WHAT MAKES STUDENTS LEARN FOR LIFE

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ABSTRACT

As a master student, Jakupovic, the first author explored if and how computer science (CS) education may be up-to-date when the computer engineering area is such a moving target. Jakupovic interviewed former students, now working as programmers or project managers in industry, and found the following themes: The education laid the foundation for the programmers' careers, but the transition from school to industry was rather difficult, and furthermore, what was taught, and expected by industry, did not correspond to students' expectations of what to learn at the university.

In this study, we use these interviews to discuss the following questions: How can we make the transition into worklife smoother? How can we motivate students that what we are teaching is not outdated and obsolete? There are many studies on motivation, and especially using CDIO-courses as a motivating factor – how can these studies together with our study enhance CS engineering education?

The students speak about specific content they learned, the theory-practice gap and how teachers either teach or facilitate students' learning. They also reflect on the fact that they, prior to the interviews, had not realized that the university courses had made such an impact on their career.

KEYWORDS

Student expectations, Computer Science Education, Curriculum Development,
CDIO Standards 2, 3, 4, 5, 8, 9, 10, 11

INTRODUCTION

One of the most striking findings in Jakupovic's (2016) master thesis was that former students, now engineers in industry, acknowledged that the higher education gave the foundation they needed, and that it wasn't as outdated as they thought it to be. Of course, one may argue that these findings were an effect of the interview, but since Jakuopovic's hypothesis, at the time, was that the education was outdated and he thus did not expect this result it is interesting and striking. In his master thesis, Jakupovic's research questions dealt with students' transitions from university studies to industry work, how to enhance Computer Science and Informatics (CSI) education and adapt the curriculum in order to produce industry ready individuals. He conducted interviews with former students now working in the industry, and teaching staff at

the university. Students had no troubles finding a job in the industry, however, the transition to industry was not easy.
Findings obtained show that both students' expectations and university commitment to curriculum development play an important role. However, one of the findings was that students' expectations of what CSI-companies do and need, seem not to be aligned to what industry expects. This study aims at reanalyzing the data from the interviews and relate the results to other studies on students' expectations and motivation. Prior studies on students' expectations have mainly concentrated on enrollment and retention (Sahami et al., 2010, Klawe and Schneiderman 2005, Langan, Dunleavy, and Fielding, 2013), and studies on factors leading to study success (e.g. Tynjälä et al. 2005). More recent studies on students' expectations have dealt with how students develop their identity as computer science (CS) majors, or CS Engineers (Peters, 2014, Kinnunen et al. 2016). These studies have shown what students expect CS studies to contain, and what students believe their worklife will be like. They have focused on CS specific factors, such as "what CS-related knowledge and skills the students most relate to and what aspects of CS they perceive as relevant with respect to not only their previous experiences but also their envisioned future, trajectories and goals" (Kinnunen et al. 2016, p.4).

PURPOSE

The purpose of this paper is to start at the other end of the story, to study what former students, now working in industry, tell about their former studies, the expectations they recall about their envisioned future, and possibly how these expectations were treated. Our focus in this paper is to study the transition from higher education to industry, how it may become smoother and how to motivate students that what we are teaching is not outdated and obsolete.
By reanalyzing the interview data asking a new research question (not asked in the interviews), we hope to get new insights:
How can engineering schools, from this study, learn to bridge the gap between what students believe CSI studies should teach and what industry wants students to learn?

This paper is first in of a planned study on the same topic, following up with a similar interview research with teaching staff and industry representatives in the near future.

