Design and Technology Education: An International Journal

23.2

Review of Curriculum Development for University-Industry Collaborations with a Comparative Analysis on Master of Industrial Product Design Education

Onder Erkarslan & Zeynep Aykul, Izmir Institute of Technology, Turkey

Abstract

University-industry collaboration (UIC) provides not only effective training for students but also knowledge production in universities for industry to contribute to the economy (Bektaş & Tayauova, 2013). The paper proposes to analyse reasons for deficiencies in UIC with a comparative analysis of the curriculum of the industrial design (ID) department of Izmir Institute of Technology (IZTECH) and Linnaeus University (LNU), and taking feedback from industry. As a comparative analysis of curriculum, ID programmes in IZTECH and LNU were examined to understand differences and similarities. To develop UIC for IZTECH, LNU was accepted as an example, and then the two institutions were compared according to each curriculum. For comparison of ID courses, the taxonomy method in the National Association of Schools of Art and Design (NASAD) Handbook 2014-2015 was used. There are three categories for design courses, which are professional design practice (PDP), design studies (DS), and design thinking (DT). Within the scope of curriculum development for university-industry collaboration, feedback was taken from companies that have a design department or are an employer of new ID graduates. For this purpose, surveys were sent to different companies. As a result of curriculum analysis and a survey with industry, courses that need to be developed belong to PDP and DT groups, which are more practice and teamwork based. A solution can be adding new courses to curriculum that contain more teamwork and innovative and collaborative activities. Also, content of existing courses can be developed on DT characteristics.

Key words

Industrial product design education; curriculum; master's degree programme; comparative analysis; university-industry collaboration.

1 Introduction

University-industry collaborations (UIC) are increasingly significant to make contributions to economy and society. The mutual relationship can generate knowledge used in production to achieve efficiency in economy and innovation and in this way firms gain a significant competitive advantage in world markets. University-industry collaboration also provides the following benefits regarding learning effectiveness: supporting instructors to update their knowledge; providing a basis for their scientific research; carrying out research to develop fundamental sciences; promoting scientific research by publications and students training as well (Qın, Mkhıtaryan & Bhuıyan, 2017).

Interaction can take a variety of forms, including both direct and indirect mechanisms (Guenther & Wagner, 2008), recently being labelled as 'academic engagement' (Perkmann et al., 2013). From the 1980s, UIC has intensified and therefore received growing attention from researchers, policy-makers and practitioners (Etzkowitz, 1998). Government initiatives and changes in the institutional framework have facilitated cooperation (van Looy, Debackere & Andries, 2003; Guenther & Wagner, 2008). However, there is still a gap between the knowledge produced by university researchers and what is used in practice (Siegel, Waldman & Link, 2003). Indeed, a great amount of knowledge created in academia does not come to be applied and consequently create value (Sedlacek, 2013). Given this situation, the literature has progressively dealt with the phenomenon of UIC (Barbolla & Corredera, 2009; Gulbrandsen, Mowery & Feldman, 2011), taking different perspectives, which vary significantly according to the mechanisms/interaction channels, and the units of analysis considered. Since people are considered as the universal drivers to ensure successful UIC (Plewa et al., 2013), most research has focused on the individuals acting in the field (Franco & Haase, 2015).

Firms collaborate with universities mostly to access and develop interdisciplinary scientific capabilities to solve complex industry problems and to support product development, but also to access public sponsorship. Firms may also collaborate with universities to conduct exploratory, non-targeted research to generate ideas, build technological options and search for new products, technologies and markets, and to get access to skilled labour, especially qualified engineers (Meyer-Krahmer & Schmoch 1998; Lee 1996, 2000; Feller, Ailes & Roessner, 2002; Carayol 2003; Lam 2005; Balconi & Laboranti 2006; Arza 2010; Subramanian, Lim & Sohc, 2013).

University researchers are mostly motivated to collaborate with firms to try out practical applications of their theory and research, and to advance and complement their research agendas (Lee 1996, 2000; Perkmann & Walsh 2009; D'Este & Perkmann 2011). On the other hand, they may be motivated by the need to get additional funding and resources to facilitate their research and finance graduate students and the purchase of laboratory equipment, as well as to establish a foundation for future research and collaboration opportunities (Lee 2000; Lam, 2011; Freitas & Verspagen 2017).

Innovation experts have investigated UIC performance of firms (Agrawal & Henderson, 2002; Cohen, Florida, Randazzese & Walsh, 1998; Cohen, Nelson & Walsh, 2002; Shane, 2002; Santoro & Chakrabarti (2002)). They attempted to analyse the modes through which knowledge flows from universities to industry. Nonetheless, there is no universally accepted classification of university and industry collaborations (Røed, 2000). Also, there is little consensus regarding the most effective mode of university– industry collaboration has been achieved (Bekkers & Freitas, 2008; Eun, 2009). The collaboration modes include, but are not limited to, the use of scientific publications, technology licensing, human mobility (personnel exchange, etc.), joint or collaborative R&D, contracted out or commissioned R&D, consultancy or technical guidance, incubation of start-ups, and informal collaboration. The interaction can take place between individual researchers in both a university and a company or between a company and a university (Agrawal & Henderson, 2002; Bekkers & Freitas, 2008; D'Este, Nesta & Patel., 2005 Eun, 2009; Iqbal, Khan, Iqbal & Senin, 2011; Joseph, 2009; Landry, Amara & Ouimet, 2005; Meyer-Krahmer & Schmoch, 1998; Rast, Khabiri & Senin, 2012; Pittayasophon, 2016)

In industry, companies can take many advantages of university collaborations in terms of regular activities, innovation and new design. Moreover, universities also turn their theoretical knowledge to practical. UIC is established on the transfer of knowledge and technology between them. UIC refers to the interaction between any parts of the higher educational system and industry aiming mainly to encourage knowledge and technology exchange (Bekkers & Freitas, 2008; Siegel Waldman & Link, 2003; Maietta, 2015; Scandura, 2016. UIC has been widely perceived as a promising tool for enhancing organizational capacity in open innovation — where an organization employs external networks in developing innovation and knowledge (Dess & Shaw, 2001), as a complementary option to traditional internal R&D (Coombs, Harvey & Tether, 2003) (Ankrah & Al-Tabbaa, 2015).

The involvement of practice in design education also draws the borders between education and industry. Although the various applications of relations with industry in education have been widely discussed in the literature, (Boyarski, 1998; Çırpanlı and Er, 2006; Erkarslan, 1998, 2007, Erkarslan and Imamogulları, 2010; Erkarslan, Kaya & Dilek, 2011; Evyapan, Korkut & Hasdoğan, 2005) many critical questions, such as whether design education should directly respond to the needs of industry, still remain as unanswered. Besides, policies and strategies in order to increase the intersections between education and industry is still a vital discussion in our field. Design educators and professionals are always concerned with the issue of industrial designers' competencies. However, the quality of ID graduates is not generally regarded to be at the level expected by employers (Kaufmann, 1998), and there seems to be a gap between what students learn at school and what they are required to do in practice after graduation (Ball, 2002; Yeh, 2003; Yang, You & Chen, 2005; Erkarslan, 2013).

