]: What do the end-users do? What do the end-users say? What do the end-users think? And what do the end-users feel? The DT method requires the developers to empathize with various stakeholders, and in this case, this meant feeling empathy with attention disordered children and their teachers, and in several projects with their parents as well. Following are several examples that demonstrate how empathic language was embedded in the requirements presented by the engineering students:

Empathy with attention disordered students:

"In their daily life, these people cope with missions like learning, driving, taking tests, interviewing for jobs, all of which create anxiety and stress for them. We need to help them build self-esteem".

"I feel discomfort in class, frustration because I cannot concentrate because of the noise in class."

Empathy with a teacher who has attention disordered students in class:

"I feel frustrated that I can't deliver what I planned. A few students make so much noise that the entire class is disturbed. I need to cope with these children who influence the behavior and learning achievements of the entire class."

Empathy with a parent of an attention disordered student:

"I feel guilty that my child misbehaved again. I am worried what will happen with my child, whether the teacher will transfer him to a special class or school."

With regard with the model of empathy for engineering presented in Section 2, the described learning experience created opportunities for the engineering students to acquire and practice several empathy competencies:

Empathy as a skill:

The engineering students had to communicate with the design students who are used to different working practices, regarding both tasks and scheduling issues. The engineering students had to communicate and regulate their emotional stresses, since it was the first time they were actually engaged with design student in a shared goal. Moreover, they had to transition from empathic thinking, when learning about the attention disordered phenomenon, to analytic thinking when required to come up with system requirements that relate to the design object.

Empathy as an orientation:

The engineering students had to empathize by reflecting on other viewpoints. When the design students described their design language and their influence sources, the engineering students had to translate it to their own professional language and reflect it back to the designers so that they understand each other. They moved from the micro level to the macro level; from understanding the specific project they were involved in, to a higher level of understanding how to collaborate with designers as professionals and how to value various opinions and perspectives.

Empathy as a professional way of being:

Coping with attention disorder syndrome gave the engineering students the opportunity to integrate their personal and professional values. Several of them reported having a similar problem or knowing someone with the syndrome. In those cases it was much more meaningful for them than creating a solution in an organizational context.

The findings analysis presented above shows how practicing DT in multidisciplinary teams, while coping with a human challenge, fostered empathy capabilities and developed use of empathic language with end-users during the requirements analysis phase. Executing the first steps of DT prevented the engineering students from jumping immediately to functional requirements and forced them to better learn about their end-users, and specifically their emotional needs. DT postponed addressing the technical aspects of the solution, while bringing out the voices of the various stakeholders. When dealing with inclusive requirement engineering that relate to the otherness of a user group, it is necessary to bring out the users' authentic voices and feelings, with which the developers of the needed solutions are often unfamiliar.

5 Summary and Future Work

This paper is based on the understanding that the increasing complexity of markets and social contexts involving different scales of problems and stakeholders, pushes academic institutes to restructure their traditional educational offerings towards more sustainable social and economic paradigms, opening up novel knowledge synergies [24]. In particular, DT has gained attention in the field of requirements engineering both in the academia and in the industry [25]. "Requirements engineering systems are geared for developing information system palaces and aren't what's needed for today's world of rapidly changing, app-enabled products. These Web and mobile apps are small, require rapid development, must closely fit customer needs, and change often. Requirements engineering for these would greatly benefit from design thinking — that is, a human centered, rapid-prototyping method for innovative design." [ibid, p. 91].

The learning experience discussed in this paper is part of an ongoing research that studies the development processes in multidisciplinary teams of engineering and design students [26,27]. Such multidisciplinary teams have the potential to foster innovation and develop products that enhance user experience since they address technological as well as human aspects of their outcomes. The learning experience showed that the "define the problem", and "find needs and synthesize" steps, which require developers to empathy with end-users and realize their explicit and implicit needs, which often requires emotional understanding and reflecting, are not easy tasks to accomplish. Learning from design students to extend the requirements phase and to move more slowly toward the solution phase is an important practice that can enhance empathy with end-users. Hence, following the reported multidisciplinary learning experience, the paper argues that implementing DT practices in multidisciplinary teams of engineers and designers that cope with social issues as well as addressing the otherness of end-user groups, can expand the capabilities of the different disciplines and help engineering students to include empathic elements when designing IS systems. Future research will continue to study and evaluate this approach in additional multidisciplinary learning settings.

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