Analyzing the importance of teaching about testing from alumni survey data

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Abstract

The Department of Computer Science (IDI) at the Norwegian University of Science and Technology (NTNU), conducted a survey among its master alumni in 2007 and 2011, with the scope to retrieve the educational topics relevant to their field of expertise based on the work experience accumulated after graduation. The results enabled the identification of topics which proved mandatory to learn after graduation, and the two sets of data registered four years apart, provided us with an overview of the trends and a certain shift in the importance of the most favored topics. The data available from this two surveys was analyzed from the perspective of software testing topic and the results of this analysis are presented in this paper.

1 Introduction

"An investment in knowledge pays the best interest" (Benjamin Franklin), and those preparing the future software professionals are responsible for providing them with the skills required and desired in software industry. Many of the young graduates who are entering the work field of software engineering are lacking knowledge in key topics such as requirements engineering, software testing, human related factors and project management [1].

The mismatch of expected knowledge between academic curricula and industry has its roots in the set of acquired skills which accompanies the students at the moment of graduation. This knowledge gap affecting the industry needs was highlighted by [2], [3], [4] and reconfirmed in various studies conducted worldwide [5], [6], [7] and [8]. In order to decrease the existing gap it is mandatory for the universities and colleges to adapt their educational programs while listening to the industry requirements and also ensure that it is conveyed in a manner allowing future professionals to handle correctly the problems that they are most likely to face during their professional career.

An essential part of any software engineering process which ensures the high quality of the software products developed is software testing. Analysis of the current practice and education programs in the US Academia presented by [9] and [2] emphasizes a need for improvement of the current curriculum and of focus on software testing. The lack of knowledge and necessary skills in this domain for the young graduates can be translated as an additional expense for the companies which find themselves in the need of providing additional training for the young testers [10]. Since many companies spend more than 60% of the development cost on testing, and testing is the main process of ensuring a high quality system, as described by [11], it is imperative to search for improvement of the methods, not only among testing techniques, which are extensively covered in the literature, but also on those performing the testing activities, namely the testers.

This paper presents an analysis with the main focus on software testing on the results, of the two web based surveys, conducted by the Department of Computer Science (IDI) of the Norwegian University of Science and Technology (NTNU) among IDI alumni students in

2007 and 2011. The focus of the surveys is to retrieve the educational topics relevant to the participants' field of expertise based on the work experience accumulated after graduation and on the emphasis the IDI department is assigning on these topics. The data available collected by this two surveys was analyzed from the perspective software testing topic at the stage where but the design and collection processes were already completed.

2 Related work

The gap between industry expectation and the knowledge and skills provided by the academia has been the focus of various studies conducted worldwide. The study performed by [9] combines a presentation of testing as an industry profession, a survey of the software testing curriculum in United States and a discussion on the efforts made with the scope of increasing the status of testing in the academic curriculum. The study also highlights the low number of Software Testing journals and societies in comparison with other areas of software engineering. These results show a minimal content for the field of software testing in the undergraduate students. The testing topic is generally included in software engineering or programming courses.

The study conducted by Astigarraga, [9], makes an interesting observation by pointing out that "software testing work is often not seen as glamorous or intellectually stimulating to the average Ph.D.-level researcher who might rather pursue novel development-oriented challenges instead". This lack of glamour associated with software testing in comparison with the software development topic is extended beyond the research area towards the industry as well. The study advises on changes to the curriculum which will lead to more focus on software testing courseware and opportunities to obtain and improve education for software test engineering.

Lethbridge conducted 2 surveys [2] and [12], with software professionals to identify the areas which would benefit from an improved education curriculum. The scope of these surveys was to provide information and data to educational institutions and companies which will allow them to adjust their curricula and training programs. The survey described in [12], presented a list of 57 topics related to software (31 topics), mathematics (9 topics), engineering (4 topics) and other concerns (13 topics) with four questions described in section 3.1 for each topic and answers organized on a six-point ordinal scale. The result of the survey emphasized the lack of necessary education for practitioners and the necessity of updating the curricula.

