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Impact of Job Requirements on ICT Curriculum*

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This study presents an approach to address the issue of keeping curriculum content in synch with the changing demands; in other words dynamic curriculum delivery or dynamic curriculum updating based on a model. In this approach, the analysis of Information and Communication Technology (ICT) job data from the industry, and as well as the ongoing use of expert knowledge from the field of information science keep the ICT curriculum content up-to-date, relevant, and consistent with the educational goals of the universities, and students in a variety of educational and cultural contexts. A number of recommendations are put forward for educating students in Turkish universities in order to enhance their opportunities in the international job market.

Keywords: ICT curriculum; curriculum content updation; ICT programs; ICT jobs; content organization

1. Introduction

The National Academy of Engineering report titled 'The Engineer of 2020' calls for the engineers of the future to exhibit 'practical ingenuity' [1]. This requires an educational environment where students can adopt a systematic approach to engineering design. Today's fast technological growth demands that engineering schools update their programs and facilities on frequent basis.

One of the most valuable aspects of action research is collaborative activity and is gaining interest in the field of Information Systems (IS) and other design disciplines. Kurt Lewin [2] the pioneer in social science, defined action research as a specific research approach in which the researcher generates new knowledge about a social system while attempting to change it in a quasi-experimental fashion and with the goal of improving the system. Action research is a qualitative research approach, which is not only suitable for multidisciplinary research teams but also for mixed teams of researchers and practitioners. It aims to improve practice through the collaborative work of researchers and practitioners.

In such an arrangement, schools should work together with the ICT industry to help improve the curriculum according to the industrial requirements, so that action research can aim to contribute to the practice of the curriculum. Such industrial requirements depend on the context and the specific needs of the industry; the importance, requirements and purposes of the curriculum; the subject matter and the experiences reflected in the curriculum, the learning activities, and the assessment and evaluation of the curriculum assessment.

This study will propose a model which will analyze the flow of information in the curriculum in terms of industrial feedback. Two aspects (curriculum and industry) will be discussed by looking at the current curriculum of two universities: METU (Middle East Technical University), Turkey and UW (University of Wisconsin), United States. Note that both universities are subject to ABET (Accreditation Board for Engineering and Technology) [3]. The current ICT curriculum content at METU is reviewed in detail in the light of a brief historical survey of technical education from year between 2000 and 2007. A framework is to develop new curriculum content and to remove many of the serious shortcomings of the present curriculum and of the influence of past history. The framework is explained and justified from an industrial perspective. As for, the ICT curriculum content at UW is reviewed in general within the years 2003 to 2005.

This study will also propose recommendations regarding decision-making processes for the ICT curriculum content updating primarily at undergraduate engineering schools. The model describes why these processes are needed, what they are intended to accomplish, and also what they involve. In addition, it will also explain the importance of carefully monitoring how and by whom the decisions would be made throughout the curriculum reform process [4]. The decision as to the curriculum structure needed to be critically evaluated, and possibly reformed, is prompted by the changing needs of the industry and the desire to remain

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competitive [4]. That is why our aim is to analyze how industry affects the ICT curriculum content.

Several curricular models are reviewed as a part of literature review and their appropriateness to engineering education is examined briefly. Besides, related works to this study will be discussed as well. Upon reviewing of the literature, one can notice that there exist many researches concentrating on the collaboration of universities and the industry to enhance educational programmes [5–6]. For example, in one study [7], authors have identified some skills and knowledge to be possessed by graduates so that the industrial needs can be matched with the curriculum. In another study [8], Koska et al (1988) assessed the required skills for the future engineers and the successive need of change in the curriculum. In addition, the study conducted by Waks and Frank (2000) [6] addresses the updating of engineering educational programs with an eye toward the industrial needs. In these studies, authors developed questionnaires in order to inspect the need for describing and examining the qualifications required by engineers at work. Furthermore, another study [9] done by Dym et al (2005) concentrates on the involvement of project work in the curriculum so that engineering students can integrate, apply, and transfer the knowledge gained from theoretical courses to real world tasks.

As seen later in our study (based on findings related to experience), the universities and the industry need to collaborate in order to provide real life projects to the students in order to teach experience. From the literature survey, we can realize that the related works concentrate on findings based on questionnaires. However, in our study, the findings have been based on the analysis of sample data gathered from employment agencies. This means that the ICT industry itself decides on what type's skills are expected from candidates and also what content should be taught in the ICT curriculum.

