MOTIVATION FOR CONTINUOUS SOFTWARE ENGINEERING EXPERTISE DEVELOPMENT THROUGH LIFELONG LEARNING

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ABSTRACT

It is important for software developers to keep up with technology, be able to adapt, learn new things to be competitive in the labour market, and be exposed to new and different things to avoid getting stuck in their old roles. This requires a long-term commitment to lifelong learning from those in working life in order to extend their software engineering skills. However, there is no information on how much time software developers spend on developing and maintaining their skills within a year. We have carried out an industry survey in Finland to assess, among other things, how much time software developers dedicate to professional development activities over one year. The survey had 88 respondents, all of them involved in software development within their own organization. The results show that surprisingly few participated in any lifelong learning activities or have completed professional certifications at all. This was unexpected given the importance of such education and certifications for software engineers. In this study, we reflect on the industry survey results through a discussion on the experience of organizing lifelong learning training in the field of IT sector at the University of Turku, Finland. Lifelong learning courses must be independent of time and place and be easily adaptable. Typically, the basic courses of university degree education are not directly suitable for lifelong learning students and they especially expect direct sector-specific relevance to working life in course content. The role of universities and higher education institutions in lifelong learning for software engineers should be strengthened. Universities should invest not only in the development of basic education but also in lifelong learning training and provide working people with multidisciplinary views and wide-ranging information on new topics. Learning does not stop after graduation, and therefore, more attention should be paid to this issue also during basic software engineering studies.

KEYWORDS

Lifelong learning, Software engineering, Industry survey, Professional certifications, Continuous learning implementation, Standards: 7, 8, 9, 10

INTRODUCTION

A successful software developer must possess a wide range of skills and talents. Typically, software developers are highly educated with bachelor's, master's, and/or doctoral degrees (Jazayeri, 2004); (de Rojas, 2019). Software developers often supplement their expertise with a product or topic-specific professional certifications, and earlier research has found that software

developers are one of the occupational groups with a large number of professional certificates ((Cunningham, 2019); (Furnell, 2021). Well-known degrees or certificates are an advantage in IT industry public procurements as a contracting entity may require tenderers to provide a certificate or a diploma as evidence for the criteria set out in the tendering process ((Ministry of Economic Affairs and Employment, 2016).

The practical knowledge in the industrial environment is crucial for software developers due to the rapid development of the industry and technology, from which follows an increasing need for continuous lifelong education for software developers to constantly update their knowledge and skills (Rösiö, Zetterlind, Brolin, & Cannmo, 2022). Software engineering education has changed and evolved greatly in recent decades. The rapid development of technologies and ever-changing skills needs pose a challenge for education providers, such as universities, to keep up with the changing skills and competencies needed in the workplace and to provide training solutions adapted to different situations.

Adult learning has been identified as a focus topic of the European Education Area (European Commission, 2021); (Ministry of Education and Culture, 2019); (Valtioneuvosto, 2022). The aim is to respond to the competence needs arising from changes in working life. Universities play a critical role in the implementation of lifelong learning. Employed software developers should be motivated to develop and maintain their professional skills. This requires universities to develop their lifelong learning practices and find training solutions that are suitable for working adult learners, as e-learning solutions, for example, bring many opportunities for students, but also include many challenges (Kara, Erdoğdu, Kokoç, & Cagiltay, 2019).

In this paper, we examine how much time Finnish software developers spend on training in one year and how many professional certifications they hold. We also examine findings on the implementation of lifelong learning education at the university level. The engineering education curriculum at the University of Turku, Finland, follows the CDIO model. Therefore, the development and success of lifelong learning training in the IT sector could be reinforced by using and strengthening CDIO objectives as part of lifelong learning curriculum and course development.

PREVIOUS WORK

Software developers are in high demand with technical skills including problem-solving and innovation. There is a shortage of skilled and trained software developers and more would be needed to meet the needs of working life. According to a report by the (Ministry of Economic affairs and Employment, 2020), software companies in Finland need around 5 000-6 000 skilled workers per year. Software workers are required to have up-to-date technical knowledge of, for example, specific programming languages, cybersecurity and privacy, and development frameworks and practices. In this sector, skills are ageing rapidly due to the fast pace of technological development (Ministry of Economic affairs and Employment, 2020). This place demands on the teaching and development of software engineering education. The practical competence of the software engineering profession needs to be complemented by the skills of professionalism, group dynamics, and communication (Garousi, Giray, Tuzun, Catal, & Felderer, 2020); (Rösiö et al., 2022); (Klaassen & de Bruin, 2022).