An updated version of the survey which was repeated later by Lethbridge provided congruent results [2]. A customized version of Lethbridge survey was run in a similar study on recent graduates by [4] in UK universities. The small survey of Finnish IT professionals, professors and lecturers, and students presented in [5] confirmed the results of Lethbridge's and Kitchenham's studies. In addition, the topic Testing obtained a higher scoring in comparison with the scores from Lethbridge's study. The software developers, academics and students ranked the importance of testing with respectively 3.5, 3.8 and 3.3 while in Lethbridge's survey, the topic of testing scored 3.0.

While Lethbridge's survey is looking at professionals with experience in industry and Kitchenham’s focuses on recent graduates only, the survey performed by IDI comprise both professionals with experience, as well as recent graduates giving us a broader picture of the knowledge gap between the education received at university level and its relevance in the industry.

3 Survey instrument and data collection

3.1 Survey instrument

The Department of Computer Science (IDI) at the Norwegian University of Science and Technology (NTNU), conducted an internal web based survey among its master alumni in 2007 and 2011, with the scope to retrieve the educational topics relevant to their field of expertise based on the work experience accumulated after graduation.

The survey was based on three sources: a candidate survey from a closely related study program in Communication Technology at the NTNU [13], the North American study conducted by Lethbridge [2] and [4]. Another source used for building this instrument is the ACM Computing curricula [14]. The NTNU Communication Technology survey had a simple structure containing few questions asking whether the graduates had a job or not and whether in that case they had a job even before submission of the master thesis or not. Other questions included in this survey are enquiring where in the country they have received a position and what were the responsibilities of that position. The survey by Lethbridge is far more detailed, but does not cover the entire IDI professional profile as well, as it has a main focus on software and system development. The 75 topics provided in this survey are inspired by SWEBOK (IEEE's Guide to Software Engineering Body of Knowledge [15]). For each of these topics the Lethbridge survey includes four questions, all answered on a scale from 0 (nothing) to 5 (very much):

i. How much did you learn about this topic in your formal education (college / university)?
ii. How much do you know about this now?
iii. What are the direct benefits, this topic had for you in your work?
iv. What were the indirect utility, this topic had (even if you have not directly used it, so it is believed that it has affected one's ability, so that one does a better job, for example, ability to analytical thinking)?

Using this enables the identification of topics which alumni have been forced to learn after graduation and topics covered during studies but forgotten, since there was no need for participants to use this knowledge in their jobs. The results provide a list of topics of great usefulness, and the subjects suspected of small utility. This type of questions above will only highlight what was beneficial for the alumni so far, but since it may also be interesting to hear what they think will be important in the future based on trends they see in the industry, a final question was added: "In light of the trends you see in the workplace, mention three topics that you think should be given higher priority in education (need not be obtained from the above list)"

The ACM Computing curricula is not a survey, but advice on what different programs should contain. The overview report distinguishes between different disciplines: Computer Engineering, Computer Science, Software Engineering, Information Technology and Information Systems. The report provides an overview of the 40 data items and 17 subjects with different weights, which indicate how relevant these topics will be mentioned in the various degree programs.

During the survey of 2007 the participants were asked to state how much they needed to know to perform their work task from a topics list, regardless of whether these subjects were covered during their study periods or not. The available response options were "no direct requirements", "little need", "moderate needs ", "strong need", "very strong need" which were scored with 1 to 5 points response analysis. During the 2011 survey, a 3-points scale was used

with the following options: very helpful, useful, not helpful options plus a N/A option for those who found the topic inapplicable to their work responsibilities.

The IDI survey topics list contains 63 items based on Lethbridge topics with local adaptation which are a better reflection of the IDI educational program. The available topics are not the equivalent of established university courses, they can be thought among a full course, a partial course or they can be taught in different layers in a range of courses. The survey was web based, conducted in Norwegian and could be completed in less than 30 minutes.