Notice that the curriculum is a broad topic that consisting of processes, teaching/learning methodologies, abilities, learning outcomes, and assessment guidelines. The curriculum in this paper applies the analysis and the development of content organization. On the other hand, the meaning of the curriculum involves more than what is implied in the paper. Therefore, it is emphasized here that the meaning of curriculum is limited to analysis and development of the content, or content organization in curriculum.

2. Curriculum content organization

In this section, content organization in the curriculum model is described. The issues will be explained in four subsections: using the UML (Unified Modelling Language) as the diagramming techniques in the curriculum, the analysis of the curriculum content, job analysis, and the curriculum content updating model.

2.1 Diagramming techniques for curriculum model in UML

We use the UML as the diagramming technique for curriculum modelling in the ICT education. The UML is a standard language for specifying, visualizing, constructing, and documenting the artifacts of software systems, as well as for business modeling and other non-software systems [10–11]. Taking advantage of existing modelling approach in a mature field is beneficial to other disciplines. Therefore, this study borrows the modelling concept from a well-developed technique, and adopts it to represent curriculum development. Since UML represents a collection of best engineering practices that proven successful in the modelling of a large and complex systems. Class diagrams are used to represent high level curriculum modelling in the form of aggregation/composition as well as generalization/specialization relations among the more sophisticated concepts identified by a set of keywords.

Aggregation ('partial whole-part') is an association between two entities representing 'part-to-whole' relationship in which each part and whole may exist independently. In other words, aggregation implies that relationship is partial (or optional) depending upon the requirement. Fig. 1 displays a weak whole-part relationship between 'ICT Curriculum' as a whole and the 'ICT Elective' as a part. The relationship is weak because both entities can exist independently. In this representation 'ICT Curriculum' with a small 'diamond' corresponds to the whole and the 'ICT Elective' is the part.

The Composition ('strong whole-part') is a strong kind of 'whole-part' relationship in which parts may belong to only one whole at a time where whole does not exist without its parts. The UML representation of a composition relationship is a filled diamond shape on the containing entity that connects the parts to the whole. The rest of Fig. 1 illustrates the composite type whole-part relationship. In this case the 'ICT Core' as well as 'SE', 'Networking', 'DBMS', and 'Programming' are parts of the whole 'ICT Curriculum'. Notice that Figs. 3–5 and 7 are examples of both composite and aggregate whole-part relationships.

Generalization/specialization is the most common and intuitive association to represent 'a type of relationship' between two entities. Figs. 2, 6, and 7 are examples of 'this type of relationship'. Here, we will only consider Fig. 7. Where, the taxonomy for the 'ICT Job' is illustrated. The intuitive understanding of the relationship represented by this hierarchy is to specify that the 'Programmer', 'Software engineer', 'DBMS Specialist', 'Network Engineer', and 'IT Operator' are type of 'ICT Jobs. This relationship is also known as a generalization/ specialization because the 'ICT Job' is a generalization of the 'Programmer', 'Software engineer', 'DBMS Specialist', 'Network Engineer', and 'IT Operator'. Whereas any of the 'Programmer', 'Software engineer', 'DBMS Specialist', 'Network Engineer', and the 'IT Operator' is a specialization of 'ICT Job'.

2.2 Curriculum analysis

As shown in Fig. 1, the curriculum consists of technical skills such as Software Engineering, DBMS Programming, and Networking as well as the ICT Core and the ICT Elective. In this study, we focus on the technical aspects of the ICT curriculum supposed to be the only skills desired by the ICT industry. Apart from these categories, there exists the ICT Core to represent the core courses in the curriculum, and the ICT Electives to specialized in by the candidate students so as to enhance their skills in the area of their interest. Notice that the ICT Core and the ICT Electives (see Appendix A) are beyond the scope of our discussion and that such additional categories, which are offered for four-year degree program (see Fig. 6), can differ four-year program from two-year degree programs (ICT degree programs will be mentioned in section 2.2). For this purpose the present paper concentrate on four-year degree program and analyzing the impact of ICT Jobs on the ICT curriculum.

