WORK-BASED LEARNING IN COMPUTER SCIENCE EDUCATION – OPPORTUNITIES AND LIMITATIONS

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ABSTRACT

Collaboration with the surrounding society is increasingly identified as high priority in the governance of Swedish universities. The contribution in the universities' immediate areas, as well as more globally, should in such contexts influence the purpose and implementation of the education. Here, work-based learning has a special role where students are active in a real workplace that may correspond to their future employment, with clear win-win situations as a result. While work-based learning can be seen as relatively well-defined for, for example, teacher or nurse training, it can be more difficult to carry out corresponding training towards a highly specialized technology industry. Students do not have the skills needed in such contexts, and representatives from the technology industry do not have the resources required to train students so that they become sufficiently independent. In addition, a change is taking place in certain parts of the technology industry, where more and more work is located at a distance, and where it is therefore no longer as relevant with training elements located in a real workplace. In such circumstances, therefore, ambitions for work-based learning need to be reviewed to consider both opportunities and limitations, in order to provide good benefits, and not interfere with constrained situations that are hard to overcome. This contribution problematizes the concept of work-based learning and looks at opportunities to reach as far as possible regarding its benefits with existing limitations. The profiling regarding work-based learning at the home university for the authors of this paper, will be addressed. A survey regarding the topic is presented based on attitudes from companies in the IT area concerning opportunities and desires, as well as student attitudes, and approaches at other selected universities. Examples of implementation in courses where the authors are involved based on student activity-oriented learning, will be presented.

KEYWORDS

WBL, WIL, System Engineering, Software Engineering, IT-industry, CDIO Standards 5-10.

INTRODUCTION

Work-based learning (WBL) is a learning method that prepares students for a future profession through real-world work activities. The method thereby increases the students' employability, at the same time as employers can be given confidence that future employees have experience in real work. Here, Kristianstad University (HKR, home university of the authors of this paper) profiles itself as unique amongst Swedish universities by offering WBL for students at all undergraduate programs. WBL (or rather Work-Based Education. We will, however, in the continuation use the term WBL), is here seen as significantly rewarding for both students and potential future employers. It should be noted that students can choose freely regarding their

degree project and thereby also do their work for a company. However, this paper relates to a compulsory WBL for students in a course that is not the course for the degree project.

At the core of the concept of WBL lies that the student performs tasks at an actual workplace for a period of time. This is of great importance in profession-preparatory educations for, for example, nurses, and teachers, which are also large educational programs at HKR. Here, the tasks are often fairly well defined, and can be performed for a few weeks during the training, to the benefit of both the student and the workplace representatives. The concept of WBL at HKR, includes practical elements, but where there must also be a clear scientific foundation, and thereby unite theory and practice. In addition to this, every student is entitled to a workplace-based supervisor who guides the student through the WBL process.

Comparing WBL for computer science students with the profession-preparatory education for nursing- and teacher education there are several differences regarding the profession itself and the future employer. The future employers for nursing and teacher education students are a very homogeneous group, to the largest extent public sector employers, comparing to the IT-industry sector where most employers are privately owned companies and a very heterogeneous group. The IT-industry is a diverse industry, operating in many different markets, both national and international. This difference of the employers for computer science students compared to the profession-preparatory students makes the WBL concept more difficult to implement in a computer science education.

Furthermore, while WBL has several valuable values for certain professions, it is generally more difficult to implement in the highly specialized technology industry. Students do not come far enough to contribute during shorter periods of time, and companies are often limited in being able to provide resources for effective supervision. At the same time, the work situation in many industries seems to be changing and moving towards increasingly remote work. This in itself means that WBL also needs to be seen from new perspectives.

This contribution studies how to find forms of company-oriented teaching/learning principles for students in Computer Science educations at HKR, and at the same time fairly enough respond to HKR's profile regarding WBL. The study includes approaches to WBL in similar educations in Sweden, and in addition to this, two questionnaires have been conducted, where both companies and students have been asked about attitudes concerning WBL.

