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Exploring the relation between students' research behaviours in project courses and open innovation

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Abstract

In this study, the similarities between the actions of design students in product design project courses and open innovation processes were examined through a survey conducted among the students. Studies on open innovation were evaluated together with up-to-date discussions about design and its role in innovation and business environment in general. Since design can take crucial roles in innovation and management, the comparison of design students' actions in product design courses with probable expectations in the work environment can provide information about if these project courses could act as a preparation for a professional career. The theoretical relation between innovation and design was discussed and was followed by examination of similarities between product design project courses and open innovation environments. Afterwards, a brief field study conducted with third and fourth grade product design students was analyzed to explore any resemblance between their research preferences during product design project courses and open innovation practices. Also, their awareness on the open innovation subject was sought to understand if the possible resemblance was a result of design education's nature. The results suggest that students' attitudes during product design project courses are in line with an open innovation concept to a degree, even though their awareness of the subject is low.

Key words

design, open innovation, design education, design thinking, design students

Introduction

Since much recent literature describes design as a facilitator of innovation, the relevance of design to current ideas concerning innovation may also be worth exploring. Open innovation is a concept that has received a great deal of attention in recent years that concerns tendencies in the gathering and sharing of knowledge in industry; therefore, the role of the designer in open innovation practices may also be considered.

The relation of design to innovation and managerial activities is frequently discussed in the literature (Verganti, 2009; Norman & Verganti, 2014; Lockwood, 2009; Cooper et. al, 2009; Johansson-Sköldberg et. al., 2013). Scholars maintain that design education has the

potential to facilitate the use of designers' abilities in organisations and industry, and that therefore a more integrated understanding of design capabilities should become a part of design education (Buchanan, 2004; Boyarski, 1998; Owen, 1990). These studies are of two general types. One concerns the ways design supports innovation activities, and addresses design-driven innovation. The other concerns the use of design in managerial activities and addresses strategic problem-solving through design thinking. The literature suggests that designers, who possess skills and knowledge stemming from various disciplines, may act as supporters and managers of innovation activities in an organization (Buchanan, 2001).

To explore the role of design in innovation in a more holistic way, innovation models can be investigated. The models relevant to contemporary innovation activities may light up the current role of designers in innovation. Exploring the evolution of innovation processes suggests that recent innovation models support developing information networks and communication platforms to produce an environment that includes more participants (Rothwell, 1994). The development of information technologies plays a major role in this tendency, as they provide the platform and communication infrastructure for producing a knowledge database.

The principles and methods used to share and gather information in innovation activities have been frequently discussed. Studies have found that the innovation process tends to become more open when the aim is one of sharing information with outsiders and gathering information from external sources. These trends are in line with Rothwell's (1994) theories about future innovation trends and are currently studied within the area of open innovation (Acha, 2008). Open innovation is also linked with design practices; some of the studies that explore the relation between design and open innovation have found that designers can facilitate open innovation in the business environment (Acha, 2008; Christiansen et. al., 2013).

Because education facilitates the core capabilities of professionals, investigating design education may reveal the core competencies of designers. The methodologies and preferences of senior students have been said to resemble those of professionals; the basic behaviour of designers is shaped in the educational environment (Oscan & Dogan, 2013).

When design education is explored through student work, their product design projects and design research do represent the professional design process on a smaller scale. Buchanan (2001) states that clinical design research, a common type of research in design education, also plays a major role in professional design processes. Therefore, students' preferred methods may reflect models and tendencies in product design research and product development in general. Since design is regarded as a facilitator of innovation, an exploration of educational design projects may reveal whether recent innovation contexts have an effect on students' tendencies.

This study aims to identify similarities between design students' approach to research and open innovation, as well as their awareness of the subject of open innovation. The question of whether the core competences of designers facilitate open innovation is addressed by analyzing the role of designers in innovation processes through an alternative point of view. The results of this study can be used to enhance design education to develop students' capabilities in a way that is in keeping with recent trends in innovation and management.

Open innovation and its connection with design education

The literature suggests that innovation processes have evolved from closed models to more open practices (Rothwell, 1994). In this section, models for the evolution of innovation are examined with the aim of identifying theoretical links to the core competences of designers.

Evolution of Innovation Models and Open Innovation

The study of the models for the evolution of innovation reveals an ongoing movement towards a more open research environment. This tendency can be concluded from models that study the generational evolution of innovation.