The ICT curriculum model shown in Fig. 1 has to support the development of a variety of degree programs illustrated in Fig. 6 which also emphasize and focus on ICT-related jobs shown in Fig. 7. These programs includes B.S. in software engineering (SE), computer science (CS), information systems (IS), and computer engineering (CE). Students for these positions must be educated in the technical aspects of the ICT curriculum such as programming, database design, systems analysis and design, and network communication issues. Since the most common ICT jobs, tabulated in Table 1, are entirly related to the core categories of the ICT curriculum. The reason for this is that Fig. 1 is based on the findings from sample job data gathered in the ICT industry as well as [12–13]. The underlying causes as these four categories (i.e., programming, database design, systems analysis and design, and network communication issues) should be the main focus of ICT education will be examined in section 3. In the followings subsections, each part of the curriculum category is explained in detail.

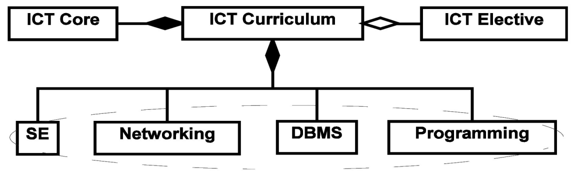

Fig. 1. The model of ICT curriculum. Technical skills for industry are located in dashed ellipse.

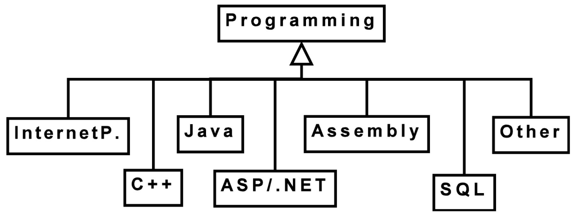

Fig. 2. Types of programming in ICT curriculum.

2.2.1 Programming in ICT curriculum

Figure 2 illustrates the taxonomic hierarchy of the programming part of the ICT curriculum (see Fig. 1). As shown in Fig. 2, the programming is a group of different categories starting from internet programming (left) to other (right). Note that 'other' can be any programming languages apart from the defined languages in the figure.

2.2.2 Software engineering in ICT curriculum

Figure 3 represent the Software Engineering domain, which is composed of several core categories: SAD, SPM, SQA, and HCI including GUI as well as an optional one such as web-based software development (WebDev). A majority of software engineering curriculum has been adopted from the most pioneering book by [14]. Based on the fourth, fifth and sixth editions of this textbook, it is easy to see how core concepts in the software engineering have becomes more mature in these latest editions. Besides, a series of new concepts has been introduced in these latest editions. For instance, web-based development was absent in the fourth edition of the textbook but introduced in the fifth edition, and eventually becoming more matured in the sixth edition.

2.2.3 Networking in ICT curriculum

Figure 4 schematically displays the Networking domain, which is composed of one core concept

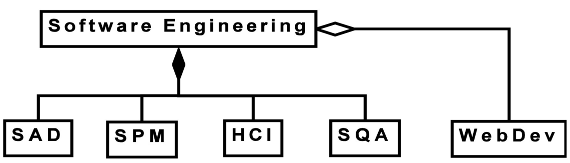

Fig. 3. Software engineering categories in ICT curriculum.

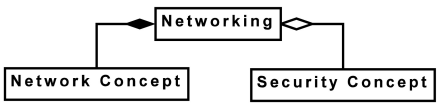

Fig. 4. Networking categories in the ICT curriculum.

(i.e., networking) and one optional (i.e., security) concept. Note that this domain has been based on job data that appears in Table 1. The network concept deals with the development as well as application of network technologies, with begining of security as the introduction. In addition it contains the basic skills of network security, but on the other hand, to strengthen the network security skills of the candidate and they may take network-security related elective courses. Such courses are, therefore provided within the university curriculum [12,13].

2.2.4 DBMS in ICT curriculum

Figure 5 shows the database management system (DBMS) domain divided into three subcategories: the first two are core areas (i.e., DBS and DBP) and third part is the optional part (i.e., WebDBS). Note that [12] incorporates web-data management in their curriculum of DBMS course in the year 2001 whereas [13] did not.

2.3 Job analysis

The job analysis was based on the types of degree requirements and the ICT job hierarchy.

2.3.1 Types of degree requirements

Various types of degree requirements exist in the ICT industry. During the analysis, it was observed that the demand for CS degree is outnumbered other degree types such as SE, CE, IS, IT, and EE. Fig. 6 shows the four-year degree types in the ICT programs whose structure, has been based on job findings. Therefore, CS program is in demand as the main desired degree in the job market, and the other degrees are yet to attrect the confidence of the job market (details appears in section 3.2).