3.2 Data collection

The purpose of the survey was to retrieve feedback from alumni with regard to the quality and the relevance of the education provided by IDI. In order to not only capture short-term first job experiences, the primary audience for the 2007 survey were people who graduated 5-10 years back, and therefore may have gained experience from several jobs, as seen in Table 2, and experienced the need for professional development. For the 2011 survey, a question asking for the graduation year was included with the results for this question being available in Table 1:

Table 1: Graduation year for 2011 participants

Year	No	Year	No
2011	3	**2004**	6
2010	10	**2003**	11
2009	4	**2002**	12
2008	6	**2001**	3
2007	12	**2000**	6
2006	16	**90-99**	26
2005	10	**68-89**	8

Table 2: Number of jobs obtained after graduation

Nr. of jobs	2007 graduates	2011 graduates
0	**0**	8
1	68	40
2	61	35
3	43	20
4	16	14
5	12	8
6+	2	8

4 Results and observations

4.1 Demographic results

The information presented in the following tables provides a profile of the participants' with regard to education in Table 3 and the type of employment is available in Table 4. The total number of participants was 202 for the 2007 survey and 133 participants for the one conducted in 2011.

Table 3: Education level

Education	2007	2011
Doctor / PhD	0	9(6,77%)
Master Technology	173 (85,64%)	99(74,44%)
Bachelor	7 (3,47%)	3(2,26%)
Master Informatic	20 (9,90%)	22(16,54%)
Other	2 (0,99%)	0

Table 4: Type of employment

Education	2007	2011
Private	146 (72,28%)	92 (69,17%)
Public	34 (16,83%)	25 (18,80%)
Self employed	8 (3,96%)	4 (3,01%)
Education	8 (3,96%)	2 (1,50%)
Available	2 (0,99%)	0
Other	4 (1,98%)	10 (7,52%)

4.2 Software Testing's perspective results

In both years alumni surveys, Testing and QA were rated among top ten relevant topics from around 63 proposed ones, gaining the 7th place in 2007 and the 8th place in 2011, while Programming remains on the top as seen in Table 5. The largest increase in importance was registered by Software Engineering Methods, Software architecture and Algorithms and Complexity each of them climbing 5 places in the hierarchy Presentation Technique and Interpersonal communication have registered the higher decline in the perceived importance by decreasing with 8 and respectively 7 places in the top 10 topics.

Table 5: Topics ranked by perceived importance

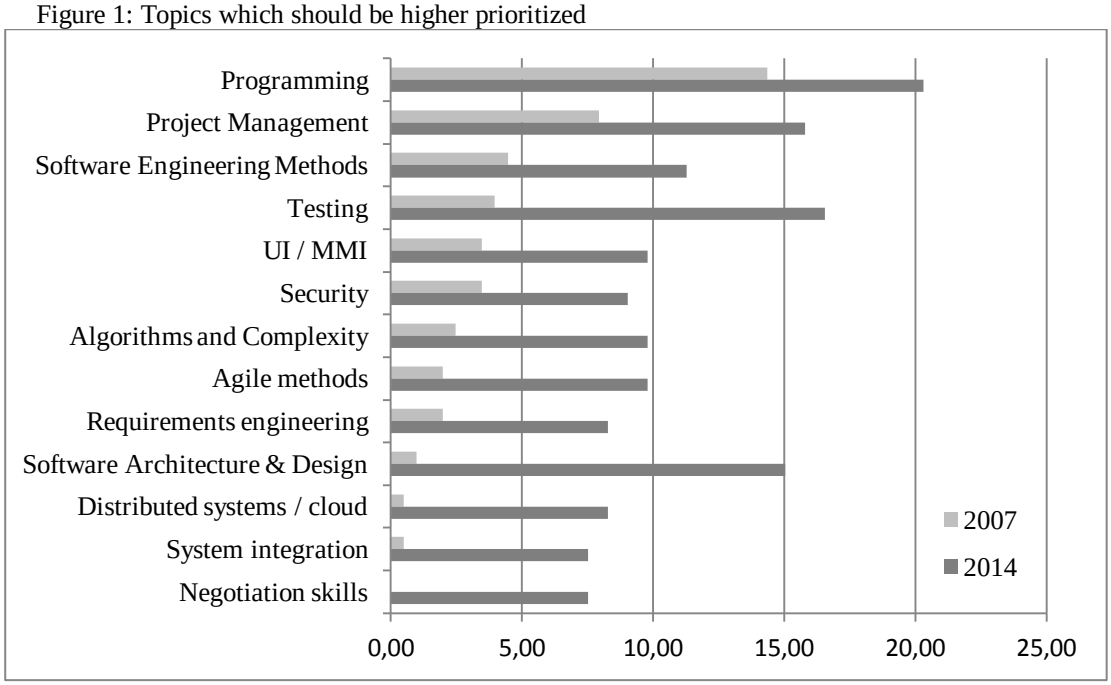
Topics ranked by perceived importance	2007	2011
Programming	89	90
Database Systems	77	86
Software Engineering Methods	75	80
Software architecture	75	80
Requirements Engineering	81	76
Algorithms and Complexity	63	75
Project Management	80	70
Testing	77	69
UI / MMI	66	68
Presentation Technique	82	67
Interpersonal communication	81	60