2 Literature Review

The lack of innovative education based on industry is a problem that needs to be overcome. Projects conducted within the framework of university and industry cooperation generally fail to come into being, leaving prospective applicants no opportunities. The rate of creation of state-of-the-art technology products was quite low in the joint studies conducted by the companies and academic researchers within the technology parks that enable cooperation between industry and universities (Kiper, 2010). The academic staff of that university designs the curricula of degree programmes within a university. It is a fundamental role of academia. Those degree programmes that lead to a license to practice will also be subject to professional body accreditation, reducing the number of elective dimensions that can be introduced by the university. Although these requirements may be seen as limiting the freedom of employers to further influence the curriculum, experience indicates that there is sufficient common ground between employer needs, quality assurance benchmarks and professional body requirements for there to be little reason why employer needs are not integrated within the process of degree programme design. The level of engagement is clearly at the discretion of the university and occurs at variety of levels of prescription. Many universities operate employers' advisory groups, often at departmental level. These groups may act as 'critical friends', monitoring the activities and development of the department; others act as industry advisors in research fields and in curriculum design. This is a demonstration of business– university collaboration that is often invisible outside a university department. In terms of future employment prospects, the existence of such a group is of legitimate interest to students. Universities that work with employers through industry advisory groups should consider including the existence of such a group, its membership and its influence, within the university's enterprise strategy and within the material that it provides to applicants and students (Wilson 2012).

When both university and industry's expectations coincide with each other, then the resulting UIC is better and easier. Responsibilities and expectations of universities can be defined as providing education, renewing their scholars, contributing to development of science and publishing their results, supporting their scholars for research and academic studies. In terms of industry, the responsibilities can be defined as technological knowledge being satisfied for market, production of solutions for industrialist's problems about manufacturing and supporting manufacturing, development of product quality, and manufacturing more standardized product. Ankrah and Al-Tabbaa (2015) explained that motivations of universities and industries can be examined under six topics; necessity, reciprocity, efficiency, stability, legitimacy, and asymmetry. Necessity is the same definition for both as a motivation, which is being responsible to policies of government and other strategic institutional. Reciprocity can be explained that universities can reach facilities and equipment in companies, when the companies can access to students for summer internship or part-time job opportunities. Thanks to UIC, new graduates find employment opportunities in companies, and industries hire faculty members for consultation. Efficiency is the third motivation for both university and industry. Universities can access funding for their research and further studies, obtain patents and be gained personal finance for academics. Furthermore, companies commercialize university-based technologies and turn them profit. When foreign technology is wanted to be used, companies should take license for it. However, thanks to patents, which are produced by universities, companies do not need to exploit foreign technology, and it is much easier and cheaper. Another saving in term of economics for companies is tax exemptions and grants. Moreover, companies increase their technological capacity and take better place in competitive markets thanks to UIC projects; they also develop their human capital with educated new graduates according to their need. Stability is the motivation, which has the largest amount of results for not only universities but also companies that start growing with new knowledge that is produced by UIC, as a result of UIC they shift in knowledge based economy. Universities take opportunities to discover new knowledge, test them and publish more papers, while companies make their business grow, access new knowledge and technology. Students can find solutions to practical problems and applied technologies of companies, which do not need in house R&D thanks to UIC. Legitimacy motivates not only universities to contribute regional or national economy, service to the industries, increase academics and their achievements' recognition, but also companies to enhance to their corporate image. As a last motivation, asymmetry supports companies to continue controlling patented technologies (Ankrah & Al- Tabbaa, 2015).

UIC has several results (Wilson, 2012, p.41-42):

- Collaboration between university and industry is resulted with progression at many level and exchange of knowledge.
- As a result of collaboration projects, companies have opportunity to find worker candidates who are new graduates, but have knowledge about sector and companies works.
- Students have opportunity to use their theoretical knowledge into practical experience.
- The companies get more theoretical knowledge, and universities can make them expert on any new concept.
- Like businesses, universities thrive on competition; competition has been a driver of performance and efficiency.
- In order to enhance graduate skills levels and ensure a smooth and effective transition between university and business environments, there is a need to increase opportunities for students to acquire relevant work experience during their studies. Sandwich degree programmes, internships and work ‐ based programmes all have roles to play in achieving this.
- Strategies to ensure the development and recording of students’ employability, enterprise and entrepreneurial skills should be implemented by universities in the context of the university’s mission and promoted through its public literature to inform student choice.
- Networking between universities and the business community is a critical component of an efficient innovation ecosystem.

3 Method

3.1. Purpose of Study

The paper analyses the reasons of deficiencies in UIC with a comparative analysis of the curriculum of industrial design department, Izmir Institute of Technology (IZTECH) and Linnaeus University (LNU), and taking feedback from industry. The early phase of the research was realized at LNU-

Sweden between September and December 2012 with the support of the Turkish Higher Education Council Grant. After the analysis on curriculum and industry, the main aim is to develop an efficient curriculum for UIC.

UIC contributes to the economic success of manufacturing organisations, because companies' success in their R&D activities also support their success in marketing, design and manufacturing together (Kotler, 2000; Bruce & Bessant, 2002). Universities and companies have different missions and cultures. However, UIC provides that they bring their problems and difficulties, and when these are solved, both side of UIC gain (Lambert, 2003). UIC contributes to design students training in terms of innovation, identifying problems, producing solutions, working in teams, and coordinating team activities (Spellmeyer & Weller, 2003).

In the view of this information, the importance of UIC can be understood for design students. Thus, improvement of UIC in IZTECH industrial design department the purpose. For this purpose, two methods were used. The first method was the comparative analysis of IZTECH and LNU, and second was to take feedback from the design departments of companies.

One of the reasons to choose LNU for comparative analysis is that both universities have an engineering and architecture based industrial design education tradition. Education is in English at both universities. Moreover, collaboration between LNU and IKEA is the multidisciplinary and collaborative project example that includes research and education about life at home. In this project, business administration, industrial design, engineering and wood technologies researchers worked together. LNU has significant importance for IKEA in terms of employable educated human source, experts and producing results of research. The Bridge Program, which is the name of UIC between LNU and IKEA, determines the education programme in economics, technology, and design departments.

3.2 Comparative Analysis

In this section, curriculums of industrial design departments at IZTECH and LNU are analysed according to NASAD. The aim is to identify similarities and differences between two industrial design programmes, so deficiencies and strengths for UIC in IYTE can be defined after the analysis.

According to NASAD Handbook 2014, practice, study and action are three area of design, and each institution aims to give design education with one or more focusing area of the three. Their focus determines the aims, programme details, levels of engagement, and requirement of resources for success. The courses of the industrial design departments are divided into three subjects: professional design practice (PDP), design studies (DS) and design thinking (DT).

PDP courses aim to develop skills, knowledge and inclinations to design communication, products, environments and services for today and the future. DS courses contain research and critical analysis about how design affects people, their activities, and places. They also study the effects of design on physical, cognitive, social, cultural, technological, and economic aspects of context.