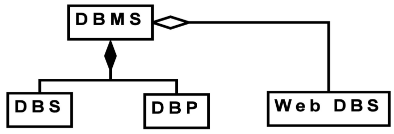

Fig. 5. DBMS categories in the ICT curriculum.

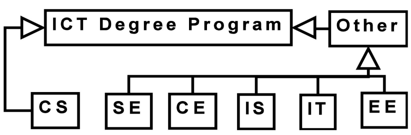

Fig. 6. The structure of degree requirements.

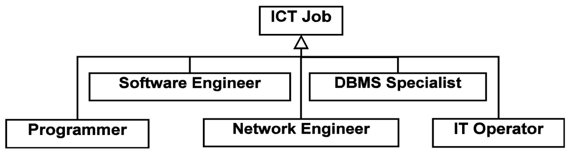

Fig. 7. The structure of the ICT job hierarchy.

2.3.2 Job hierarchy for ICT

The Job hierarchy for ICT, is illustrated in Fig. 7. The reason to adopt this diagram is the industrial demand, because, while collecting the job data, it was realized that these particular job types are the keywords for the job search. What is more these keywords also match the parts of the ICT Curriculum, except, the IT operator (see Fig. 1). Notice that the in general, the IT Operator requires technical knowledge and the expertise of the ICT Curriculum.

2.3.3 Curriculum content model

In order to establish a relationship between the ICT Curriculum part (see Fig. 1) and the ICT Jobs (see Fig. 7), a decision matrix (also called 'decision table') is generated as in Fig. 8. This matrix, which defines a tabular structure, models the complicated logic under which a decision is made. Each column of the table represents the ICT curriculum, and each row corresponds to the type ICT job. With the help of the decision matrix, one can check which ICT skills are appropriate for which type of ICT Jobs, that is, which topics can best fit for which job type. As a sample, a Programmer must have Programming and SE skills (i.e., Programming and SE are core) whereas DBMS skill can be either elective or core. However, Internet-working skill for a Programmer is optional (i.e., technical elective). It should be noted here, that the aim of decision matrix is to synchronize the rows (in this case ICT Job) with columns (part of the ICT Curriculum). The relationship between two concept ICT Job type and ICT Curriculum content will be elaborated in the later section.

2.4 Analysis of the curriculum content

Upon analyzing the curriculum cataloges of METU belonging to the periods between 1995–1997 and 2005–2007 (six years of data all together) results were obtained:

- The introduction to functional programming was changed from Pascal to C,
- The introduction to computer engineering contents were also updated,
- The programming language concepts also were updated,
- The course content and their titles were updated in general.

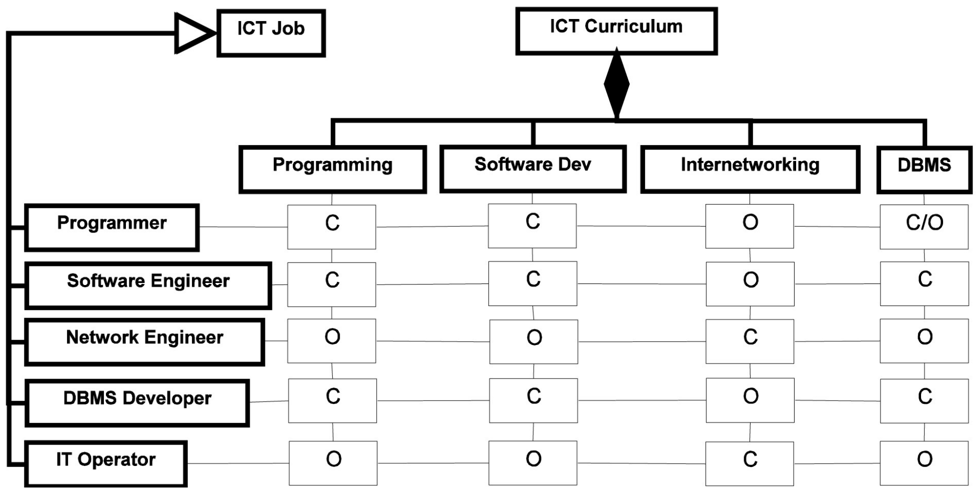

Fig. 8. The decision matrix: ICT Jobs versus ICT Curriculum. (C: core, O: optional).

- The DBMS was entirly updated and included web data management as a new topic.
- The IS courses were developed, made more mature and systematic or more market-oriented compared to six years before.