As a background to the study, the concept of WBL, especially as it is presented at HKR, and related concepts such as Work-Integrated Learning (WIL) will be investigated and problematized. By turning more to WIL, openings can be made that better suit the conditions for the computer science education. This includes industry-oriented working methods, such as in the context of CDIO, and meetings with company representatives online.

The study behind this contribution is furthermore based on two courses where well-known Software Engineering-based work processes are used, and where IT-oriented companies participate through online-based meetings with students. Surveys are performed in order to provide further information regarding attitudes towards WBL. As a result of those studies, it is presented how courses in Computer Science at HKR can be designed to meet requirements and ambitions regarding WBL at HKR.

BACKGROUND

The Swedish Council for Higher Education (UHR, 2021) defines WBL as *higher education located in the area of activity where the student is expected to work after completing their education.* Typically, teacher education and nursing education are also here examples where WBL occurs. That is, that definition, and that approach is much in align with that of use at HKR. Still, the WBL-concept at HKR is further explained to not only include practice at the workplace, but that learning activities should be performed from a perspective of the educational program- and course syllabi, clearly based on the foundation of the educational field. In addition to this, students must be offered five weeks of training at workplace. There must also be well-developed routines for collaborations with WBL-committed organizations, where the external part can receive and supervise students in work situations relevant to the education. Moreover, students can here contribute through development projects, and provide valuable reflections on the organization's situation and contribute with ideas on potential development and renewal paths. In addition, there must also be a close collaboration between supervisors in the external organization and teachers at the university, where the WBL-supervisor must be offered to participate in supervisor training.

Atkinson (2016), distinguishes between WBL and WIL, based on a main perspective in the learning process. WBL is here a platform for the students to develop practical and conceptual skills, while WIL rather has the educational curriculum as the prime point of view, for the development of new experiences and skills. In either case, besides for placement-based workplace, Atkinson opens up for a rather loose coupling towards practice where simulations of real-world work-activities may be considered. Moreover, actually, the cite (Atkinson, 2016) '*Simulations are most effective and beneficial to students when they are considered to be a realistic experience of the workplace or the commercial environment'*, may also be seen from a CDIO perspective.

CDIO aims to foster students in practicing real world-close, complex-enough projects. That is, with that perspective, and with the rich flora of the CDIO Syllabus learning outcomes, CDIO may be seen as a WIL-method, mainly based on simulations. Säisä, Määttä & Roslöv (2019), shows an example where students are practicing work in a learning environment called "theFirma", that provides *ICT-focused development projects to small and medium sized companies (SMEs) and third-sector organizations*. A focus of that paper is on the soft skills that were acquired by the students. Here, focal CDIO learning outcomes, such as, *Teamwork,* and *Communication*, are especially well met, but also further generic skills, such as, *Leadership*, *Problem solving, Presentation skills*, and *Time management*. It is thus interesting to see WBL/WIL not only from the perspectives of the workplace-close practice, but also from those of generic skills of interest.

In addition to the above, a rather new situation has occurred because of the pandemic, where the workplace in itself is critical. Einarson & Klonowska (2021), shows that more and more work within the IT-sector (but also elsewhere) will go online, and also points out the need for education to prepare students for such a change of future work. Furthermore, desired soft skills amongst students, based on a survey amongst IT-companies, are presented. Here the four top desired skills are: *Good communication*, *Good cooperation*, *Presentation techniques*, and *Structured documentation*. Moreover, today several articles can be seen that are debating on required skills for the future careers in remote working (e.g., (Klein, 2021), and (Smith, 2021)). A recurring theme does here seem to be that the top skills are *communicating and collaborating in a virtual context*, and furthermore, *work independently*, *manage their time*, and *show self-motivation.*