The first-generation innovation model is defined as a technology-push model, while the second generation is described as a market-pull model (Liyanage et. al., 2002). The third-generation model occurs as a feedback process between technology-push and market-pull perspectives, balancing them within a portfolio management system that is in line with companies' strategies (Van der Duin et. al., 2006; Groen & Linton, 2010). The fourth- and fifth-generation models stress a more open approach for innovation. The fourth-generation model describes a product development process that runs in sync with every partner both inside and outside the company, forming a structure that has been described as a "rugby model" (Rothwell, 1994). The fifth-generation model is a more expanded version of the fourth, involving every possible partner, including customers (Dodgson et. al., 2008); this model makes use of developed communication platforms to broaden innovation networks (Rothwell, 1994).

The change to a more external-oriented innovation process is also recognized within the study of open innovation (West et. al., 2014). Chesbrough (2006) defines open innovation as "use of purposive inflows and outflows of knowledge" to support internal innovation and broaden the external use of innovation. The practice of open innovation uses aspects of closed innovation to balance information flow and the protection of core competencies. (Chesbrough & Euchner, 2011). Gassmann and Enkel (2004) state that open innovation is likely to occur when there is an increase in interface complexity, industry speed, and product modularity; they also note that requiring tacit and explicit knowledge and developing positive externalities favour open innovation. Chesbrough (2012) also stresses that employee mobility enhances open innovation.

The definition of open innovation and its ability to bring new insights to existing practices and concepts, such as supply chain management, has been questioned within the literature (Trot & Hartmann, 2009). In a more recent work, Chesbrough (2012) clarifies that, while open innovation opposes closed models, it does not include every open model, such as open source. One of the main distinctions between open source and open innovation is said to be that open innovation maintains the protection and trading of intellectual property. (Chesbrough, 2012). Sharing unused innovation can be regarded as another aspect of open innovation that differs from former practices and theories (Chesbrough, 2004). Although there is no clear-cut definition of open innovation, and development of its theories is still needed, defining and setting boundaries to open the practices of companies has been described as generally beneficial (Huizingh, 2011).

Enkel et. al. (2009) observe that studies discuss three types of open innovation processes: the outside-in process, the inside-out process, and the coupled process. The outside-in

process refers to the broadening of a company's sources through external knowledge integration, while the inside-out process has to do with bringing ideas to the market to be developed by other parties (Enkel et. al, 2009). Dahlander and Gann (2010) describe the pecuniary dimension as another aspect of open innovation; the outside-in and inside-out processes may both involve selling or revealing information. Finally, the coupled process defines a co-creation produced within strategic networks by various partners (Gassmann & Enkel, 2004); this is similar to the fifth-generation innovation process described by Rothwell (1994).

The literature reveals that the core difference between the innovation models of the past and open innovation is that the borders and dynamics of research are not pre-defined in open innovation practices (Chesbrough, 2004). Firms can announce that their R&D gaps will be filled by external sources (Chesbrough & Euchner, 2011). Companies can also share projects that have, in the short term, been evaluated as unsuccessful; this sharing allows them to monitor reactions to these projects in an effort to understand any potential that may have been missed (Chesbrough, 2004). Therefore, it can be said that open innovation benefits an organisation through the sharing of information in a collectively creative environment.

Open Innovation, Design and Design Education

Recent studies discuss design as an element supportive of innovation in general, and as an important aspect of open innovation in particular (Verganti, 2009; Acha, 2008). However, design as a source for innovation has generally been neglected in studies (Hobday et. al., 2011). Earlier studies defined innovation as a phenomenon that resulted from basic scientific research (Cooper & Press, 1995). It was understood that innovation grew from research, which formed the basis of a technology that evolved into a product (Trott, 2005). More recently, however, alternative approaches to the concept of innovation can be seen in the literature.

Verganti (2009) analyses the concept along the two axes of technology and meaning. The axis of technology refers to innovations created by technical improvements, which are similar to the developments that characterize the earlier definitions of innovation. The axis of meaning, however, includes changes that are created by design, which alters the product language and perception of the users (Verganti, 2009). Both axes also have radical and incremental dimensions; design-driven radical innovations result largely from research activities and interdisciplinary work, while incremental innovations result from user-centered design activities (Norman & Verganti, 2014).

The abilities of designers can enhance the open innovation process. One important dimension of open innovation is user involvement (Gassmann et. al., 2010). The ability of designers to work with customers is stressed in the studies that discuss the concept of design thinking. Design thinking combines designerly problem-solving with user-focused competition strategies. (Brown, 2008; Cooper & Junginger, 2009).