According to the curriculum update, universities have shifted their strategies on teaching programming languages. Thus, instead of second-and/or-third generation programming languages, the curricula support more 4th generation languagees. For example, Java was started to be tought in the late 90s.

2.5 Analysis of the ICT job requirements

2.5.1 Duration of data collection

For the purpose of data collection, two careers websites -Yahoo hot jobs and MSN hot jobs were used as the sources. In order to make a statistical ICT job analysis, sample job data were collected for three months in 2007-08s.

2.5.2 Characteristics of data sampling

During the process of data collection from the Internet, following criteria were taken into consideration. Prior to adding the candidate samples into data depository, the samples were skimmed and scanned to check whether they are suitable for the purpose. The data analysis is based on information bounded by the following criteria:

1. Websites (e.g. MSN & Yahoo) were the only source for using data collection.
2. Date posted for each job sample was kept so that we could avoid data duplication.
3. Company name for each job sample was kept so that the companies which are global recruiters and placing people globally were preferred as good job sample.
4. Experience is another factor of ICT job requirements.
5. Degree type has been mentioned in Fig. 6.
6. Job title is the type of ICT job was mentioned in Fig. 7.
7. Technical skills were mentioned in Fig. 1.
8. It has assumed that the job data collection has been based on long term jobs, and location is global.

3. Results and discussions

As mentioned earlier we had collected sample job data for three months. The number of data samples fitting the mentioned criteria is 189. The ICT job distribution based on the types of jobs in Fig. 7 has been depicted in Fig. 9. The results indicate that software engineers are the most required job type with 28% of the share, whereas Programmer is less required (14%). On the other hand, if we combine software related jobs (such as Programmer, Software Engineer, and DBMS Specialist) together they will dominate with 62% compared to IT related jobs such as IT operator and Network Engineer with (37%). This shows that the industrial demands toward the software development related-jobs are higher than the other type of jobs.

3.1 Job hierarchy results

Table 1 shows the categorized findings of the data processed during the research. It is a decision table (or matrix) in which each column is an instance of the parts (programming, software engineering, internet working, and DBMS) of the ICT Curriculum as displayed in Fig. 1. On the other hand, each row is an instance of the ICT Job types shown in Fig. 8. In the following subsections, each job type is analyzed

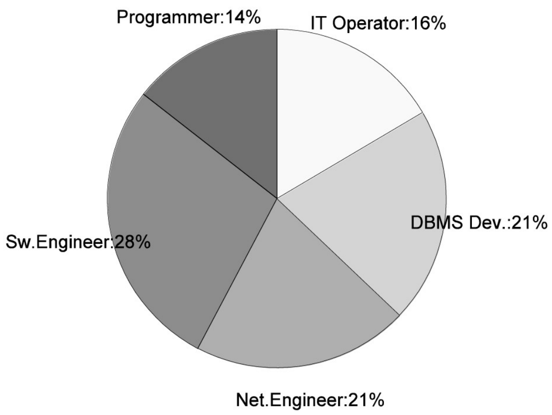

Fig. 9. ICT job distribution.

on the basis of ICT curriculum descriptions illustrated from Fig. 1 through Fig. 5.

3.1.1 Programmer as an ICT job type

Based on the collected data, there are two findings related with this category. As shown in the first row of Table 1, the first finding is that 96.4% of the companies' explicitly specify the minimum level of specific requirement on the particular programming language types (see Fig. 2). Secondly by 3.6% of the companies do not explicitly specify which programming language is required. This does not mean that they are not expecting programming language skills, but experienced programmers in different environment are preferred. In addition to these, the companies need more experienced professionals (i.e. senior level programmer as tabulated in Table 3). This result shows that 34% of the company explicitly specifying which Programming skills they desire. Also, the candidate programmers are expected to have an equal weight of knowledge concerning software development and database skills.

3.1.2 Software engineer as an ICT job type

As shown in the second row of Table 1, the candidate software engineers is expected by the job market to posses skills and experience in software development displayed in Fig. 3. As can be seen from Table 1, 90.4% requires the knowledge in Programming. 9.6% requires the knowledge in Internetworking; 40.4% requires the knowledge in DBMS. Notice that the majority of the software development jobs require the knowledge of DBMS skills.

3.1.3 Network engineer as an ICT job type

Table 1 illustrates the percentage of expected skills from the candidate. For instance, the networking job market requires that 81.6% knowledge of Networking skills and 5.3% Programming skills are required. However Software Development and DBMS skills are not required. The reason is that networking itself is a very specialized domain; therefore industry needs experts with networking skills instead of software development and DBMS skills.