THEORETHICAL BACKGROUND

"*Education is not preparation for life; education is life itself*."
-John Dewey

Engineering Education, as well as CS education have been, and still are, the subject of reform efforts (Froyd, Wankat and Smith 2012). One of the more recent is the CS2013 (ACM & IEEE Computer Society 2013), which builds on the curriculum designed by Sahami et al. (2010). This lead to a large boost of the number of applicants for a Computer Science undergraduate programme at Stanford University. A follow-up survey showed that 36% of the applicants applied only due to the curriculum change. These numbers imply that offering up to date and modern education leads to higher attractiveness which results in a higher number of applicants. ACM & IEEE Computer Society (2013) state that students may misunderstand the nature of a programme/curriculum and that this may divert them from applying. They state that a common belief among students is that CS is all about programming and hence do not choose to apply. This is also confirmed in other studies such as Lewis et al (2010) and Kinnunen et al. (2016). Developing, and - more importantly - presenting curricula so that they show the diversity of

aspects of CS may assure that students get a broader picture what CS studies are about. The mismatch between student expectations and the offered curriculum will both lead to students not enrolling at all and to students dropping out (Kinnunen et al., 2016). According to Jakupovic (2016), there is an obvious problem with students having wrong or unknown expectations when approaching university studies, since this leads to them being either unprepared for certain courses or unsatisfied with the knowledge offered within the particular program. One of the aspects debated throughout history is the theory/practice-divide Malmberg (2007). This is also reflected in the studies by both Peters (2014) and Lewis et al. (2010), who claim that the students expect to learn programming just by practice, whereas the teachers try to make the students learn also the theory. The gap between students' expectations and teacher's views are in some cases closing, but in other aspects widening, according to Lewis et al. (2010). They discuss the gaps and how they change throughout the education, but concludes with this being a challenge. Peters et al. (2014) are engaged in a longitudinal study on how expectations and attitudes change during the whole education, as a change in students' identity.

Although the CDIO initiative has tried to meet some of these challenges by aligning education to learning outcomes expected by industry, it seems that the challenge to convey these intended learning outcomes is still in need of reform. Some basic examples of how to enhance motivation are given in table 6.1 in Crawley et al. (2008) and some of them tightly connected to this paper are:

> *Set clear intended learning outcomes relevant to engineering practice.*
>
> *Develop teaching activities and assessment tasks that help students reach the intended learning outcomes.*
>
> *Focus on deep working knowledge of basic concepts and provide connections to engineering practice.*
>
> *Design learning activities with built-in interaction.*

Are these criteria met in CS education? And, if so, are they perceived by the students?

APPROACH

We have built our investigation semi-structured interviews (Kvale 2014). In such, it is very important to design the interviews in a way where the interviewees themselves could fully express themselves. The amount of data for analysis was directly related to the interview length. Therefore, we made notes during transcribing to catch the data we found meaningful. Thus, we eliminated a large amount of data that we found unrelated to the topic, hence making the analysis more directed. We verified the data by determining validity, reliability and generalizability. Guba & Lincoln (1989) offer several ways to ensure quality of data and they are confirmability, dependability, credibility and transferability but since our data came directly from the source we can only assume it is dependable and credible.

We held interviews with seven former students of Jönköping School of Engineering, now engineers in the industry. The interviews were afterwards transcribed verbatim for easier usage of collected data. This interview research was conducted in seven stages as proposed by Kvale (2014):

1. **Thematizing an interview project –** Decided upon who to interview, what we aim to collect through interviewing and how to proceed after collecting the data.
2. **Designing –** What information we want, and what topics would lead the interviewee towards answering them. This step directly impacts the results.
3. **Interviewing –** Guba & Lincoln (1981) stated that *the interview is but an instrument*, which would make the interviewer the user.
4. **Transcribing –** Often considered the straight forward part of the approach, where audio/video data is transferred into digital form for easier use.
5. **Analyzing –** Sewell (1998) suggests making data meaningful before we proceed with analyzing since that will allow us to work with less, but more valuable, data. While conducting the analysis we started to recognize that certain themes were present.
6. **Verifying –** In order to verify traditional research terms, Sewell (1998) states that you need to determine the validity, reliability and generalizability. We decided to verify the data during the interview session by asking the interviewee to confirm our understanding of the matter.
7. **Reporting –** The report must meet some accepted scientific criteria, ethical standards and be readable and usable for the user (Sewell 1998).