Content of DT courses are process oriented like visualisation, prototyping, etc. and problems of these subjects being solved (NASAD Handbook 2014, 2015).

In Table 1, courses of industrial design departments in LNU and IZTECH are divided into categories of PDP, DS and DT according to their course content. The table also contains information about credits and if courses are mandatory or elective. Courses under the PDP category teach basic skills such as computer aided design, basic material and manufacturing technologies, and presentation. In addition to PDP characteristic, DT characteristics make courses more advanced, like concept development or problem analysis and solving.

University	Courses	Credit	Category	Mandatory/ Elective
LNU	Local Innovation	22,5	PDP+DS+DT	M
	Methods at work	7,5	DS	M
	Innovation for Global Impact	22,5	PDP+DT	M
	Action Research and Interactive Methods	7,5	PDP+DS	M
	Material Culture and practices	7,5	PDP+DS	E
	Philosophy of Science with emphasis on Design	7,5	DS	E
	Methods for exploration	7,5	DS	E
	Articulation	4,5	PDP	E
	Seminar Series 1	3	DS	E
	Human Centred Design, processes, methodology	7,5	PDP+DT	E
	Design, advanced study 1	7,5	PDP+DT	E
	Design, advanced study 2	7,5	PDP+DT	E
	Design theory, advanced study	4,5	DS+DT	E
	Seminar Series 2	3	DS	E
	Co-operative design work, methodology, deepened studies	7,5	PDP+DS+DT	E
	Design in practice advanced study 1	7,5	PDP+DT	E
	Design advanced study 1	7,5	PDP+DT	E
	Design work advanced studies project	12	PDP+DT	E
	Seminar series 3	3	DS	E

	Degree project	30	PDP+DS+DT	M
IZTECH	Industrial Design Studio	8	PDP+DT	M
	Research Methods in ID	6	PDP+DS	M
	Advanced Product Development	8	PDP+DT	M
	Seminar	6	DS	M
	Consumption Trends and Material Culture	8	DS	E
	Evolution of Communication Tools	8	DS	E
	Evolution at Design	8	DS	E
	Material Science and Manufacturing Technologies	8	PDP	E
	Design Management	8	PDP+DT	E
	Ergonomics and Human Factor in Design	8	PDP	E
	Design Engineering	8	PDP	E
	Communication Design	8	DS	E
	Semiotics in Design	8	DS	E
	Sustainable Design	8	DS	E
	Product Innovation	8	PDP+DT	E
	Philosophical Context of Design Research	8	DS	E
	Fashion Concept in Design	8	DS	E
	Industrial and Graphic Photography	8	PDP	E
	Cinema and Design	8	DS	E
	Packaging Design	8	PDP+DT	E
	Furniture Design	8	PDP+DT	E
	Computer aided product design 1	8	PDP	E
	Computer aided product design 2	8	PDP	E
	New Product Design	8	DS+DT	E
	Time and Space Design in Transnational Cinema	8	DS	E
	Special Topics in Industrial Design	8	DS	E
	Special Studies	4	PDP+DS	M

	Special Topics	4	PDP+DS	M
	Master Thesis	26	PDP+DS+DT	M

Table 1. Taxonomy of industrial design courses at LNU and IZTECH according to NASAD Handbook 2014.

In the data analysis section, there are two different analyses, which are separate characteristics and general characteristics. In separate characteristic method, each courses characteristics are examined, then these are observed; PDP, DS, DT, PDP+DS, PDP+DT, and PDP+DT+DS. This method shows that some courses contain one than more characteristics. In graphs of the general characteristic method, the total number of each course which has any characteristics, is shown as PDP, DS and DT.

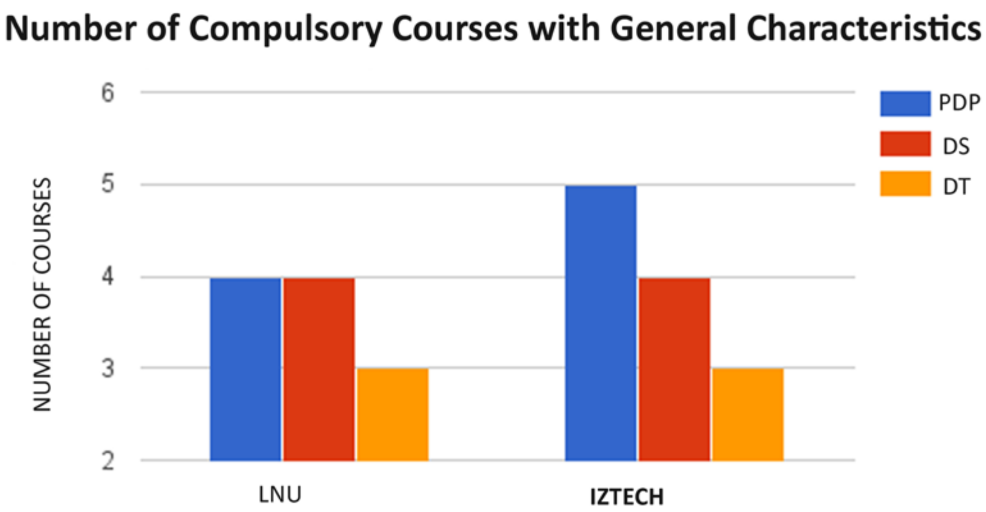


Figure 2: Number of compulsory courses in industrial design department at LNU and IZTECH and their general characteristics.

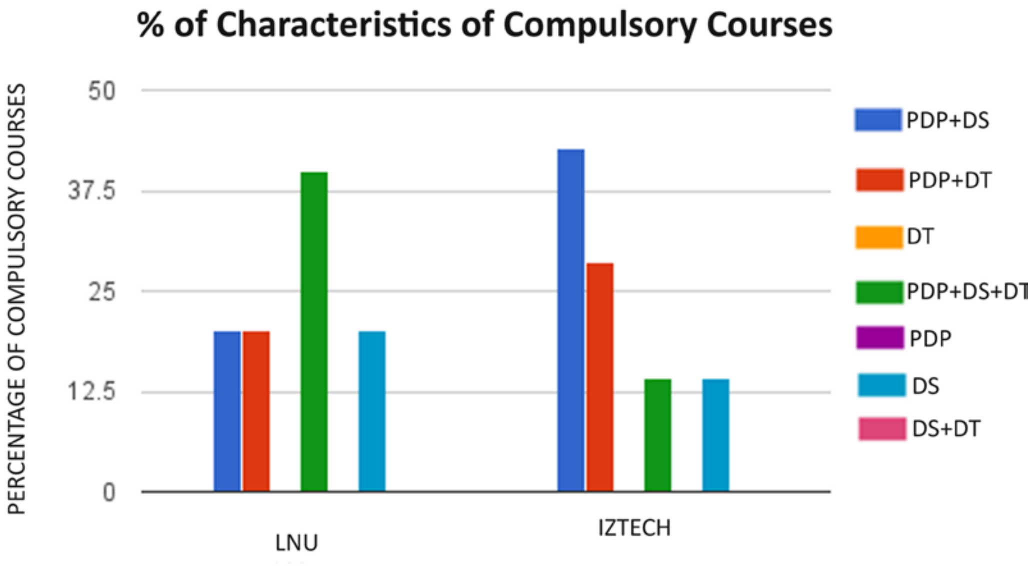


Figure 2 Percentage of distribution of characteristics into compulsory courses in industrial design department at LNU and IZTECH.