3.1.4 DBMS developer as an ICT job type

According to Table 1, the job market requires DBMS skills from the DBMS developer (i.e., DB specialist). In addition, 89.7% and 56.4% require knowledge in programming and software development skills respectively. While 3% networking skills is expected in those jobs.

3.1.5 IT operator as an ICT job type

According to Table 1, the job market requires complete knowledge in network-related skills. In addition, 28.1%, 15.6% and 18.75% require knowledge in programming, software development and DBMS skills respectively. Notice that all IT operators 100% depend upon networking skills.

3.2 Results for job analysis

As mentioned before, a decision table has been successfully created to establish the relationship between the ICT jobs and the ICT curriculum (see Table 1). Similarly Table 2 in order to associate the ICT Jobs with the related degree types. Each column of the table represents the ICT Degree types, (Fig. 6) and each row corresponds to the ICT Job types. The matrix form describes which degree type (column) is preferred by which ICT job type (row).

Having prepared the structure of the degree requirement, Fig. 10 illustrates the distribution of the average degree preferences. Note that approximately 69% prefer candidates who graduate from CS programs exclusively, while 11% prefer those

Table 1. Decision table (or matrix) for the ICT job and the ICT curriculum (tabulated in percentage (%)).

	Programming	**Software Development**	**Internetworking**	**DBMS**
Programmer	96.4	82.1	17.9	85.7
Software Engineer	90.4	100.0	9.6	40.4
Network Engineer	5.3	0.0	81.6	0.0
DBMS Developer	89.7	56.4	7.7	100.0
IT Operator	28.1	15.6	100.0	18.8

Table 2. Graduation preferences of the ICT job types in terms of CS, CS/Others, and Others

	CS	CS/Others	Others
Programmer	75.0	21.4	3.6
Software Engineer	57.7	15.4	26.9
Network Engineer	89.5	2.6	7.9
DBMS Developer	61.5	2.6	35.9
IT Operator	71.9	12.5	15.6
Average	69.8	10.6	19.6

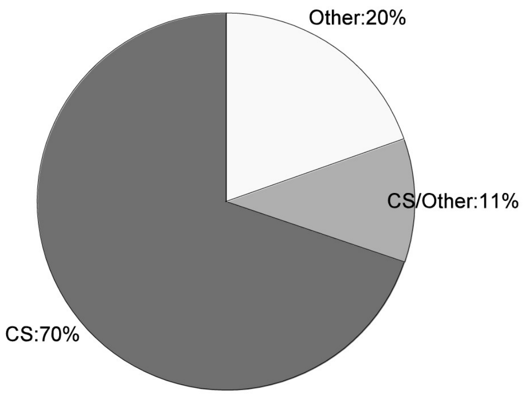

Fig. 10. Expectation of degree requirement.

who graduate from CS but, if not so then other degree types. This implies that graduation from CS with a totaling 80%, are dominated for specified job types. As shown in Fig. 10, only 20% seeks graduates from other degree type. This means that other ICT related programs are not as developed as the CS programs from the perspective of the industry.

3.3 Results for job experience percentage

In addition to the degree requirements, job experience is also plays an important role to get a job. We may ask the following supportive questions.

According to the findings in Table 3, why does 77% of the employers prefer approximate 6.3 years of experience on the average? Does this (employers' complain) mean that new graduates of computing programs do not have knowledge or the skills desired by the industry?

Table 3. Job market demands from experienced candidate and the average years of experience required by each job category.

	Average years of experience	Expectation of Experience (%)
Programmer	6.2	96.4
Software Engineer	4.7	78.8
Network Engineer	8.3	78.9
DBMS Developer	7.5	74.4
IT Operator	5.0	56.3
Average	6.3	77.0

The type of preferences is based on:

- What percentage of companies demand experienced people? See Table 3.
- What is the average years of experience in each job category? See Table 3.

According to findings, the result shows that job markets giving more importance to experience than to degree. The result of data analysis has forced to these two universities to update their curriculum content to get some real life industrial experience. This is evident from Table 3, which shows demand for experience to be the highest in the programmer category (96.4%), the lowest in the IT operator category (56.3%) and the overall demand of average experience in all categories is 77.0%.

With regards to the average years of experience as shown in Table 3, the highest demand is in networking with 8.3 years, and the in the IT operations with 5 years. The average number of years of experience is 6.3 years. This result shows that job companies are more interested in experience apart from education:

> The number of years experience has gained is more important than the number of years that is spent for four year degree program.