After completing these seven stages we had reasonable amount of data to proceed with concluding and discussing our research. We built an argument based on the themes captured in the interviews and further suggested adequate CDIO Standards as possible supporters in contributing and/or solving certain problems. The findings, discussion and conclusion will be presented in the upcoming Results section.

PRESENTATION OF INTERVIEWEES

Interviews were held with 7 former students from Jönköping School of Engineering, now working in companies within the CSI field. They have been working in industry two or less than two years after finishing their degree.
For ethical reasons, in line with an agreement with the interviewees we will not use names, gender and age whilst presenting them. They will be labeled as Interviewee_X and will be addressed in a masculine form. We have followed an inductive approach of analyzing and will present an interpretive analysis (Kvale 1996). For easier navigation, information about the interviewees, their background and current employment is presented in Table 1.

Table 1. Interviewee Background and Employment

Name	Education	Employment	Employed for
Interviewee_1	Bachelor	Software Engineer	2 years
Interviewee_2	Bachelor	Software Engineer	2 years
Interviewee_3	Bachelor	Engineer and Server Admin	2 years
Interviewee_4	Bachelor	Software Engineer	2 years
Interviewee_5	Bachelor	Consultant (Software and Test Engineer)	2 years
Interviewee_6	Master	Software Engineer / Researcher	1 + 1 years
Interviewee_7	Master	Consultant (Software Engineer)	1 year

RESULTS

Our findings are presented using a theme-wise analysis, where the themes emerged from the collection of data. They are not exclusive categories, rather they are themes to be used in further analysis. The themes we identified are “Learn by doing”, “Solve or learn how to solve”, “University studies laid the foundation”, “Importance of Group Projects” and “Expectations from higher education”. Below we present these themes in more detail:

Learn by doing

Several interviewees state that it is upon themselves to learn by utilizing knowledge gained at the university and combining it with self-studies. That way they believe they’re investing in their studies and learning by doing is an important way to learn.

> *“The reason I learned so much, well I think I learned so much, is because of it takes a lot of time and effort from you, and not a lot of people want to invest in that; and I did. But even after I finished school I felt like I didn’t know enough, and I still do. After, well, 2 years, I still feel like I don’t know enough – and I’m probably going to think that all my life…” (Interviewee_3)*

They also state that it is not the higher education per se, that will bring them to the next level, but rather their own involvement and will to grow. This also helps in the transition into work-life.

> *“Since I took responsibility while studying, I was feeling kind of secure, I know I can do this but it wasn’t like, ‘I can do it and it’s very easy’. Because it was still a big hill to climb, but due to my responsibilities during my studies I think that I adapted pretty quickly.” (Interviewee_4)*

Solve or learn how to solve

The majority of interviewees mentioned the importance of learning how to do something rather than just doing it without understanding the core. They comment how some teachers believe they are helping by solving the task instead of directing and guiding them, yet letting them solve it on their own and therefore learn how and why it works.

> *"The WHY - I always believed that as long as you understand something, you can always make it work. Not enough classes had labs that worked like that; most of them want to check out the box and see that you're done…" (Interviewee_3)*

Understanding the *why* and *how* may differ from one student to another, but if the approach of teaching the *why* and *how* are not right then it is hard to expect that the students fully understand what is being taught.

> *"There was a huge gap (between knowledge with students) … and that made it, for us newbies, really hard because we felt so bad… The problem is, that we get an assignment – where we should do this and that, and if we get stuck, the teachers sat down and coded it themselves and then – here's the solution. And you don't learn anything with that…" (Interviewee_5)*

Teaching the *why* and *how* does not only depend on the competences of the teaching staff but also of sufficient background knowledge that the students have. The ability to utilize the theory and combine it with practice leads to learning the *why* and *how.*

> *"When you sit at home, if you don't have the theory you're sitting and working on something; sooner or later you're going to get your application to work, but you don't really know why. You don't know what's going on and in some areas, or in some businesses, THAT'S MOST IMPORTANT!" (Interviewee_7)*

University studies laid the foundation

Although the interviewer held the hypothesis that the CS education most likely would be outdated, the interviewees, during the interviews turned from a rather negative view of their higher education, and realized that the university studies still had impact. Especially teaching of basics and laying the foundation for further development, was mentioned.