Cross (1990; 2001; 2004) asserts that the nature of problem solving in design involves coping with uncertainty. This idea is in line with the suggestion that design offers a means of addressing some aspects of 'wicked problems' that are hard to define (Rittel & Weber, 1973; Buchanan, 1992; Dorst, 2011). Cross (1990) also states that designers can (a)

generate novel and unusual solutions, (b) work with incomplete data, (c) cope with uncertainty, and (d) apply their imagination to solve practical problems. The ability of designers to cope with complex problems may enhance a company's open innovation capability. Acha (2008) asserts that open innovation may occur as a result of a company's design activities, claiming that ". . . firms which actively undertake design activities for innovation and which use design to control the innovation process, are more likely to also pursue open strategies for innovation." This view is in line with the concept of design thinking, which defines design activity as a strategic problem-solving action that broadly enhance an organisation's practices (Hobday et. al, 2012).

Incorporating design in innovation activities may also enhance innovation through knowledge mobility. Radical design-driven innovation occurs more often in multidisciplinary environments and when designers work within a variety of areas (Dell'Era & Verganti, 2010). Chesbrough (2012) also points out that workforce mobility is more common in "artistic kinds of industries," suggesting that designers may be more willing to work in various fields. Therefore, designers may serve as facilitators of knowledge transfer both because of their innovation strategies and their tendency to work within different industries and companies.

Because design tends to support open innovation, design students, who cannot develop every aspect of their projects entirely alone, may be expected to practice the sharing techniques of this approach. However, whether their tendency to use open systems derives from their working environment, or whether it is a preference deriving from intentions compatible with the principles of open innovation, is unclear and merits further exploration.

Research

A research with senior design students was conducted with an aim to understand their preferences of data gathering and sharing, together with their awareness of open innovation. The research questions were as follows;

- What are students' tendencies for searching/gathering information in industrial design project courses?
- What are students' tendencies for sharing information in industrial design project courses?
- Are students' aware of open innovation concept?

A total of six questions were asked through a survey, including Likert-scale questions with non-mandatory open-ended questions. A survey was conducted with undergraduate students who were attending industrial product design programs of various universities in Istanbul. The questions aimed to uncover following issues;

- Frequently used research methods and their selection motives
- Students' behavior for sharing information with other students and their reasons
- Students' definition for an ideal research process in a professional work environment

Industrial design education entered Turkey's agenda with the American Marshall Aid Program in the early 60s. Even though the opening of the first program has been edited in Middle East Technical University (Asatekin, 2006), the education began in the early 1970s in Istanbul State Academy of Fine Arts (Küçükerman, 2006). When examined, it can be seen that at the beginning of the industrial design education in Turkey, contrary to world, Turkish industry did not see design as a requirement (Er, 1993, Özcan, 2009). In the '60s Turkey, industrial design education began with support from the modernist, developing and developmental circles, especially from the architectural and interior architectural academies (Celbiş, 2006). This situation has resulted in the adaptation of systems which are taken from other professions and disciplines in order that the industrial design cannot create its own language during the education process (Günal Ertaş, 2011; Bayazıt, 2006).

As a result of these adaptations, design education in Turkey has evolved around two diverse disciplines which can be summarized as LYS (undergraduate placement examination) and aptitude examinations. The two major universities that conducted aptitude tests are Marmara University and Mimar Sinan Fine Arts University; while others mainly accept their students through LYS examination. Through this examination, eligibility for solving problems on topics such as math's and physics are evaluated. However, in aptitude tests students are asked to make drawings that answer the requirements provided by the judges.

Industrial design education, influenced by the origins of architecture and interior architecture education, has found its identity nowadays. Design education, especially in project courses, encourages students' own design ideas and identities by excluding trends, styles and movements (Balcıoğlu, 2009). There is a transition from a design education concept where the design student is tested in terms of technical and aesthetics, to a process in which many elements are tested and questioned during the development process of the design idea.

Within this study, students from two differing disciplines are included as all of them are employed as "industrial product designers" following their graduation. Therefore, to portray a more holistic "designer" profile at the beginning, no separations were made between students. However, it should be noted that students may have differing preferences on gathering of information. There are various types of problem-solving approaches in design mentioned in the literature (Dorst, 2003), which maybe create different profiles among students related to their educational background (Resnick, 1999).

Within the research, surveys were conducted with 50 students from a total study population of 160 from 5 different universities in Turkey. Descriptive univariate analysis was conducted with an intention to form insights together with open ended questions (Cooper & Weekes, 1983). The questionnaire was answered between November 2016 and December 2016, and the data was analyzed with SPSS and Excel according to ±4.62 % sampling error with a confidence level of 95 % Z = 1.96 p = q = 0,5 (Cohen, 1988; Soper, 2016; Westland, 2010). All of the students were senior students (either third or fourth grade) of product design undergraduate programs. Since senior students have more experience in a design process, purposive sampling was used (Robson, 2002). The questionnaire was mostly filled by researchers during a short interview with students; other students completed surveys by themselves, following the instructions provided from

researchers. The surveys were filled anonymously, no personal information was required from students.