Based on the study, our suggestions are:

- Universities establish a link with the job market and their own curriculum to provide real life project.
- Universities should update their curriculum not only theoretical but also include some 'real life' experience based education.
- We should teach experience of professionals (from Industry) to the students in somehow. Teaching experience of senior ICT professionals by an analogy of software design pattern [16].(Our recommendations in details are in Section 5).

3.4 Curriculum content updating model

Figure 11 illustrates a model to update curriculum, supported by findings as mentioned before. As a result, this study establishes the relationship among the important keywords such as university, student, industry and ICT curriculum. As shown in this figure, industry demands the ICT curriculum content updating because of technical and scientific innovations so that universities can graduate individuals accordingly. In other words, universities and industry have to cooperate with each other in order to update the curricula. Universities should offer ICT based curricula to educate students, so that industry can employ them based on their innovative skills. Furthermore, as mentioned before, students can gain work experience from industry by involving them in some real life industrial

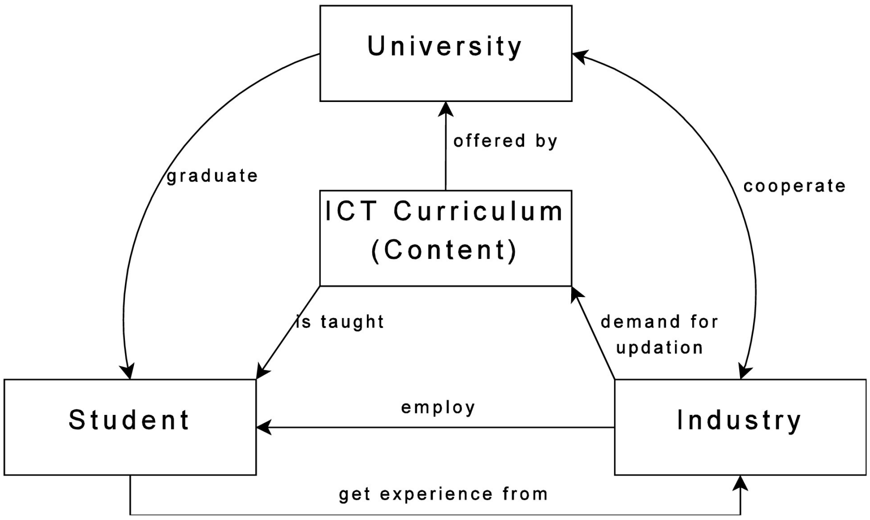

Fig. 11. Model for curriculum content updating.

projects as early as possible during their education. The decision such as the curriculum content updating needed to be critically evaluated and prompted by changing needs of the industry and the desire to remain competitive in education [4]. This model describes why this process is required and also explains the importance of monitoring how and by whom decisions are made throughout the curriculum updating process. The curriculum content organization model supports the development of a variety of degree programs as shown in Fig. 6.

4. Conclusion

The updating of curriculum development process (why updation is needed & for whom) studied in this paper, indicates that industrial demand plays a significant role in this process to update the curriculum by collaborating in order to asses and to reflect on performances by means of job data analysis. As for under-graduate education, this process can be done in a manner in which academic objectives and personal goals can be reconciled. A host of related questions with this subject evidently present a great contemporary challenge to the university academic board. In this context, research evidence provides an important foundation for policy. The solution we have started to explore is the use of curriculum updating model as a method for bonding together procedures, which are individually error-prone, into instrument strong enough to bear the weight of policy-making. The present study also analyzes the impact of the job market on updating of the curriculum content, and how it can support policies that encourage such updation in curriculum based on industrial demand.

Universities and industry have to cooperate to each other to update the curriculum. We believe that the curriculum updation model supports the development of a variety of degree programs Indicating that the industrial demand is playing a significant role to update curriculum by collaborating with their needs The updation of curriculum development process can be applied to other undergraduate program.