When data in the Table 1 were analysed, the number of compulsory courses of industrial design departments at LNU and IZTECH and their characteristic can be seen in Figure 2 which shows IYTE has more PDP characteristic courses, but there is no other difference in terms of general characteristics. However, when each course is examined according to their individual characteristics in Figure 2, LNU offers more PDP+DS+DT characteristic courses than IZTECH. This type of courses teaches not only basic skills but also working with teams, developing concepts and analysing and solving problems. As seen Figure 3, both programmes offer almost the same number of elective courses, but courses at LNU have equal distribution in contrast to courses at IZTECH which have more DS characteristic elective courses. All elective courses are examined separately; IZTECH has some missing characteristics, while LNU offers courses in more various characteristics as seen Figure 4. As a result of the first method, differences and similarities were determined between curriculum of industrial design programmes at IZTECH and LNU. The most noticeable difference between the two programmes is distribution of characteristics in elective courses. The number of PDP+DS+DT courses at IZTECH is less than LNU. Moreover, LNU offers elective courses in each characteristic in contrast to IZTECH.

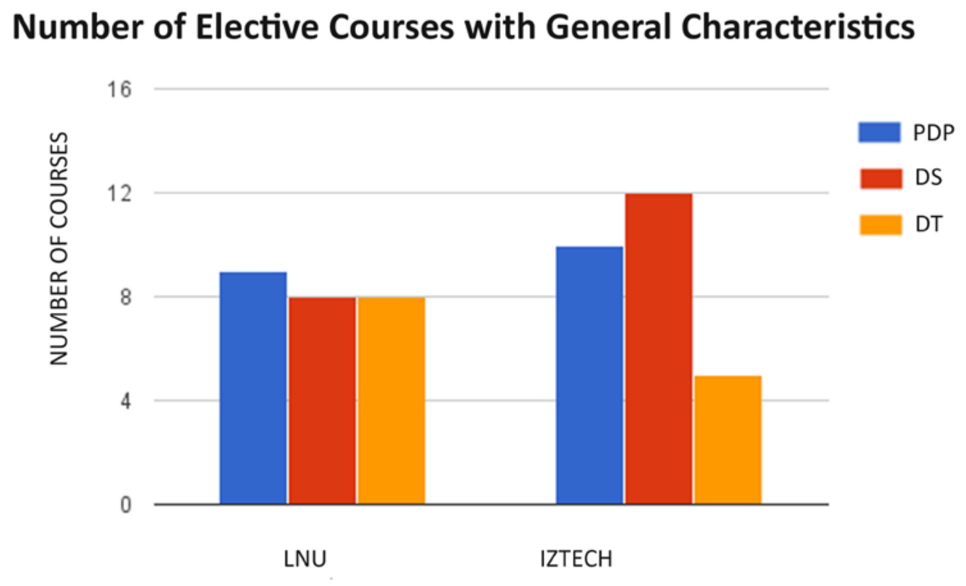


Figure 3. Number of elective courses in industrial design department at LNU and IZTECH and their general characteristics.

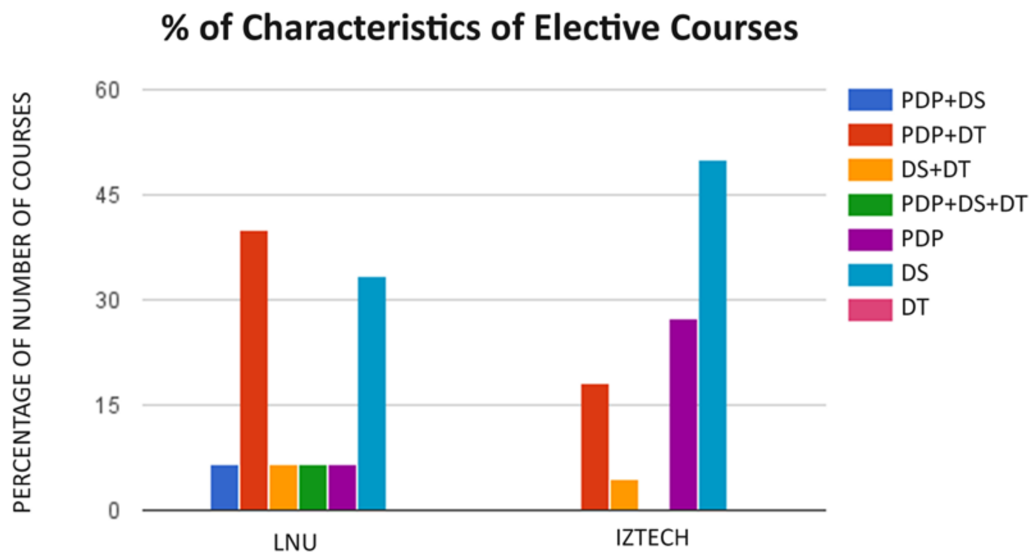


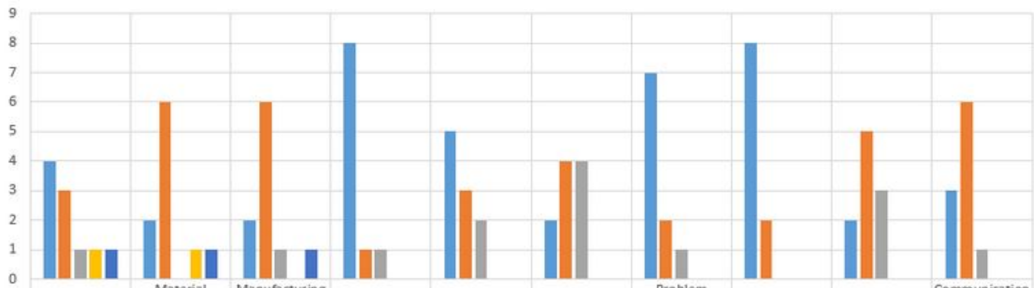
Figure 4. Percentage of distribution of characteristics into elective courses in industrial design department at LNU and IZTECH.

3.3 Feedback Session with Industry

A second method was taking feedback from industrial design departments of companies or individual designers that had opportunity to work with new graduate of industrial design departments. For this purpose, a survey, which had 11 questions, was sent to design department managers or industrial designers. The first 4 questions aim to learn who they are, and how much experience they have, the next 6 questions are about the situation of new graduates and what companies or employers' expect from them, and the final question asks additional opinions of participants.