The last question of the survey asked the participants "What three topics should be higher prioritized during education, based on the trends you see in the workplace?" Testing came on the second place on the list of Topics that 10 or more people have responded as requiring more focus in our education for the 2011 survey and was mentioned 8 times during the 2007 survey as seen in Table 6 and illustrated in Figure 1.

Table 6: Topics which should be higher prioritized

Topics	2007	2011
Programming	29 (14,36%)	27 (20,30%)
Testing	8 (3,96%)	22 (16,54%)
Project Management	16 (7,92%)	21 (15,79%)
Software architecture	2 (0,99%)	20 (15,04%)
Software Engineering Methods	9 (4,46%)	15 (11,28%)
UI / MMI	7 (3,47%)	13 (9,77%)
Algorithms and Complexity	5 (2,48%)	13 (9,77%)
Agile methods	4 (1,98%)	13 (9,77%)
Security	7 (3,47%)	12 (9,02%)
Distributed systems	1 (0,50%)	11 (8,27%)
Requirements engineering	4 (1,98%)	11 (8,27%)
System integration	1 (0,50%)	10 (7,52%)
Negotiation skills	0	10 (7,52%)

Figure 1: Topics which should be higher prioritized



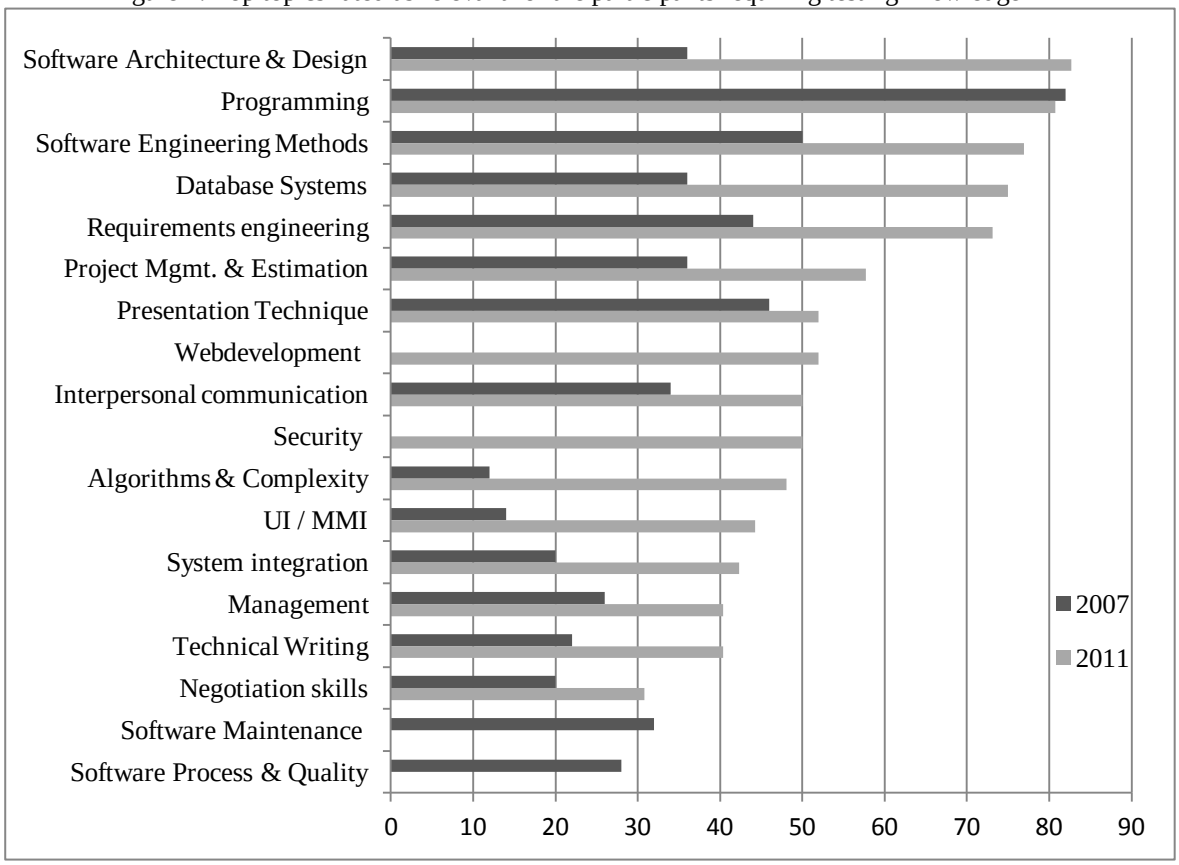
For the participants who stated Testing as a very relevant topic for their work, we selected the next first 15 topics rated. In case the topic mentioned in the next first 15 topics rated in one year was present on a lower scale in the other year we decided to include both years' data. For the 2007 survey 50 participants out of 202 who stated testing as being very much needed in their work, while in 2011 survey, 52 out of 133 participants stresses the importance of the testing knowledge for their workplace. In Table 7, we can see that, both years programming was mentioned as the most important topic, which is much needed in their work assignments with around 80% of the participant stressing its importance alongside testing knowledge.