As the IT industry is rapidly changing and evolving with technological developments, software

developers must be committed to lifelong learning, where their skills and their up-to-dateness must be verified by a third party (e.g. customer, recruitment situation). This situation is particularly evident in public procurement, where the degrees and professional certifications of the supplier's employees play an important role as part of the selection criteria (see: a certificate as proof; (Ministry of Economic affairs and Employment, 2020)). For this reason, software engineering education must be able to develop and provide the skills and competences necessary for working life. Previous research is twofold. Some point out that the current training does not meet the expectations of industry (Garousi et al., 2020);(Tuzun, Erdogmus, & Ozbilgin, 2018); (Aasheim, Williams, & Butler, 2009);(Lethbridge, 2000). However, previous research also shows that students learn the knowledge and skills needed during their IT studies, and thus the teaching of software engineering would not be badly outdated (Jakupovic & Carstensen, 2017).

Adult learning has been identified as a focus topic of the European Education Area for the period 2021-2030 (European Commission, 2021). In Finland the reform of continuous learning focuses on the development of the competence of working-age people (Ministry of Education and Culture, 2019). The aim of this reform is to respond to the competence needs arising from changes in working life. This places expectations on higher education institutions in terms of continuous learning arrangements.

The terms competence, knowledge and skill often come up when defining training and education expectations. In this paper, the terms are defined according to the EN 16234-1:2019 e-Competence Framework (e-CF): Competence: demonstrated ability to apply knowledge, skills and attitudes for achieving observable results; Knowledge: body of facts which can be applied in a field of work or study (know what to do), and Skill: ability to carry out managerial or technical tasks, and they may be cognitive or practical (know how to do it). (European Committee for Standardization, 2019)

It is clear that the structure of the curricula and courses for lifelong learning requires systematic development and innovation to find teaching methods and solutions suitable for various situations. In the early stages, lifelong learning courses and curricula may start out as individual courses, or be a collection of good courses, or a composite set of existing courses that may not be linked to other courses or even crucial content is missing (Granholm, Haajanen, Ketola, & Norström, 2021). Running continuous learning courses also involves various challenges, such as, challenges related to internal, external, and program-related factors (Kara et al., 2019). In this context, the use of the CDIO objectives can bring benefits and promote industry links to lifelong learning curricula, courses, and teaching methods. The CDIO standards (Crawley, Malmqvist, Östlund, Brodeur, & Edström, 2014) guide course developers in this task, and several standards explicitly refer to industrial relevance and characteristics that need to be acquired during engineering education (Rösiö et al., 2022);(Klaassen & de Bruin, 2022).

RESEARCH APPROACH AND RESULTS

In this chapter, we summarize the research approach and describe how the industry survey was designed and carried out in Finland. It should be noted that the survey was designed to answer several research questions related to quality, security, and privacy practices than those discussed in this paper. However, the survey was specifically designed to find answers in terms

of time spent on training. In this chapter, we will also discuss the results of the survey related to the development of the competence of IT professionals.

Questionnaire and industry survey implementation

The industry survey was targeted at Finnish software engineers/developers, and others directly involved in software development processes. Two approaches were used to collect responses. First, the research was conducted as an invitation-based online survey. The survey was communicated through the University of Turku Alumni Monthly letter and in the communications and events of FISMA (Finnish Software Measurement Association) and Sytyke Ry. The second method used was direct email invitations. The e-mail addresses were collected manually from the website of the Finnish Software Entrepreneurs Association. For ethical and privacy reasons, only software developers of those companies that clearly stated and indicated email addresses or the format of the email address were sought. The survey was open from mid-October 2019 to the end of February 2020. Two reminders were sent: at the beginning of November and at the end of November. A total of 88 valid responses were received. The exact response rate cannot be calculated as the survey had a public web link, but the response rate can be interpreted as low, which is typical for similar kind of online surveys. In this study, approx. 71 % of the responses were received through the public web link to the survey. The public web link method was the most productive compared to direct invitations.