The feedback session was designed as a small-scale survey (Owen, Fox & Bird, 2015), which is used where researchers have limited resources that can cause limitation in terms of the size and scope in the survey. Small-scale surveys can be examples for student's projects or dissertations in a social science area (Punch, 2003). When participants are determined, a variety of department and business segments are given importance, because nowadays graduates of industrial design departments are not only working for manufacturing industries, but also working for interaction or user experience design projects. There are 10 participants who answered 11 of the questions, and the detailed answered sheets are in Appendix 1.

The second part of the survey includes questions to learn current situation of new graduates and expectations of companies from them. In this part, the fourth question aims to learn expectations of companies from new graduate industrial designers in terms of skills and knowledge. Answers of 8 participants show that the most important two skills are teamwork and concept development (Figure 5).



	CAD software knowledge	Material science knowledge	Manufacturing technologies knowledge	Tendency for team work	Ability of presentation	Marketing knowledge	Problem analyzing and solving	Concept Development	Project Management	Communication with other department
Definitely Required	4	2	2	8	5	2	7	8	2	3
Required	3	6	6	1	3	4	2	2	5	6
Not a must	1	0	1	1	2	4	1	0	3	1
Unrequired	1	1	0	0	0	0	0	0	0	0
Definitely unrequired	1	1	1	0	0	0	0	0	0	0

Figure 5. Answers of the question 4 which is about expectations from new graduates from industrial design departments

The next question is "In which level new graduate industrial designers meet your companies' expectation?". According to answers as seen in Figure 6, none of the companies found 100 % matched industrial designer, and the majority replied that new graduates met as only 50 % as their expectations.

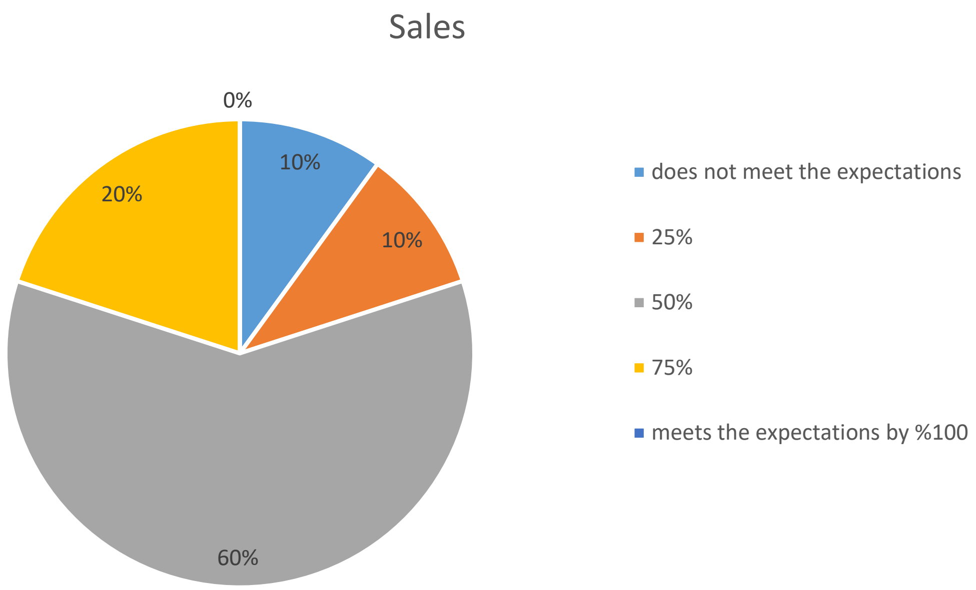


Figure 6. Companies expectations and meeting them with new graduates' ratios

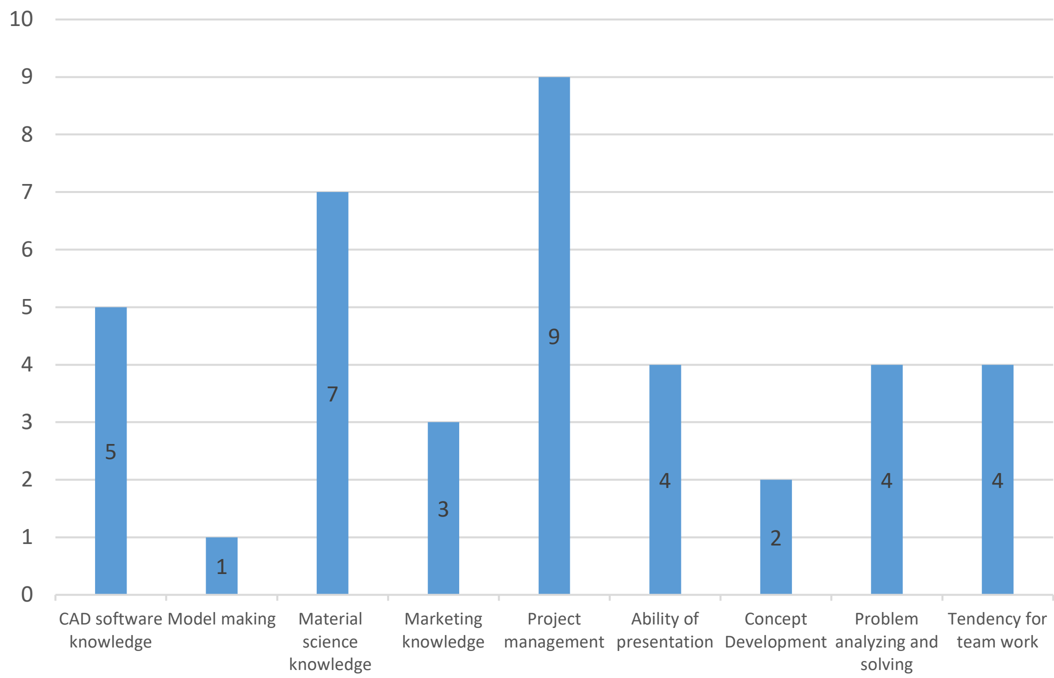


Figure 7. Insufficiency in specific subjects of new graduates according to companies

The following question in Figure 7 asks in which skills and knowledge new graduates have an insufficiency. In contrast to companies' expectations, they do not have enough knowledge in project management and technical subjects. However, companies want more qualified new graduates in teamwork and concept development.