Table 7: Top topics rated as relevant for the participants requiring testing knowledge

Topics	2007	2011
Software Architecture & Design	18 (36%)	43 (82,69%)
Programming	41 (82%)	42 (80,77%)
Software Engineering Methods	25 (50%)	40 (76,92%)
Database Systems	18 (36%)	39 (75,00%)
Requirements Engineering	22 (44%)	38 (73,08%)
Project Mgmt. & Estimation	18 (36%)	30 (57,69%)
Presentation Technique	23 (46%)	27 (51,92%)
Webdevelopment	0	27 (51,92%)
Interpersonal communication	17 (34%)	26 (50,00%)
Security	0	26 (50,00%)
Algorithms and Complexity	6 (12%)	25 (48,08%)
UI / MMI	7 (14%)	23 (44,23%)
System integration	10 (20%)	22 (42,31%)
Management	13 (26%)	21 (40,38%)
Technical Writing	11 (22%)	21 (40,38%)
Negotiation Skills	10 (20%)	16 (30,77%)
Software Maintenance	16 (32%)	0
Software Process and Quality	14 (28%)	0

We can notice in Figure 2 a certain shift in the importance of the top topics selected by those who required more emphasis on software testing education. We notice a tremendous increase for Software Architecture and Design (46,69%), Database Systems (39%), Algorithms and Complexity (36,08%), UI / MMI (30,23%), Requirements Engineering (29,08%) and Software Engineering Methods (26,92%) topics, while Programming has a slight decrease (-1,23%) although overall it still keeps a strong position.

Figure 2: Top topics rated as relevant for the participants requiring testing knowledge



For the participants who stated Testing as not relevant topic for their work 32 (15,85%) in 2007 and 7 in 2011 (5,26%), we selected the 3 most topics rated. The participants of the 2007 survey who stated testing as not being in their work stated Interpersonal communication (14 participants), Management (10 participants) and Presentation Technique (11 participants) as the most relevant areas for their work responsibilities.

4.2 Validity threats

The questionnaire used in this set of surveys was based on an instrument previously developed and used by [2] and [4] at a later stage, which serves a strengthening factor for the surveys' internal validity while the reliability is assured by the same standardized questions presented to all participants [16]. The completion of the survey was done voluntarily from a participant population with a graduation year covering a white range of 40 years from 1968 to 2011. The participants answered questions about each of 63 topics which were much inspired by the topic list used in the [2] survey, but with some local adaptations.

A possible limitation of the survey with respect to testing professionals is the selection of participants with mandatory technological background which is not allowing us to make an

assessment for the professional testers which might have a different educational background such as a financial one. For future it will be interesting to see the result of such a survey at an entire university level, but still we consider the population involved to be the representative one since a computer science based education is the most recommended one for a professional tester. One downside regarding our methodology is related to the survey as not being designed with main focus of software testing. The data collected from the 2 surveys was ready and available, and analyzed from the testing perspective, but the design and collection processes were already completed.