The survey included 4 Likert-type questions with independent sub-sections, which were evaluated with frequency distribution (Likert, 1932; Gray, 2013). Likert type questions were formed to explore the students' tendencies for using different mediums in various scenarios that could be involved in a research process. Each Likert type question was followed by a non-mandatory open-ended question to explore the motives behind the students' tendencies. At the end of the questionnaire, 2 non-mandatory open-ended questions were also added to study students' awareness on open innovation concept and how they define an ideal design research process.

The open-ended questions were thematically coded (Braun & Clarke, 2006). The most frequent codes were identified and they were evaluated according to their nature, such as supporters and hindrances of students' attitudes.

The questionnaire was evaluated in three parts. The first part explored how students search for relevant data during their projects. It is usual for a student to search for a data from sources outside, as they do not have the necessary know-how or research sources themselves. Also, the data that is provided at universities can be somewhat limited, as product design covers various types of artifacts that are produced in an industrial environment. Therefore it was necessary to conduct interviews with students to understand their preferences, and motives related to them. Their motives about why they choose a certain medium can provide clues on their awareness or willingness on open innovation. These tendencies could be identified by tendencies on both gathering and sharing of the data. Therefore, in the second part, their tendencies about sharing information were studied. It is not mandatory for a student to share information with others; therefore the general willingness and motives may hint at their overall behavior. Finally, their awareness about the research processes in general and open innovation was sought. The clarification of their knowledge on the subject can address if their motivation and actions are affected by their theoretical knowledge and education, or if they are originated from their routine actions.

Students' Tendencies on Gathering Information

The first two questions in the survey explored students' tendencies on gathering information. Therefore, their preferences of media for searching data and asking questions were studied.

The first question of the questionnaire asked students how often they used the listed media for their research purposes. The question was followed by an open-ended question about the general reasons for their choices. The 5 media, frequencies and mean values for those media are listed in the Table 1 below.

Table 1. The medium students prefer for searching data

Medium	1	2	3	4	5	Mean
Search engines and general portals (Google, shopping websites, consumer forums, etc.)	0	0	0	26%	74%	4,74
Design / engineering oriented portals (Coroflot, Designboom, etc.)	4%	12%	22%	26%	36%	3,74
Project-oriented student groups (Facebook, WhatsApp, etc.)	20%	26%	36%	10%	8 %	2,54
Other students that work on similar subject	2%	32%	26%	26%	14%	3,18
Specialists /experts	4%	19%	33 %	31%	13%	3,12

The reasons for students' choices were thematically coded. Among the 50 students that answered this question, 29 mentioned "ease of access" as a motive for their tendency. "Access to trustworthy information and experienced people" were mentioned as a reason 8 times, "gathering alternative opinions" were mentioned as a reason 6 times and "gathering alternative opinions" were mentioned as a reason 5 times. "Catching a new idea" and "information exchange" motives were mentioned once each.

Some of the expressions from students can be seen below.

"Because I can easily reach them" (Ease of access)

"Because they have experience" (Access to trustworthy information and experienced people)

It can be sensed that students' motives were reflected in the choices they declared. As the most accessible media, "Search engines and general portals" had the highest mean value. "Design / engineering-oriented portals" had the second highest mean value with 3,74 as it can be referred an easy way of reaching to experienced people on the subject. "Other students that work on similar subject" and "specialists/experts" both have mean values above average, as they are accessible and trustworthy, respectively.

The second question about students' tendencies for gathering data asked the participants how often they posted or asked questions in the listed media. The Likert-type question was followed by a non-mandatory open ended question which asked the reasons for their preferences. The media, frequencies and mean values are listed in Table 2 below.

Table 2. The medium students prefer for asking questions

Medium	*1*	*2*	*3*	*4*	*5*	*Mean*
Search engines and general portals (Yahoo Answers, forums, etc.)	*28%*	*26%*	*22%*	*16%*	*8%*	*2,56*
Design / engineering oriented portals' forums (Coroflot, Designboom, etc.)	*42%*	*30%*	*6%*	*14%*	*8%*	*2,20*
Project-oriented student groups (Facebook, WhatsApp, etc.)	*18%*	*18%*	*36%*	*20%*	*8%*	*2,86*
Other students that work on similar subject	*0*	*14%*	*32%*	*30%*	*24%*	*3,68*
Specialists /experts	*6%*	*20%*	*20%*	*24%*	*30%*	*3,40*

When the motives that students declared for their tendencies were coded, “ease of access” was again the most mentioned reason, as 24 students among 50 mentioned it. “Access to trustworthy information and experienced people” rated the second most mentioned reason as it was declared 16 times. “Gathering alternative opinions” was mentioned 7 times, and “information exchange” was mentioned once. Hindrances were also mentioned in these questions as “confidentiality” and “data pollution” were mentioned once each.