Based on the survey data, 92 % respondents had a degree from a higher education institution: bachelor (32 %), master (53 %) and doctoral/licentiate (7 %), and 8 % had either upper secondary school or ongoing studies. The respondents were highly experienced: less than 1-year: 3 %, 1-5 years: 22 %, 6-10 years: 16 %, 11-15 years: 13 %, and more than 16 years of IT work experience: 46 %. Respondents work on the following kinds of topics: development, design, architecture, testing, project management, quality management, security management and privacy management. About 10 % work in organizations with less than 10 employees, 22 % in 10-50 employees, 13 % in 51-100 employees, 9 % in 101-250 employees and about 44 % in organizations with more than 250 employees. The range presumably reflects the current structure of Finnish software companies and is close to other similar studies. These results show that the survey was able to reach especially those who have been working in the IT industry for a long time. This was probably made possible by the communication carried out by FiSMA ry (Finnish Software Measurement Association) and Sytyke ry (Sytyke ry brings together Finnish software development professionals and is the largest nationwide theme association of the TIVIA, Association of Information and Communication Technology Professionals).

Industry survey results: IT professionals' time spent on training and the number of professional certificates

Based on the survey results, we can identify that IT professionals spend surprisingly little time developing their skills over a one-year time period. In fact, 14 % of respondents report that they have not spent any time on skills development during the year. On average, 46 % did not attended training during the year, 29 % 1-3 days, 9 % 4-10 days, 6 % 2-4 weeks and 6 % more than 4 weeks. When looking at the entire group of 88 respondents (Figure 1). Most time has been spent studying security and privacy issues. And even for this, the time spent has mainly been a maximum of 1-3 days. At the time of the survey's implementation, GDPR issues were particularly topical and urgent (In Finland, the GDPR entered into force on 1.1.2019). For this

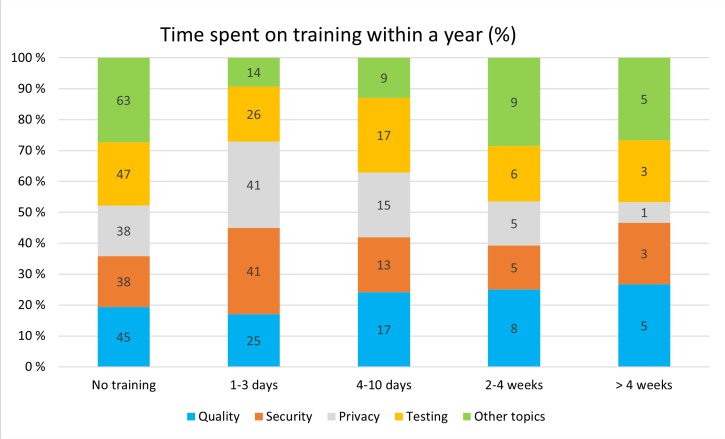

Figure 1. Time spent by IT professionals on training within a year

reason, the time spent studying privacy issues is also remarkably low. In addition, it should be noted that the respondents have separately given the training time spent on a specific topic (e.g. quality topics: 1-3 days, technical/other topics: 1-3 days, etc.). Therefore, some have reported more training time per year, while others may have chosen only one topic or none. This further demonstrates the IT professionals' limited time allocated to training.

When analyzing the training times, we can identify that the work experience of IT professionals does not have a noticeable positive correlation with the time spent on training. In a similar way, the size of the company also does not contain a positive correlation with the time spent on training. In this study, searching for information on the Internet is not defined as participation in training and competence development, and thus, training is at least participation in a slightly more formal training event.

When looking at the number of professional certificates, approx. 67 % do not have any professional certificates. This result is surprisingly low, given the importance of degrees and professional certifications as part of procurement tenders in the IT sector. The results show that work experience has a strong negative correlation with the "no certificate" result (-0.460). This means that IT professionals as a whole do not have many professional qualifications, regardless of their educational background, work experience or the size of their company. However, work experience has a significant positive correlation with technology certification (0.283), project management certification (0.330), and the rest of the certificates specified in the section "Other" (0.278, such as SAFe, ITIL, COBIT, TOGAF certificates). The results showed that the more experience, the more likely an IT professional was to have a professional certificate. And having one professional certificate increases the likelihood. As can be seen in Figure 2, the number of certificates starts to increase for IT professionals with 11-15 years of work experience, and especially for IT professionals with more than 16 years of work experience.