Some typical threats to validity that are often considered for questionnaire surveys like this one are clearly relevant to this study:

- *Sampling error*. For the questionnaire survey as it was originally made, the target group was all candidates having graduated from a certain university department. Of more general interest, however, would be the competence needs of testers regardless of what department they had graduated from.
- *Coverage error*. Even within the more limited pool of graduates from IDI, far from all graduates had registered themselves in the alumni database, and some were registered with email addresses that were no longer valid, thus not receiving any offer to participate in the survey.
- *Non-response error*: Not all who got the offer to participate did so. In total there would be more than 2000 alumni from the department aggregated over the years, meaning that coverage and non-response problems taken together, only around 10% of the target population responded (or even less for the 2011 survey). This is normal for such surveys, and would only pose a serious problem to the study if the non-respondents were very different from the respondents, e.g., if non-respondents were generally much less interested in testing and more interested in other things. However, since the questionnaire was not specifically targeting testing but asking about all kinds of courses, there is no particular reason this should have happened.
- *Measurement error*. Candidates might answer inaccurately as may be hard to estimate on a scale how much need one has had for various course topics in the job. In particular, there might be a tendency that the answer is dominated either by the most recent needs, since these are freshest in memory at the time of response, or by needs in the very first job obtained, since this maybe feels most important for getting started in the career at all (as the first job is probably the one where the recruitment decision is most heavily based on the university diploma, whereas for later jobs references and previous job experience and performance gradually diminish the impact of the university diploma.

All these threats are of course relevant, and it would ideally have been better if all the alumni had responded to the surveys (which would also have given much more data to work with). For comparability between the two surveys, it would also have been an advantage if exactly the same questionnaire had been used twice, avoiding changes to the scale and some changes of questions. Still, it is hard to see how any of this would cause a particular bias for software testing, whether positive or negative. For the issue of measurement error, an important point to notice is that the survey investigates the need for testing (and other subjects) over time, throughout the respondents' careers, which may be different from the current need in industry. However, considering the fact that test-driven development has become a very hot topic in industry recently, it seems unlikely that the importance of testing now would be less than it has been over time. Also, the extra question where respondents were asked to consider trends that they now see in work-life and suggest which topics should

be prioritized due to this partly compensates for the retrospective angle of the other questions - and testing came out as important also here.

5 Discussion and future work

Based on IDI survey results which showed that Software Testing topic scored high in the Topics ranked by perceived importance list as well as in Topics which should be higher prioritized list, there is an obvious need to increase its emphasis in the educational programs. Our results corroborate with previous results published by Lethbridge's survey which showed that Testing is one of the topics requiring greatest on-the-job learning effort. Another similarity with Lethbridge's finding is the strong status of programming which is maintaining its top position among topics ranked by perceived importance classification. One positive results of the two survey is the obvious decrease in numbers from 32 (15,85%) in 2007 to 7 in 2011 (5,26%), for the participants which do not consider software testing knowledge relevant to their work.

Teaching students about testing in high level or master study can be ineffective since they have already acquired a foundation in programming. If the testing skills are built into the students' education from the early levels, these skills will be perceived as a mandatory knowledge and the testing practice will be incorporated in the programming style of the student rather than be seen as an additional skill. Educating software testers and providing them with the necessary knowledge and skills to perform their jobs efficiently and properly remains an important goal to be reached by the academia while keeping in mind the trends and practices from the IT world.

Informing students about the possibility and the options of a career in software testing should also be taken in consideration. Not many students are focused on a testing career in their final years of studies, but since software tester is also an entry level position on the job market the probability for a beginner to enter in a testing position is quite high.

There are two directions in which the results of this study can be applied. From the perspective of high level educational organization the conclusions of these surveys can be applied to retrieve the areas where industrial requirements are not or partially addressed and new curriculum can be developed or the existing one can be redesigned. The results of the study can also be used by students when selecting their computer Science courses, especially for those who are considering an industry career path and/or who would like to pursue a Master Program which is oriented towards the industry. From another point of view, the industry can also be a beneficiary of this study by identifying possible skill gaps among future software testers and graduates and utilize this information useful for planning and organizing the relevant industrial training.

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