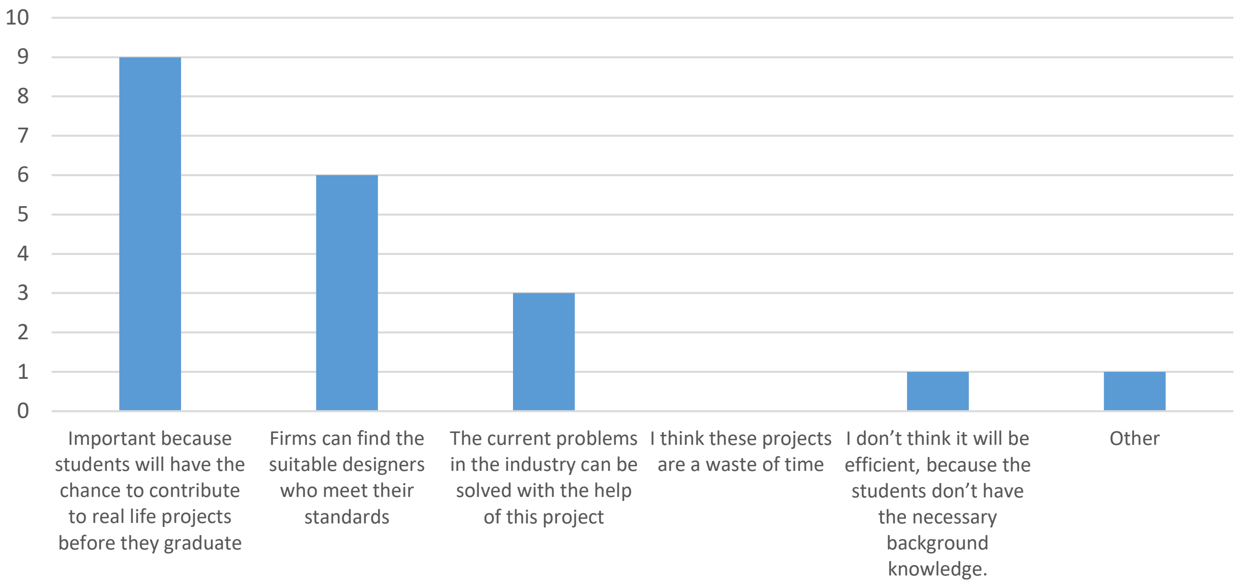


Figure 8. Companies opinion about UIC with industrial design departments

As seen in Figure 8, the majority of companies think UIC with industrial design departments are important, because thanks to UIC projects they can have opportunities to work on real projects before graduation. Moreover, when the answers are examined, 5 participants who agree with majority opinion select one more opinion that is that companies can reach designers who are suitable for them.

Participant companies or designers never contributed to any facility for industrial design project labs or workshops, but 30 % of them plan to in the future.

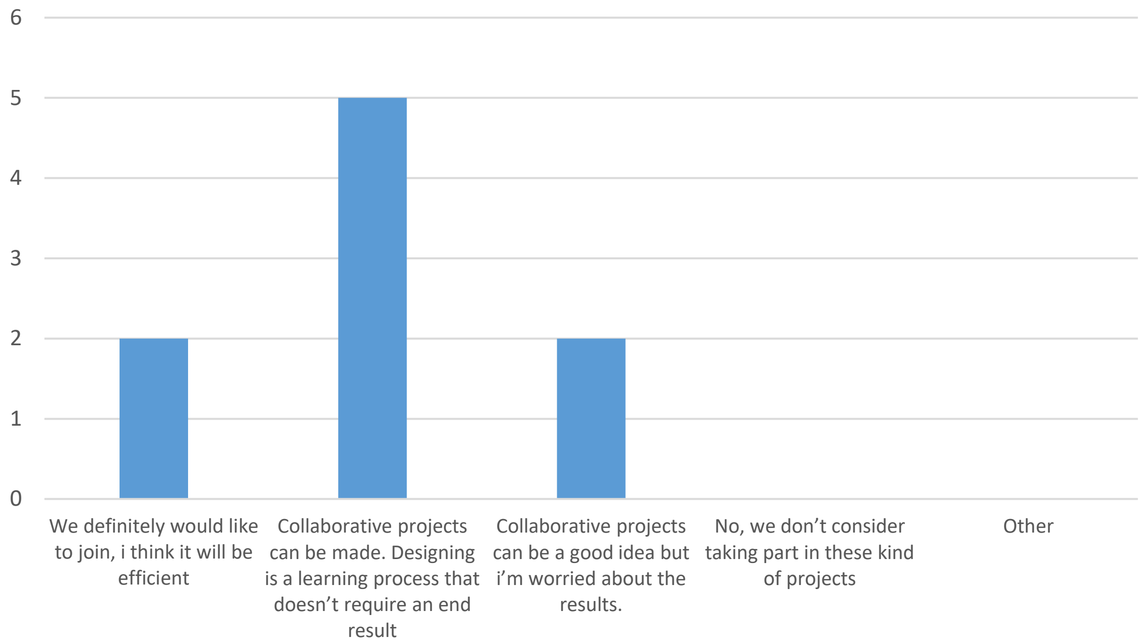


Figure 9. Companies and designers' tendency for UIC

In Figure 9, how much companies and designers are willing to collaborate with universities is asked, and according to answers, opinions of the majority is that UIC projects are possible, and there is no obligation to reach to results, because the important point in UIC is the process of learning together.

When companies or designers' additional opinion is asked at the last question, one response was "Before graduation, students should learn different department's needs, project management, and concept of business analysis, because these make advantage in business life. Thus, internships, teamwork and projects are important to gain experience".

Results

1. When compulsory courses are examined in terms of general characteristics, both industrial design programs have similar structure. However, when the percentage of characteristics of each course is calculated, there is difference in PDP+DT+DS characteristic between LNU and IZTECH. LNU has more courses in PDP+DT+DS, while IZTECH has more courses in PDP+DS.
2. In LNU, characteristics are equally distributed into elective courses, but there is no balance in IZTECH. When characteristic of each courses are examined, LNU offers each of them, except only DT characteristics, however, there is some deficient characteristic in elective courses, which are offered by IZTECH. PDP+DS and PDP+DS+DT are lacking characteristics.
3. Expectations of companies and designers from new graduates can be listed, according to rate of definitely required and required; tendency of teamwork (8/10 definitely required), concept development (8/10 definitely required), problem analysis and solving (7/10 definitely required), CAD software using (4/10 definitely required), material science

knowledge (6/10 required), manufacturing techniques knowledge (6/10 required), communication with other departments (6/10 required), project management (5/10 required).

4. New graduate industrial designers meet 60% companies' expectations in 50%, and 20% of companies think that new graduates meet expectation in 75%.
5. According to companies, new graduate industrial designers lack qualification in terms of project management, material science knowledge, manufacturing techniques knowledge and CAD software using ability.
6. The majority of participants agree "UIC is important for industrial design departments, because thanks to it, students take opportunity to work on real projects."
7. In terms of tendency of companies and designers for UIC, they agree that collaborative projects can be done; there should not be obligation to reach tangible results, because design is a learning process.

Conclusion

There are two methodologies, which are applied in this research, and they aim to determine reasons for the limited engagement with UIC in IZTECH. To reach a result, outcomes of two methods are compared and the relationship is built to see how UIC can be developed in IZTECH.

The missing subjects are under PDP and DT characteristics. According to Figure 2 and Figure 4, both compulsory and elective courses offer limited number of DT characteristic courses that provide knowledge and experience about project management. DT is a side characteristic which means that there is no course with only DT characteristics as seen Table 1, because DT makes courses more advance and adds team work, concept development etc. which are the most wanted qualifications by companies or designers according to survey result as seen Figure 5.

To make the curriculum more suitable for UIC, adding new courses is not the only option, making improvement like adding team projects, or other research assignments can contribute curriculum.