When examining the size of the company, it was found that professional certifications have been completed especially in large companies. (Figure 2). This indicates that large companies have an interest in investing in workers' professional certifications, as qualifications and certifications play an important role in tendering situations, and large companies may have better financial conditions to pay for employees' certification training.

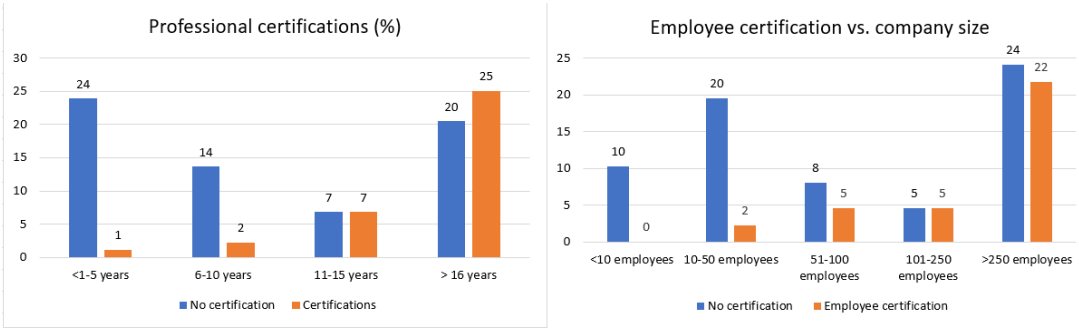

Figure 2. Professional certifications per IT professionals' work experience (%) and per company size (%)

Lessons learned from organizing continuous learning at the department of Computing

Over the past three years, the Department of Computing at the University of Turku has offered and implemented several training modules for continuous learning in the IT sector. These include projects, such as: ICT-Sote (30 ECTS module of several IT courses), SOTE-Akatemia (courses, suc as, Digitalisation in healthcare and social welfare services; Information and Cybersecurity courses), FITech university network (various IT courses across seven universities), LEADBEHA (Information and Cybersecurity course), and also various Open University courses. These are the observations and experiences of several teachers who have been in charge of continuous learning courses, which have been discussed together in the context of course implementation and development activities.

General topics. *Communication and course marketing*: Promoting and marketing courses is time-consuming. The most effective marketing approach is through employers. Marketing is easier if there is money available for marketing. *Administrative aspects*: Time must be reserved for collecting, maintaining, reporting to the funder, making user IDs and records of students and their studies. *Low completion rates*: Free courses collect enrolments, but the completion rates are low. Free courses are easy to drop out of because there is no financial loss for students. *Employee related challenges*: Successful course implementation should not be built on several part-time employees. Participating employees must be motivated to implement continuous learning courses. Otherwise they will slow down or, at worst, hinder the implementation of the course. *No possibility to get a recognised certificate after the completion*: Universities do not usually give out certificates or diplomas after the course. Instead, universities can give course credits and it is possible to acquire a transcript of academic records, which are not as well recognized in the IT sector as professional certificates. This raises the question of why students should choose a course for which there is no possibility of obtaining a recognized certificate or diploma as proof of course/content completion.

Curricula and Courses. *Students prefer time- and place-independent courses*. It should be noted that students can participate in lifelong learning throughout the country. For this reason, remote participation should be made possible, even if on-site teaching is available. Course materials should be provided as ready-made lecture videos, and materials and assignments directly available in the course area. That way the student can complete the course at a time and at a pace convenient for themselves. In addition, we have observed that an extension to the completion of courses is often requested or the students continue the course with the next im-