Computer Science at HKR has two undergraduate educational programmes, *Bachelor Programme in Computer Science and Engineering, specialisation in the Internet of Things*, and *Bachelor Programme in Software Development*, both 3-year programmes on 180 credits, where WBL must be included. In each of those two educational programmes, a course in the last year has been selected to have special WBL-elements. In total, there are about a hundred students, about half of whom are non-Swedish-speaking. Experiences say that it is generally difficult to find traditional WBL places for students at computer science. This is based, among other things, on the fact that it is difficult to find continuously established forms for collaboration with highly specialized companies in the IT industry, where these are driven by requirements regarding resources and competition. Furthermore, even though English is a common language within the IT-business, seen from a context with smaller companies within the local region, demands on Swedish speaking skills may be a critical aspect. Moreover, experiments have been made with an intermediary organization that has been responsible for contacts between the academy and the companies. Here a small number of volunteer students have participated in projects with low demands on participation from the companies (Einarson & Lundblad, 2014). At a larger scale, however, this is far more complex. In this context the future of remote work, is not only important from an educational perspective, but may also be seen as a possibility to approach WBL/WIL, where a smaller amount of industry representatives may collaborate online with significantly lower efforts than at a physical workplace.

SURVEYS

Documentation review

An online documentation review approaches a view of the state of the concept of WBL in educations in Sweden similar to those covered in this paper. There are 25 universities in Sweden, where 11 of those collaborate in the CDIO initiative, offer study programmes in computer science and/or computer engineering. The computer science/engineering-based educations at these universities show a variety of types of activities involving companies in the educations. It is interesting that no matter what form of activities, this is still seen as positive values for the students. Activities here include, study visits, guest lecturers, project work, and degree work, often with companies as customers. Three CDIO-universities offer Industrial Placement courses as program courses, while two non-CDIO-universities offer Engineering Training / Internship courses as optional courses, even during the summer (vacation) time. In all cases for all industrial placement courses the student him/herself seeks contact with companies, authorities, or organizations. This means that the home-department is not responsible for arranging the contacts, and probably neither responsible for the time it takes for finding an appropriate workplace, and the training period required for the student to be contributing. Only two universities provide education corresponding to the WBL or WIL concepts. These are Kristianstad University (WBL, information in Swedish) and University West (WIL).

It is interesting here to see that WBL and WIL are rare within the surveyed universities. Positive WBL values, such as study visits (contact with physical workplace), and guest teachers (contact with company representatives) are there, but not in a developed WBL form. Another common form is *labour market days*, where contacts are made between students and companies. Such an activity corresponds to the value of the employment opportunities within WBL. One possible conclusion from the survey, based on the low number of WBL/WIL examples, is that it is generally not an easy thing to arrange WBL in computer science/

engineering-based educations, as previously mentioned in this paper. Still, as shown, WBL-values can at least partly be achieved in other ways.

Questionnaires

A second study is based on two questionnaires sent, in the end of November 2021, to both companies and students. The questionnaires were essentially divided into three parts: (1) Cooperation between students and potential employers in our study programmes; (2) Content of student projects; and (3) Structure and content of future cooperation. These questionnaires are more elaborated on in (Frisk, Klonowska & Einarson, 2022). The questionnaires do not especially focus on WBL but more generally on meeting points between academia, students, and companies through different kinds of projects, and experiences achieved at the parts of the students on one hand, and companies on the other hand.

The first questionnaire consisting of 46 questions was sent to 30 contact persons in companies and organizations cooperating with our department. Below the companies and organizations will be referred as *employers* for short. The response rate from the employers was 37% (11 of 30), the significance can therefore be questioned. Traditionally, it is quite hard to get higher response rates from companies. A possible explanation to this may actually be at the core of the problem of this paper. That is, companies are driven by short-term requirements, and do not have the resources to prioritize the requests from the academy, even if there is a good will.

From the answers provided by the employers it can be seen that there is a satisfaction with the students' contributions. There is also a willingness to continue collaborations with the universities, for further future student projects. Mainly student projects have been performed in contexts of degree work, but other forms of projects are of interest. The employers are mostly interested in groups sizes of about 2 students, and where projects should be performed both on distance and at the workplace of the company. Furthermore, the size of a student project may vary from about 2 months to one full semester, and the amount of guidance varies from about two times a week to once a month.