Some of the answers provided by students are listed below.

“Ease of access and potential to lead to other sources” (Ease of access)

“To reach experts of the subject” (Access to trustworthy information and experienced people)

It can be claimed that students tend to use media that are easy to reach and trustworthy. Students ask questions to the other students that currently work or previously worked on similar subject with more than average frequency. The “other students that work on similar subject” has the highest mean value with 3,68; while “specialists/experts” have a mean value of 3,40 which reflects students’ need for reliable data. All of the other media had a mean value below average.

Students’ Tendencies on Sharing Information

The third and fourth questions in the questionnaire aimed to clarify students’ general tendencies about sharing information. Since their tendencies may differ according to relevance of the data to their projects, their tendencies about information that are directly related to their projects were asked, to be followed by their tendencies about sharing data that are not directly related to their projects.

The third question of the questionnaire asked students how often they shared information (technology, idea, etc.) that is significant for their current projects on the listed media. Again, the question was followed by an open-ended question about the general reasons for their choices. The 4 media, their frequencies and mean values are listed in the Table 3 below.

When the reasons that were mentioned by students were coded for this question, it was seen that “information exchange” and “gathering alternative opinions” were mentioned both 25 times out of 50 students. Two students declared “sincerity” was a reason for their choices, while “ease of access” and “access to trustworthy information and experienced people” were mentioned twice. Three different hindrances were mentioned in this question, as “not being social” was mentioned 8 times while “confidentiality” was mentioned 6 times and “inefficient communication” were mentioned 4 times. “Dilatoriness” was also mentioned once.

Table 3. The medium students prefer for sharing information related to ongoing projects

Medium	*1*	*2*	*3*	*4*	*5*	*Mean*
General portals (Pinterest, personal blog, Facebook timeline, Twitter etc.)	*52%*	*22%*	*8%*	*16%*	*2%*	*2,00*
Design / engineering oriented portals (Coroflot, Behance, etc.)	*72%*	*14%*	*8%*	*0*	*6%*	*1,54*
Project-oriented student groups (Facebook, WhatsApp, etc.)	*38%*	*20%*	*26%*	*4%*	*12%*	*2,38*
Other students that work on similar subject	*22%*	*12%*	*12%*	*28%*	*26%*	*3,10*

Students mostly mention “information exchange” in the context of being helpful to others. Some of the examples for the answers can be seen below.

“To provide benefits to other students” (Information exchange)

“To get information that is beneficial to my project” (Information exchange)

“To get feedback” (Gathering alternative opinions)

Only “other students that work on similar subject” scored above average with a mean value of 3,10. “Project-oriented student groups” has also a mean value of 2,38; while others scored below 2.

The fourth question of the survey asked students how often they shared data (technology, idea, etc.) that is not significant for their current educational projects on the listed media. The following open-ended question invited them to declare reasons for their preferences. Again, the 4 media, their frequencies and mean values are listed in the Table 4, which can be seen below.

Table 4. The medium students prefer for sharing information that is not related to ongoing projects

Medium	*1*	*2*	*3*	*4*	*5*	*Mean*
General portals (Pinterest, personal blog, Facebook timeline, Twitter etc.)	*36%*	*28%*	*18%*	*10%*	*8%*	*2,30*
Design / engineering oriented portals (Coroflot, Behance, etc.)	*64%*	*18%*	*8%*	*2%*	*8%*	*1,72*
Project-oriented student groups (Facebook, Whatsapp, etc.)	*34%*	*10%*	*28%*	*20%*	*8%*	*2,58*
Other students that work on similar subject	*18%*	*20%*	*20 %*	*24%*	*18%*	*2,94*

The most mentioned reason in this question was “information exchange” as it was mentioned 31 times out of 50. “Sincerity” was mentioned 7 times, while “Gathering alternative opinions” was told 4 times and “access to trustworthy information and experienced people” was mentioned once. “Not being social” was mentioned 4 times as a hindrance, while “inefficient communication”, “no contribution” and “dilatoriness” were mentioned once.

Some of the answers provided by students can be seen below.

“To share information with the people that are interested” (Information exchange)

“…interdependence with friends” (Sincerity)

Again, “other students that work on similar subjects” was the only option that was rated above average with a mean value of 2,94. “Project-oriented student groups” had a mean value of 2,58, which was relatively closer to average. These preferences can be linked with students’ motives to exchange information with the people that are relatively sincere to them.

Students’ Awareness on Open Innovation

The last two questions aimed to identify students’ awareness of modern innovation concepts, and open innovation, specifically.