plementation instance. Also, taking exams may be an obstacle for some students, and therefore do not participate in the course if it includes exams. *Building course content*. Building course content requires a lot of content and contextual knowledge in the field. It is necessary to have a clear idea of the needs of students and, on the basis of these, if necessary, make changes to the content of the courses. *The courses require a lot of customization*. The courses offered to the university's degree students are not directly suitable for students of continuous learning. Students of continuous learning want sub-specific topics that benefit them quickly and directly instead of general knowledge. *The importance of relevance to working life*. The requirement for relevance to working life takes on an even greater role. For this reason, a clear working-life connection must be built into the courses. And one way is, for example, to include several guest lecturers from various workplaces to bring in sub-specific competencies, e.g. information security, law, data protection, procurement process, and robotics. Success requires a good network of experts and partners in the field from the course creators. *Communication during the course*. Communication is very time-consuming. A separate resource should be nominated for this role, who will take care of motivating students, communicating, and contacting students personally. This is a kind of "supertutor" who can teach courses, instruct, communicate and supports students' progress, etc. Through communication and support activities, it is possible to improve the completion of the courses by maintaining connection with the students. *Learning verification*. Students' coursework must meet the university's course requirements for it to be eligible to be included in a degree.

Student related. *Lack of employer's support*: The motivation to complete the courses decreases if the employer does not support studying during working hours. *Time management challenges*: Quite many have challenges combining work and training or combining training and family or social life. *Lack of technical skills*: Problems with technical things, such as, cannot open lecture videos, and changing passwords. *Inability to understand course materials*. Typically, students participate in continuous learning courses with very different basic education and competence backgrounds. Especially if the student's basic education is from another field than IT, the concepts and language of the IT field can become a challenge.

From teachers' perspective, students who complete life-long courses are typically motivated and active. Students' work experience helps them to reflect topics in more depth. This reflection is particularly interesting for teachers because it allows them to see and hear examples of work-life applications and situations related to the subject being taught.

DISCUSSION

Often participants on a life-long learning course are already established professionals looking to deepen and gain multi-professional insights and expertise. In our experience, courses for life-long learning are not a by-product of regular curriculum teaching, but rather require their own dedicated group for designing, implementing, and evaluating learning contents and outcomes. Life-long learning courses are more often arranged in non-traditional ways. Rigid on-site classroom teaching is not feasible for most working professionals. Application of flexible and new teaching methods, technologies, and practices is thus more likely utilized in life-long learning courses. In addition, due to the coupling with work life, new course content developed for such courses can be integrated to regular courses.

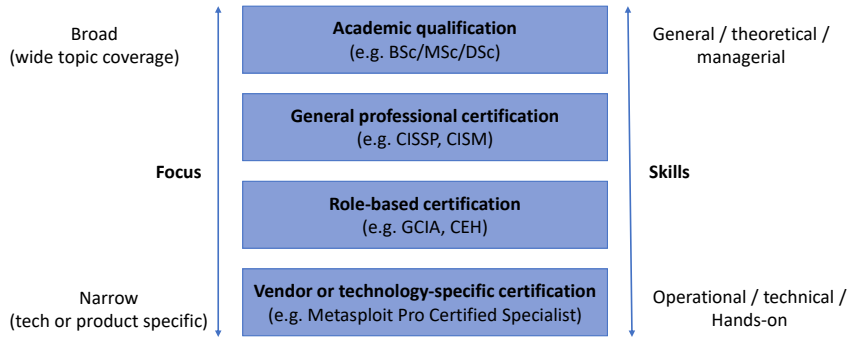

Figure 3. Focus and skill types for cybersecurity certifications. Adapted from (Furnell, 2004).

The unique potential for multidisciplinary view of universities should be more readily utilized to provide students with new insights into their chosen field of profession. One potential approach would be to use life-long learning courses to give students from industry an opportunity to learn the latest research directions and topics from academia. Here the research-based education that universities are responsible for can bring more added value to industry students. The focus should not only shift from teaching at university to maintaining and developing skills after the transition to work. The CDIO community and standards should also play a role in the process of continuing engineering education. The real learning in software engineering starts after graduation. The aim should be a continuum of continuous learning of technical subjects throughout a career. This is also reflected in the CDIO standards, which clearly outline a path for both creating suitable educational content and methods for life-long learning courses for software professionals. At the same time, the competence of educators must be enhanced. Educating postgraduate software engineering professionals requires a different set of competences compared to degree students. Industry co-operation and experience, demonstrated by for example professional certifications is one solution.