5. Recommendations

The following recommendations are:

- There is one more problem with the students, is the lack of confidence as a teacher we know that they have knowledge of the subject, but due to lack of interaction with the professionals (industry) they are unable to express their point of view. So we recommend industrial training for the students at least once in an academic year and this also supported by [5, 10];
- Graduate schools must review their ICT programmes on a regular basis to ensure that their offerings are relevant and in tune with the demand of the ICT job market and apart from producing more quality graduates, the move will also address the critical issue of mismatch of ICT skills, which has often resulted in graduates not able to land a suitable job, and employers complaining of not getting the people with skills required [6];
- Universities should conduct a detailed study on their capabilities and directions as well as they identify current job specifications in the industry before they begin a quality improvement initiative on their ICT education;
- There should be a mutual understanding between

the industry and universities on various technology and business areas to prevent further mismatch of ICT graduates and available jobs. For example, what does programming skills means? There is such a wide range of possibilities in terms of the depth and width of knowledge implied here also supported by [15];

- ICT programmes should incorporate methods, such as exposing students to' success stories' in the industry. In addition, key personalities from the industry can be invited to speak and inspire students while they are still on campus and also students should be exposed such experience from the semester one. Students must equipped with not only technology, but also business knowledge. This way, the ICT graduates will be more in demand in the job market.

References

1. National Academy of Engineering (NAE) report, *The Engineer of 2020: Visions of Engineering in the New Century*, The National Academies Press, 2004
2. K. Lewin, *Action research and minority problems in Resolving Social Conflicts*, G. W. Lewin (Ed.), New York: Harper & Row, 1946.
3. www.abet.org
4. K. R. Wilkinson, C. J. Finelli, E. Hynes and B. Alzahabi, *University-wide curriculum reform: two processes to aid in decision making*, Frontiers in Education Conference, 2000, FIE 2000. 30th Annual.
5. A. See, O. S. Geok, C. Nair and J. Lai, Bilateral Collaborative Partnership Joint Industry/University Perspective, *Int. J. Engng Ed.*, **23**(5), 2007, pp. 973–980.
6. S. Waks and M. Frank, Engineering Curriculum versus Industry Needs-A Case Study, *IEEE Transactions on Education*, **43**(3), 2000, p. 349.
7. S. Waks, *Curriculum Design-From an Art Toward Science*, Germany: Tempus, 1995.
8. D. K. Koska and J. D. Romano, *Countdown to the Future: The Manufacturing Engineer in the 21st Century*. Detroit, MI: Soc. Manufact. Eng. 1988.
9. C. Dym, A. Agogino, O. Eris, D. Frey and L. Leifer, Engineering Design Thinking, Teaching, and Learning, *Journal of Engineering Education*, **103**, 2005.
10. J. Rumbaugh, I. Jacobson and G. Booch, *The Unified Modeling Language User Guide*, Reading, MA: Addison-Wesley, 1999.
11. M. Fowler, *UML Distilled*, Third edition, Reading, MA: Addison-Wesley, 2004.
12. METU (Middle East Technical University), General Catalog, pp. 525–539, pp. 805–833, 2005–2007, Ankara-TURKEY.
13. UW (University of Wisconsin), 2003–2005, Undergraduate Catalog, College of Letters and Science, pp. 13, UW- Madison, USA.
14. R. S. Pressman, *Software Engineering: A Practitioners Approach*, McGraw-Hill, 6th edition, 2005.
15. G. León, Public-private Partnerships in ICT Education from the Open Innovation Perspective, ITI 6th International Conference on Information & Communications Technology, 2008.
16. E. Gamma, E. R. Helm, R. Johnson and J. Vlissides, Design Patterns: Elements of Reusable Object-Oriented Software, Addison-Wesley 1995.

Appendices

A. ICT Curriculum (*other concepts*): ICT Core and ICT Elective

Some of the ICT related concepts (or courses) are part of the ICT curriculum and some of them are optional. Those parts are important for the curriculum, but, are beyond the scope of our discussion.

1. Computer Architecture,
2. Operating Systems,
3. Automata and Formal Language,
4. Discrete Mathematics,
5. Data Structure and Algorithm
6. Numerical Analysis
7. Computer Graphics
8. Multimedia technology
9. At least one procedural language (generally C)
10. Management Information System or equivalent
11. E-commerce

B. Abbreviations

B.1. Four Year Degrees Types in ICT Education

CS	Computer Science
SE	Software Engineering
CE	Computer Engineering
IS/MIS	Information Systems/ Management Information Systems
IT	Information Technologies
EE	Electrical Engineering

B.2. Course or Module Abbreviations

SAD	software analysis and design
SPM	software project management
SQA	software quality assurance
HCI	human computer interaction
Web Dev	web-based software
DBMS	database management system
DBS	database system management
DBP	database programming
Web DBS	web-based database system management

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