References

Agrawal, A., & Henderson, R. (2002). Putting Patents in Context: Exploring Knowledge Transfer from MIT. *Management Science*, 48(1), 44-60.

Ankrah, S., & Al-Tabbaa, O. (2016). Universities—industry collaboration: A systematic review. *Scandinavian Journal of Management*, 31(3), 387-408.

Arza, V. (2010). Channels, benefits and risks of public-private interactions for knowledge transfer: conceptual framework inspired by Latin America*, Science and Public Policy*, 37(7), 473–484. doi: 10.3152/030234210X511990.

Balconi, M., & Laboranti, A. (2006). University-industry interactions in applied research: the case of microelectronics. *Research Policy*, 35(10), 1616–1630. doi: 10.1016/j.respol.2006.09.018

Ball, L. (2002). Preparing graduates in art and design to meet the challenges of working in the creative industries: a new model for work. *Art, Design and Communication in Higher Education*, 1(1), 10–24.

Barbolla, A., M., B, & Corredera, J., R., C. (2009). Critical factors for success in university-industry research projects. *Technology and Strategic Management*, 2(5), 599-616.

Bekkers, R., & Freitas, I., M., B. (2008). Analysing Knowledge Transfer Channels between Universities and Industry: To What Degree do Sectors also Matter? *Research Policy*, 37(10), 1837–1853.

Bektaş, Ç., & Tayauova, G. (2013). A Model Suggestion for Improving the Efficiency of Higher Education: University–Industry Cooperation. *Procedia Social and Behavioural Sciences*, *116* (2014), 2270 – 2274.

Boyarski, D. (1998). Education: Designing Design Education. *SIGCHI*, 30(3), 2.

Bruce, M., & Bessant, J. (2002). *Design in Business*. London, UK: Prentice Hall.

Carayol, N. (2003). Objectives, agreements and matching in science–industry collaborations: reassembling the pieces of the puzzle. *Research Policy*,32(6), 887–908. doi: 10.1016/S0048-7333(02)00108-7.

Cohen, W., M., Florida, R., Randazzese, L., & Walsh, J. (1998*).* Industry and the Academy: Uneasy Partners in the Cause of Technological Advance. In Noll, R. (Eds.), *Challenges to the Research University* (pp.171-199). Brookings Institution Press, Washington DC.

Cohen, W., M., Nelson, R., & Walsh, J., P. (2002). Links and Impacts: The Influence of Public Research on Industrial R&D. *Management Science*, Special Issue on University Entrepreneurship and Technology Transfer, 48(1), 1-23.

Coombs, R., Harvey, M., & Tether, B., S. (2003). Analysing Distributed Processes of Provision and Innovation. *Industrial and Corporate Change*, 12(6), 1125–1155.

Creswell, J., W. (1994). *Research Design*, Qualitative and Quantitative Approaches. Thousand Oaks, Cal. USA: Sage Press.

Dess, G., G., & Shaw, J., D. (2001). Voluntary turnover, social capital and organizational performance, *Academy of Management Review*, 26(3), 446-456.

D'Este, P., Nesta, L., & Patel, P. (2005). *Analysis of University-Industry Research Collaborations in the UK: Preliminary Results of a Survey of University Researchers*. SPRU Report.

D'Este, P., Perkmann, M. (2011). Why do academics engage with industry? The entrepreneurial university and individual motivations*. Journal of Technology Transfer*, 36(3), 316–339. doi: 10.1007/s10961-010-9153-z.

Çırpanlı T, Er HA (2006). Tasarımı KOBİ'lerle Buluşturmak: Türkiye ve İtalya'dan İki Üniversite-Sanayi İşbirliği Projesi, In: *III. Ulusal Tasarım Kongresi: Türkiye'de Tasarımı Tartışmak Bildiri Kitabı*, ed. H. A. Er, Ş. Timur, L.N. E. Arıburun, H. H. Bağlı, A. O. İlhan, A. Z. Turan, G.Turan, E. Küçüksayraç & A. Ensici, 42-59. Istanbul: Istanbul Technical University Press.

Erkarslan, O. (2013). A Systematic Review of the Relations between Industrial Design Education and Industry in Turkey through SWOT Analysis, *The Design Journal*, 16(1),74-102.

Erkarslan, O. (1998). Tasarımda Doktora Egitimi Üzerine Alternatif Öneriler (Suggestions for PhD education in design. In Er H. A. & Er, Ö. (eds) Endüstriyel Tasarım Egitimi: ITÜ Endüstriyel Tasarım Toplantıları 1998–1999 (Proceedings *on Industrial Design Education 1998–1999 ITÜ).* Bildirileri *ITÜ Endüstri Ürünleri Tasarımı Bölümü, Nisan 2004.* Istanbul: Istanbul Technical University Press.

Erkarslan, O. (2007). Inter-disciplinary characteristic of design profession: Bridging the gap between design education and industry. *Designtrain Congress Trailer I,* Amsterdam, The Netherlands, 10–12 May 2007, 213–218.

Erkarslan, O., Imamogulları, B. (2010). Comparative analysis of master of industrial design education in Turkey, *Design and Technology Education: An International Journal,* 15(3), 41–57.

Erkarslan, O., Kaya, A., & Dilek, O. (2013). Comparative analysis of recruitment qualifications of industrial designers in Turkey through undergraduate education programmes and online recruitment resources. *International Journal of Technology and Design Education,* 23(1), 129-145.

Etzkowitz, H. (1998). The Norm of Entrepreneurial Science: Cognitive Effects of the New

University Company Linkages'. *Research Policy*, *Elsevier Science*, 27(8), 823-833.

Eun, J., H. (2009). China's Horizontal University-Industry Linkage: Where from and Where to. *Seoul Journal of Economics*, 22 (4).

European Commission Innovation Union Scoreboard (2013). Retrieved from http://ec.europa.eu/enterprise /policies /innovation/files/ius-2013_en.pdf

Evyapan, N., Korkut, F., & Hasdoğan, G. (2005). *Implications of collaboration with industry for educational strategies in industrial design: the graduation project course*. 137-159. Ankara: METU, Faculty of Architecture Press.

Feller, I., Ailes, C., P., & Roessner, J., D. (2002). Impacts of research universities on technological innovation in industry: evidence from engineering research centres. *Research Policy*, 31(3), 457–474. doi: 10.1016/S0048-7333(01)00119-6.

Franco, H., & Haase, H. (2015). University–industry cooperation: Researchers' motivations and interaction channels. *Journal of Engineering and Technology Management,* 36(April–June) 2015, 41-51. https://doi.org/10.1016/j.jengtecman.2015.05.002

Freitas, I., M., B., & Verspagen, B. (2017). The motivations, institutions and organization of university-industry collaborations in the Netherlands. *Journal of Evolutionary Economics*, 27(3), 379–412.

Gulbrandsen, M., Mowery, D., & Feldman, M. (2011). Introduction to the special section: Heterogeneity and university–industry relations. *Research Policy*, 40(1), 1–5.

Guenther, J., & Wagner, K. (2008). Getting out of the ivory tower – new perspectives on the entrepreneurial university. *European Journal of International Management*, 2(4), 400-417.