The importance of life-long learning might not be recognized or even required in companies in the same way as for degree students. The reason may be the lesser attention and importance of continuous education and its importance as a form on competence development. For example, in cybersecurity, established professional certifications are usually very highly regarded and are understood as proof of competence and skill in the area. Figure 3 shows the different focus and skill ranges for cybersecurity certifications. Academic qualifications are clearly in the domain of universities. In the other end of the spectrum are vendor and technology-specific certifications (e.g. Cisco product certifications provided by Cisco Systems, Inc.). In the middle are generic and role-specific certifications, where new openings for life-long learning can be made for universities.

One potential way of bringing certifications available to university students is to collaborate with technology vendors. As an example, at University of Turku we have successfully done this in the past (see e.g. (Hakkala & Virtanen, 2012)). Unfortunately, university-industry cooperation is also vulnerable to shifts in company policy or external circumstances, such as mergers and acquisitions. A better solution would be for universities to be in control of the certification. The landscape of professional certifications is also varied and there is a plethora of certifications to choose from. As observed by (Furnell, 2021), there are multiple certifications in the same areas of cybersecurity that are not interchangeable, and that there is no clear way to reliably

choose the correct certification for a role or position, making it difficult to navigate the potential pitfalls of unsuitable certifications. This phenomenon is not limited only to cybersecurity but can be generalized to other fields as well. The role of universities could be to provide a clear continuum from academic qualification towards general and role-based certifications.

Given the reputation and societal role of universities as the givers of highest education by law, why have universities not yet developed a system for granting certifications for life-long learning activities? The way Finnish universities only give ECTS is clearly not a viable solution in industry. We recognise that the situation may be different at universities in other countries, and in some countries there are certificates called "graduate certificates". These are partial bachelor's or master's degrees, but not specifically designed for professionals already in industry. Therefore, it is questionable whether these certificates granted by universities are really globally recognised in the same way as, for example, the CISSP certificate. Our idea is that the content of continuing education can actually be something quite different from what is taught to degree students, i.e. a real professional certificate that supports the maintenance and development of skills and competences. What is produced for degree students is not adequate for this purpose. A large proportion of software developers already know all this, as they have work experience and a BSc/MSc or even a DSc degree from an IT field.

Professional certificates are significantly more valued in IT industry, and universities should leverage their institutional strengths to create such respected professional certifications for IT professionals. It is understandably difficult to establish a new professional certification and to gain sufficient recognition for it to be considered proof of competence for the certificate holder, but universities are in a good position to do this. Life-long learning degrees and programs in economics and commerce (e.g. MBA and management courses) are proof that universities can provide credible study packages in the open market. This capability should also be leveraged in other fields of study.

CONCLUSION

The purpose with the paper was to find out how much time software developers use on competence development and training within a year, and how many professional certificates they have. Surprisingly, software developers spend relatively little time on training and skills maintenance during the year, regardless of work experience and company size. Contrary to expectations, software developers did not hold many certifications. The number of certifications only started to increase after more than 10 years of work experience and the larger the company they work for. This indicates that after graduating from higher education institutions, software developers do not commit to long-term lifelong learning. This mindset of lifelong learning should be instilled in students already during their graduate studies. The implementation of lifelong training should be invested in the same way as degree education. For this reason, it should not be done alongside other work but requires systematic planning, funding, and dedicated human resources. In addition, universities should offer real options as producers of lifelong learning and look at the possibility of offering students not just credits, but also recognized certificates that have value in the industry. The implementation of lifelong learning can be developed and strengthened through CDIO standards related to (7) Integrated Learning Experiences and (8) Active learning.

FINANCIAL SUPPORT ACKNOWLEDGEMENTS

The author(s) received no financial support for this work.

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Ville Leppänen is a Professor in software engineering and software security at the Department of Computing, University of Turku, Finland. At the moment, he is also vice dean of Faculty of Technology. He has now over 230 international conference and journal publications. His research interests are related broadly to software engineering and security, ranging from software engineering methodologies, practices, and tools to security and quality issues, as well as to programming languages, parallelism, and architectural design topics. Leppänen is a member in several boards and working groups in University of Turku and outside the university.

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