> *"Probably a great deal more than I think; I think much stuff is probably somewhere in the back of your head at least. There were good courses and bad courses, good courses I remember stuff, it taught me how to think in programming. A lot of that stuff is still there…" (Interviewee_1)*

Interviewees also mentioned that it would have been beneficial to work in a specific programming language, but also realized that higher education would teach them basics – allowing them to continue and master a programming language of their choice.

> *"I think the only reason why I'm able to work at [Company Name] is because I really learned the basics good. So even though I did not learn any of the technologies I work with today, I did some basic stuff – but not deep stuff, and because I learned the basics, I understood everything that I did. And that I do, even though I haven't had any prior experience." (Interviewee_3)*

Pears (2015) states that higher education is not only about learning various subjects, but also growing as an individual in many other aspects. One of the interviewees came up with the same conclusion during the interview, saying that higher education made him a different

person, laying not only the foundation for professional development but also personal development.

> *"The education that came with this degree, this program at JTH, it improved – increased my knowledge, in a sense that it gave me more confidence, it provided theoretical background for various subjects." (Interviewee_6)*

After a couple of years in the industry, they claim that the impact of their studies is still present. In addition, even though some knowledge is lost, the rest has been utilized and built upon.

> *"Since I'm still green, less than one year out of school, everything I refer to is from the time at the university, or projects from home. It (referring to school) still has a great impact on me." (Interviewee_7)*

Importance of Group Projects

The importance of group work and projects is mentioned at many occasions. We noticed how the interviewees mostly work in teams at their industry workplace and they claimed that they benefited from group projects during their higher education studies.

> *"We had two courses that mainly focused on running and planning projects, and those were very good courses because then you tried out your wings at school…" (Interviewee_4)*

Group projects ideally tend to recreate real-life environment to help students experience the real-world, how to handle problems that come their way, and most importantly how to interact and benefit from working together (Jakupovic, 2016).

> *"I've benefited from group assignments, particularly group work, interactive work with teachers and students, other students." (Interviewee_7)*

Expectations from Higher Education

The interviewees demonstrate different expectations depending on their background. Some have already knowledge about software engineering and thus had no trouble passing the courses, some of them therefore believing that the university studies contributed very little to their development. Others had no experience and felt like higher education did not provide enough basic knowledge, and they either looked for help via distance courses or invested a lot of effort in studying through practice. But they also sometimes show that they know very little what to expect, as is also described by Kinnunen et al. (2016)

> *"When I studied, we had the first year, where everyone went and then the second year you could choose whether to go web or hard programming. I'd guess I'd rather see it be even more specific, I want to maybe work Java or .NET… I went web, and I don't know why I chose that, I didn't get enough info, I don't like web." (Interviewee_2)*

It is hard to expect that curricula can be developed to suit every student, some want more practice while others better cope with theory. This was also demonstrated by the answers, but that the interviewees also expected a balance between theoretical and practical studies and did it contribute.

> *"It would be wrong to have only practice, it should be the combination of both… but we should focus more on practice compared to theory because most students get*

into the industry, while only a couple continue with academics. There, the theory will help but you need to know how to do it practically…" (Interviewee_6)

The interviewees discussed that certain courses were not fulfilling the expectations and even that some lecturers did not convey learning. Some believe that the teachers were not engaged in their subjects, and also that universities should invest in the competence of their teaching staff.