In the fifth open-ended question, students were asked to describe an ideal research process in a professional working environment. The aim was to code data that referred to open innovation.

Among the 48 students that replied this question, 31 mentioned “interaction with customers”, while 16 mentioned “talking with experts”. None of the students mentioned any medium such as patent databases, cooperation with other firms or open access data use.

As the final question, students were asked if they had any idea about open innovation concept. From a total of 45 students that answered this question, 39 declared that they did not have an idea about the context. Three students correctly described open innovation, while two mentioned open source development and one mentioned both open source concept and open design concepts together.

Discussion

In evaluating the results of the survey, it can be seen that student behavior is to a degree in line with the principles of open innovation. However, they have only a slight awareness of the subject, and they do not think that they should continue to access and share information in an open way when they have entered professional practice.

The behavior of students seems to change as they are required to give more information about the project they are working on. When they search for general information, they do not have to reveal anything about their projects, so they use the media more frequently. As they provide more specific information about their projects, the frequency of their media use seems to lessen. This tendency can be seen in their preferences for data collection; when they are required to ask for specific information that may provide clues about their project, they tend to talk with the students they are close to, while they talk with experts, relative outsiders, during the project development process. The same preference is also seen in how the students share data; when they are sharing information that is not directly linked with their projects, they use media more frequently. “Confidentiality” is mentioned as a hindrance when they are sharing information that may

provide a hint about their projects. The same tendency can also be seen in their research methods.

Some of the reasons they mention, such as “ease of access” and “access to trustworthy information and experienced people,” can be understood as issues that lead students toward a more open process. As students cannot build every detail of their projects themselves, they rely heavily on outside data. Current communication technologies, easy to access and up-to-date, may also direct students to more open information sharing.

Conclusions

In this study, applications of the students in product design programs were studied regarding open innovation. The students’ awareness of open innovation was also explored to see if their tendencies were affected by this context. It can be seen that although students lack awareness on the subject of open innovation, their research activities are in line with the context. Encouraging students about the application of open innovation might be helpful in maximizing their potential in innovation processes, preventing them from developing ineffective understandings about product development processes.

The results suggest that students seem to behave in a way that is compatible with the practices of open innovation. They search and share data in an open way; however, they prefer not to provide details that will reveal the essential qualities of their projects. This preference is in keeping with the core principle of open innovation concerning the protection of intellectual property (Chesbrough, 2012). Companies do not use the open innovation model in every aspect of their research process; instead, they use a mixture of open and closed models to find a balance between gathering useful data and not damaging the advantages obtained from their core competencies (Chesbrough, 2004; Chesbrough & Euchner, 2011).

Even though their behavior may be consistent with open innovation practices, students do not seem to have a sense of the subject. They conceive of product development research as a closed process; they do not describe collaboration with outside sources as a necessary or beneficial part of research and development. As they do not mention implementing some of the research techniques they use during their projects, it could be that most of their preferences are determined by their ease of access and the credibility of the mediums. Lacking knowledge of the subject may lead them to waste of their potential as participants in open innovation. Because students feel that closed processes are more preferable in professional environments, their research practices may be better directed to avoid a strong propensity towards these outdated methods.

To sum up, the way design students behave in their project design courses is consistent with the core concepts of open innovation. However, their actions should be supported by theoretical knowledge about the subject to create awareness about their potential as professionals in a modern business environment. Otherwise, their prejudices about the sharing of knowledge in the product development process may harm their roles in business and management, preventing them from being employed as open innovation facilitators based on their tendency to work between fields.

Additional studies could further explore students' ideal design project research scenarios. Students could be interviewed about what an ideal research process would be for their practice. A workshop could then be modelled according to these results to provide the media mentioned by students along with others; in this environment, it would be possible to see whether they indeed favour closed research scenarios or whether they end up using the methods of open innovation. The same workshop could be conducted with students who are already informed about the open innovation to see if their lack of knowledge has an effect on their actions.

Another point that could be considered would be the differences between student groups from two different disciplines. Students from diverse educational backgrounds could be expected to differ in their practices, especially in terms of gathering research.

References

Acha, V. (2008). Open by Design: The Role of Design in Open Innovation. *Academy of Management 2008 Annual Meeting: The Questions We Ask*, AOM 2008.

Asatekin, M. (2006). ODTÜ Mimarlık Fakültesi Endüstri Ürünleri Tasarımı Bölümü "BAŞLANGIÇ NOTLARI". *Tasarım+ Kuram Dergisi*, *3*(5), 28-33. http://www.tasarimkuram.msgsu.edu.tr/index.php/tasarimkuram/article/download/24/26

Balcıoğlu, T. (2009). *İçimizdeki Bauhaus: İzmir Ekonomi Üniversitesi Güzel Sanatlar ve Tasarım Fakültesi Eğitim Programları. Bauhaus: Modernleşmenin Tasarımı Türkiye'de Mimarlık, Sanat, Tasarım Eğitimi Ve Bauhaus*. İletişim Yayınları, İstanbul.