Iqbal, A., M., Khan, A., S., Iqbal S & Senin, A., A. (2011). Designing of Success Criteria-based Evaluation Model for Assessing the Research Collaboration between University and Industry. *International Journal of Business Research and Management (IJBRM)*, 2(2), 59-73.
Joseph, K., J., & Abraham, V. (2009). University-Industry Interactions and Innovation in India: Patterns, Determinants, and Effects in Select Industries. *Seoul Journal of Economics* 2009, 22(4), 467-498.

Kaufmann, J. (1998). Why design education? Infrastructure issues affecting the future of industrial design education. The 1998 IDSA National Education Conference (CD ROM).

Kiper, M. (2010). Dünyada ve Türkiye'de Üniversite-Sanayi İsbirligi ve Bu Kapsamda Üniversite-Sanayi Ortak Arastırma Merkezleri Programı (ÜSAMP). Retrieved from http://www.ttgv.org.tr/content/docs/usi_kitap.pdf [accessed 20 April 2011].

Kotler, P. (2000). *Marketing Management*, London, UK: Prentice-Hill Inc.

Lam, A. (2005). Work roles and careers of R&D scientists in network organizations. *Industrial Relations: A Journal of Economy and Society*,44(2), 242–275. doi: 10.1111/j.0019-8676.2005.00383.x

Lambert, R. (2003). *Lambert Review of Business-University Collaboration*. HMSO.

Landry. R., Amara, N., & Ouimet, M. (2005). A Resource-based Approach to Knowledge Transfer: Evidence from Canadian University Researchers in Natural Sciences and Engineering. *DRUID 10. Anniversary Summer Conference*, Copenhagen, Denmark, 42.

Lee, Y., S. (1996). Technology transfer' and the research university: a search for the boundaries of university-industry collaboration. *Research Policy*, 25(6), 843–863. doi: 10.1016/0048-7333(95)00857-8.

Lee, Y., S. (2000). The Sustainability of University-Industry Research Collaboration: An Empirical Assessment. *Journal of Technology Transfer*, 25(2), 111-131.

Maietta, O., W. (2015) Determinants of university–firm R&D collaboration and its impact on innovation: A perspective from a low-tech industry**.** *Research Policy*, 44(7), 1341-1359.

Meyer-Krahmer, F., & Schmoch, U. (1998). Science-based technologies: university-industry interactions in four fields*. Research Policy*, 27, 835–851. doi: 10.1016/S0048-7333(98)00094-8.

NASAD (2014). *NASAD advisory statement on design curricula in higher education in NASAD Handbook 2014-2015*.Virginia, USA.

OECD (2015). *Industrial production*. Retrieved from https://data.oecd.org/industry/industrial-production.htm

OECD (2015). *Gross domestic spending on R&D (indicator)*. doi: 10.1787/d8b068b4-en

OECD (2015). *Triadic patent families (indicator)*. doi: 10.1787/6a8d10f4-en

Owen, N., I., Fox, A., & Bird, T. (2015). The development of a small-scale survey instrument of UK teachers to study professional use (and non-use) of and attitudes to social media. *International Journal of Research & Method in Education*, 39(2), 170-193.

Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., Fini, R., Geunae, A., Grimaldi, R., Hughes, A., Krabel, S., Kitson, M., Llerena, M., Lissoni, F., Salter, A., & Sobrero, M. (2013). Academic Engagement and Commercialisation: A Review of the Literature on University-Industry Relations. *Research Policy*, 42(2), 423-442.

Perkmann, M., & Walsh, K. (2009). The two faces of collaboration: impacts of university-industry relations on public research. *Industrial Corporate Chang*e, 18(6), 1033–1065. doi: 10.1093/icc/dtp015.

Pittayasophon, S. (2016). *UIC in Japan and Thailand: Influence of key actors' characteristics and modes of collaboration*. PhD thesis, GRIPS National Graduate Institute for Policy Studies, Tokyo, Japan.

Plewa, C., Korff, N., Johnson, C., Macpherson, G., Bakeen, T., & Rampersad, G. (2013). The evolution of university–industry linkages-A framework. *Journal of Engineering and Technology Management*, 30(1), 21-44. Retrieved from https://doi.org/10.1016/j.jengtecman.2012.11.005

Punch, Keith. (2003). *Survey Research*. London, GBR: SAGE Publications, 22.

Qın, Y., Mkhıtaryan, D., & Bhuıyan, M., A. (2017). University-industry collaboration also provides the following benefits regarding learning effectiveness. *International Conference on Applied Mechanics and Mechanical Automation (AMMA 2017)*, 6-7 August 2017, Phuket, Thailand, 411-415.

Rast, S., Khabiri, N., & Senin, A., A. (2012). Evaluation Framework for Assessing University-Industry Collaborative Research and Technological Initiative. *APBITM*, 13-15 January 2012 Pattaya, Thailand.

Røed, H. (2000). *University-Industry Collaboration: Systemic Interaction or One-Way Knowledge Transfer?* University of Oslo-Centre for Technology, Innovation and Culture.

Santoro, M., D., & Chakrabarti, A., K. (2002). Firm size and technology centrality in industry university interactions. *Research Policy*, 31(7), 1163-1180.

Scandura., A. (2016). University–industry collaboration and firms' R&D effort. *Research Policy*, 45(9), 2016, 1907-1922.

Sedlacek, S. (2013). The role of universities in fostering sustainable development at the regional level. *Journal of Cleaner Production*, 48(1), 74-78.

Shane, S. (2002). Executive Forum: University Technology Transfer to Entrepreneurial Companies. *Journal of Business Venturing*, 17(6), 537–552.

Siegel, D., S., Waldman, D., & Link, A. (2003). Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: An exploratory study. *Research Policy*, 32(1), 27-48. DOI: 10.1016/S0048-7333(01)00196-2

Spellmeyer, G., & Weller, B. (2003). Design Transfer, *ICSID 2. Educational Conference,* Design Congress 2003, Hannover, September 5-7, 2003, 28-33.

Subramanian, A., M., Lim, K., & Sohc, P., H. (2012). When birds of a feather don't flock together: different scientists and the roles they play in biotech R&D alliances. *Research Policy*, 42(3), 595–612. doi: 10.1016/j.respol.2012.12.002.

van Looy, B., Debackere, K., & Andries, P. (2003). Policies to stimulate regional innovation capabilities via university-industry collaboration: An analysis and assessment. *R&D Management*, 33(2), 209-229.

Wilson, T. (2012). *A Review of Business-University Collaboration HM Government*, (Report), UK. Retrieved from http://www.ncub.co.uk/reports/wilson-review.html

Yang, M., Y., You, M., & Chen, F., C. (2005). Competencies and qualifications for industrial design jobs: Implications for design practice, education, and student career guidance. *Design Studies*, 26(2), 155–189.

Yeh, W., D. (2003). The demand and the evaluation of industrial design profession from the industries. *The 6th. Asian Design Conference* (CD ROM), 14-17 October 2003, Tsukuba, Japan.