"The university should be a mix of it, the theory and the practice. Some courses are better at it than others, some teachers are a lot better than others, mixing good lecturing with good lab assignments..." (Interviewee_7)

We noticed that, even though our university offers all the necessary information regarding programmes and courses, students rarely take upon themselves to read about what's expected from them and what the program and courses offer. As one example they expect the masters level to be directly preparing for industry, rather than further academic studies.

"But at masters level, I think it should focus more on practical level as compared to more theoretical level." (Interviewee 7)

Students may also think that university programs are outdated because advanced topics were not covered:

In technology yes because we work with proven technology and that's very important in some areas but in other…in other areas and other aspects the university is perhaps ten years behind in education. You don't see you know, how do you say? Artificial intelligence courses today that matches what some companies has already achieved. I mean self-driving cars okay, we have…we have experimented with some robots that navigate in a small hallway here but the algorithms are so bad, so it crashes into the walls after a couple of turns but a lot of companies have get…got self-driven cars on the roads. So they are light years or not light years, I shouldn't say, cause that's a measure of distance not time, but they are many years ahead.

DISCUSSION

Both the transition into university, from high school, and the transition into work-life are difficult, and the expectations are often not in accordance with what the students meet. Kinnunen et al. (2016) discuss this in terms of short- and long-term expectations. Having no, or little experience of programming before entering university makes choices within the education difficult. Furthermore, it may take time before they study efficiently, e.g. interviewee 7 mentions that it took a long time before he started to study, not only to pass the courses, but to learn by practicing. Students who knew what to expect from higher education were better prepared and they had a more serious approach towards studies. They embraced the knowledge presented at the university and used it as a foundation to build on. By investing additional time in their homework, project work and studies, resulted in much better results and the accomplishment of self-set goals. On the other hand, some students that had earlier experience with computer science, felt they were not challenged, which resulted in them being either, uninterested and missing some valuable education or not following at all and therefore not comprehending.

A common pattern with the interviewees was to start off rather negative about their experience with higher education, in accordance with the hypothesis of the interviewer, but, as the interview continued, they concluded that they do use knowledge obtained at the university; then also followed up with constructive comments for both staff and other fellow students. One suggestion was to stimulate the teachers to engage in their subjects, another to use alumni in the courses to bring up-to-date technology into the courses.

When asked about the overall transition from higher education to industry their experiences differed quite a bit. It was obvious that those that had industry placement during their internship course and thesis work found a job position and adapted to the industry tempo much easier. Even though some had trouble finding a job right away, many of the interviewees either begun working straight out of university or shortly after. They all confirmed the importance of internship courses and writing thesis work with companies.

CONCLUSION

This interview research shows that former students, now computer science engineers in the industry, still reflect on higher education. Some acknowledge that they often use knowledge acquired through higher education while others state that it has laid the foundation, but that they really started learning when they started working. The biggest impact theoretical studies provide are the guidelines and basis for students to endure any obstacles set upon them (Jakupovic, 2016).

Our findings are also highlighting the findings from Kinnunen et al. (2016) that students often have rather narrow expectations of what CS studies are about, but when they reflect on their studies they realize that they have a much broader education, including e.g. project skills they need in industry.

Expectations vary from student to student but it is in best interest for the university and the student to understand and meet those expectations. This can only be accomplished through mutual engagement. The university needs to learn what students expect, as well as what industry expects. The latter is often done through conversations between university staff and industry representatives, and also through initiatives such as CDIO. However, this needs to also be conveyed to the students: the university needs to explain not only the learning outcomes (the what and the how), but also the purpose of the learning outcomes (the why), set for each program. But we believe that it is also of crucial importance to learn more about the students' expectations. If the students' expectations differ from industry's needs, this also needs to be addressed. This is a first attempt to do so, and similar studies are carried out (Peters, 2014, Kinnunen et al., 2016).

Longitudinal studies where the change in expectations are the focus will hopefully give further insight in both what it takes for students to understand what they need to learn and teachers what they need to convey beyond knowledge. This may result in an action research testing different ways of meeting these expectations and comparing the end results with a follow-up research of this kind.

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