Bayazıt, N. (2006). İTÜ'de Endüstri Ürünleri Tasarımı Bölümü "DENEYİ'mim". *Tasarım+ Kuram Dergisi*, *3*(5), 41-53. http://tasarimkuram.msgsu.edu.tr/index.php/tasarimkuram/article/viewFile/26/28

Boyarski, D. (1998). Designing Design Education. *ACM SIGCHI Bulletin*, 30(3): 7-10.

Braun, V., & Clarke, V. (2006). Using Thematic Analysis in Psychology. *Qualitative Research in Psychology*, 3(2): 77-101.

Brown, T. (2008). Design Thinking. *Harvard Business Review*. June: 1-11.

Buchanan, R. (1992). Wicked Problems in Design Thinking. *Design Issues*, 8(2): 5-21.

Buchanan, R. (2001). Design Research and the New Learning. *Design Issues*, 17(4): 3-23.

Buchanan, R. (2004). Human-Centered Design: Changing Perspectives On Design Education in the East and West. *Design Issues*, 20(1): 30-39.

Celbiş, Ü. (2006). Marmara Üniversitesi, Güzel Sanatlar Fakültesi, Endüstri Ürünleri Tasarımı Bölümü. *Tasarım+ Kuram Dergisi*, 3(5), 34-40. http://tasarimkuram.msgsu.edu.tr/index.php/tasarimkuram/article/viewFile/25/27

Chesbrough, H. (2004). Managing Open Innovation. *Research-Technology Management*, 47(1): 23-26.

Chesbrough, H., (2006). Open Innovation: A New Paradigm for Understanding Industrial Innovation. In H. Chesbrough, W. Vanhaverbeke, & J. West (Eds.). *Open innovation: Researching a new paradigm*. Oxford University Press on Demand.

Chesbrough, H., & Euchner, J. (2011). The Evolution of Open Innovation: An Interview with Henry Chesbrough. *Research-Technology Management*, 54(5): 13-18.

Chesbrough, H. (2012). Open Innovation: Where We've Been and Where We're Going. *Research-Technology Management*, *55*(4), 20-27.

Christiansen, J. K., Gasparin, M., & Varnes, C. J. (2013). Improving Design with Open Innovation: a Flexible Management Technology. *Research-Technology Management*, 56(2): 36-44.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences (2nd Edition)*. Lawrence Earlbaum Associates: Hillside, NJ.

Cooper, R., Junginger, S., Lockwood, T. (2009). Design Thinking and Design Management: A Research and Practice Perspective. *Design Management Review*. 20(2): 45-55.

Cooper, R., & Press, M. (1995). *The Design Agenda: A Guide to Successful Design Management.* John Wiley and Sons, Chichester.

Cooper, R. A. & Weekes, A. J. (1983). *Data, Models, and Statistical Analysis*. Barnes and Nobles, New Jersey.

Cross, N. (1990). The Nature and Nurture of Design Ability. *Design Studies*, 11(3): 127-140.

Cross, N. (2001). Designerly Ways of Knowing: Design Discipline Versus Design Science. *Design Issues*, 17(3): 49-55.

Cross, N. (2004). Expertise in Design: An Overview*. Design Studies*, 25(5): 427-441.

Dahlander, L., & Gann, D. M. (2010). How Open is Innovation? *Research Policy*, 39(6): 699-709.

Dell'Era, C., and Verganti, R. (2010), "Collaborative Strategies in Design-Intensive Industries: Knowledge Diversity and Innovation", *Long Range Planning*, Vol. 43, No. 1, pp. 123-141.

Dodgson, M., Gann, D. & Salter, A. (2008). *The Management of Technological Innovation: Strategy and Practice*. Oxford University Press, New York.

Dorst, K. (2003). The Problem of Design Problems. *Expertise in Design*, 135-147.

Dorst, K. (2011). The Core of Design Thinking and It's Application. *Design Studies*, 32(6): 521-532.

Enkel, E., Gassmann, O., & Chesbrough, H. (2009). Open R&D and Open Innovation: Exploring the Phenomenon. *R&D Management*, 39(4): 311-316.

Er, H. A. (1993). The State of Design: Towards an Assessment of the Development of Industrial Design In Turkey, *METU Journal of Faculty of Architecture*, Vol 13(1-2).

Gassmann, O., & Enkel, E. (2004). Towards a Theory of Open Innovation: Three Core Process Archetypes. Proceedings of the R&D Management Conference, Lisbon, Portugal, July 6–9.

Gassmann, O., Enkel, E., & Chesbrough, H. (2010). The Future of Open Innovation. *R&D Management*, 40(3): 213-221.

Gray, D. E. (2013*). Doing Research in the Real World*. Sage, Hampshire.

Groen, A. J., & Linton, J. D. (2010). Is open innovation a field of study or a communication barrier to theory development? *Technovation*, *30*(11-12), 554.

Günal Ertaş, D. (2011). İTÜ Endüstri Ürünleri Tasarımı Bölümünün Kuruluş Çalışmaları, *Endüstride Tasarımda Eğitimde 40 Yıl Sempozyumu*, 7-9 Aralık 2011, MSGSÜ, İstanbul.

Hobday, M., Boddington, A., & Grantham, A. (2011). An Innovation Perspective on Design: Part 1. *Design Issues*, 27(4): 5-15.

Hobday, M., Boddington, A. & Grantham, A. (2012). An Innovation Perspective on Design: Part 2. *Design Issues*. 28(1): 18-29.

Huizingh, E. K. (2011). Open Innovation: State of the Art and Future Perspectives. *Technovation*, *31*(1), 2-9.

Johansson-Sköldberg, U., Woodilla, J., & Çetinkaya, M. (2013). Design Thinking: Past, Present and Possible Futures. *Creativity and Innovation Management*, 22(2): 121-146.

Küçükerman, Ö. (2006). 1971 Yılında Türkiye'de ilk Kez Güzel Sanatlar Akademisi ile Başlatılan Endüstri Tasarımı Eğitiminin 37 Yıllık "SEYİR DEFTERİ". *Tasarım+ Kuram Dergisi*, *3*(5), 1-27.

Likert, R. (1932). *A Technique for the Measurement of Attitudes*. Archives of Psychology. New York.

Liyanage, S.; Annerstedt, J.; Gluckman, P.; Hunyor. S.; Jones, A. J. & Wilson, M. (2002). *Serendipitous and Strategic Innovation: A Systems Approach to Managing Science Based Innovation*. Greenwood Publishing, Westport.

Lockwood, T. (2009). Transition: How to become a more design- minded organization. *Design Management Review*, 20(3): 28-37.

Norman, D. A., & Verganti, R. (2014). Incremental and Radical Innovation: Design Research vs. Technology and Meaning Change. *Design Issues*, 30(1): 78-96.

Owen, C. L. (1990). Design Education in the Information Age. *Design Studies*, 11(4): 202-206.

Özcan, A. C. (2009). An Overview of The Early Foundations and Development of Contemporary Industrial Design in Turkey. *The Design Journal*, *12*(3), 267-287. http://www.tandfonline.com/doi/pdf/10.2752/146069209X12530928086289

Ozkan, O., & Dogan, F. (2013). Cognitive Strategies of Analogical Reasoning in Design: Differences Between Expert and Novice Designers. *Design Studies*, 34(2): 161-192.

Resnick, L. B. (1999). Making America Smarter. *Education Week Century Series*, 18(40), 38-40.

Rittel, H. W., & Webber, M. M. (1973). Dilemmas in a General Theory of Planning. *Policy Sciences*, 4(2): 155-169.

Robson, C. (2002). *Real World Research: A Resource for Social Scientists and Practitioner-Researchers*. Blackwell Publishing, Cornwall.

Rothwell, R. (1994). Towards the Fifth-Generation Innovation Process. *International Marketing Review*, 11(1): 7-31.

Soper, D.S. (2017). A-priori Sample Size Calculator for Structural Equation Models [Software]. Available from http://www.danielsoper.com/statcalc.

Trott, P. (2005). *Innovation Management and New Product Development*, Pearson Education, Essex.

Trott, P., & Hartmann, D. (2009). Why 'Open Innovation' is Old Wine in New Bottles. *International Journal of Innovation Management*, *13*(04), 715-736.

Van Der Duin, P.; Ortt, J.R.; Hartmann, D. & Berkhaut, G. (2006). Innovation in Context: From R&D Management to Innovation Networks. In *Managing Technology and Innovation: An Introduction*. ed. R. M. Verburg, J.R. Ortt, M.D. Willemjin (Eds.), Routledge, New York.

Verganti, R. (2009). *Design Driven Innovation: Changing the Rules of Competition by Radically Innovating What Things Mean*. Harvard Business Press, Boston.

West, J., Salter, A., Vanhaverbeke, W., & Chesbrough, H. (2014). Open Innovation: The Next Decade. *Research Policy*, 43, 805-811