In the questionnaire the employers were asked which collaboration concepts they are familiar with, which is seen in Table 1 below. Forms for WBL/WIL probably need to be further communicated with the university side before projects of that kind will take place. From the low number of responses, it is hard to draw further conclusions. Still, the low number may, as previously mentioned, actually strengthen the experiences concerning the difficulties in bridging the gap between industry and academia.

Table 1. Familiar cooperation concepts within companies

Concepts	# of positive responses
Work based learning (WBL)	5
Work integrated learning (WIL)	1
Co-op	1
Internship	11

The second questionnaire, consisting of 49 questions, was sent in the same time period to our first-, second-, and third-year students in both undergraduate programmes as well as to our alumni who have finished the programmes during the last five years. In total around 400 students and alumni were reached. Over 100 students and alumni have responded to the

questionary, distributed as shown in Table 2. In this specific paper, the main interest is however on the third-year students, while more information is available also for the others.

Table 2. Number of responses from students and alumni

	Computer Engineering Programme	Software Development Programme	Total
Year 1	5	11	16
Year 2	11	23	34
Year 3	4	19	23
Alumni	8	23	31

Questions posed to the respondents, i.e., students and alumni include:

1. Do you think that the university should provide student projects at companies?
2. What kind of cooperation do you want with companies during the education?
3. How large do think a student project (in cooperation with a company) should be?
4. Where do you think company student project should take place?
5. How often do you need supervision, to make the project progress the best?
6. How many fellow students do you want to cooperate with in a student project at a company?

Responses from students and alumni on the above questions:

1. The answer was *yes* for 96% of the respondents, which in itself clearly shows the willingness from the respondents' side to have some kind of company contacts during their education.
2. The responses vary. While about 20% of them would like some kind of WBL/Internship, others more mention looser coupling towards companies, such as guest lectures, study visits, integrated projects (university-company).
3. This question refers to amount of time, and here 49% of the respondents prefers projects for a whole semester or longer, while 24% of those prefers projects for 3-4 months, and the rest less than that.
4. According to this question, 17% of the respondents prefer doing projects at the company, 53% of the respondents point out that they prefer both company and distance, while 25% mention that it depends on the type of project. The remaining 5% prefer to only work at distance.
5. Weekly supervision is wanted by 38% of the respondents, 30% want more supervision than that, while 14% of the respondents want less than weekly supervision. The remaining 18% of the respondents answer that the amount of supervision depends on the project.
6. About 60% of the respondents prefer smaller group sizes of about 1-3 respondents, while the rest would like to see groups of sizes 4-5, or even more.

Conclusions that can be drawn from this include that as a student there is a clear interest in preparing for a future career through some form of interaction with company representatives. The form can vary. However, it is mainly about projects where companies are involved. Other forms, such as, study visits and guest lectures are also of interest. With projects for companies, work is mostly to be performed independently and to some extent preferably at a distance.

Atkinson (2016) provides discussions on observed barriers towards establishment of effective WBL/WIL partnership. Such barriers include *financial constraints and the costs associated with hosting students*, *differing expectations about the outcomes and benefits of WBL/WIL*, and *lack of flexibility and responsiveness on the part of the education institutions to accommodate employer needs and the business cycle*, as well as *lack of a consistent understanding of WBL/WIL*, in itself. By acknowledging such inherent resistance, rather than forcing agreements that risk failing, new solutions with variations on themes of WBL/WIL may be found, as presented below. This may possibly suit all involved participants better, and still with an outcome of sufficient WBL/WIL-values.

DISCUSSIONS AND RESULTS

Swedish higher authorities for education strongly encourages universities' collaboration with the surrounding society, including industry and other organizations. From the meta-framework that governs the universities' educations regarding learning objectives, however, WBL is generally not mentioned (Still, exceptions from this can be seen for some obvious profession-preparatory study programmes). Therefore, WBL can rather be seen as an extension to such a framework, where the learning objectives still should be followed to motivate the WBL for the current educations. WBL does here contribute with values, such as, real-world experience for the students, and exchange of knowledge between the academy and industry.

This contribution addresses similarities and differences in concepts of WBL, WIL, (by Atkinson (2016)), and WBL as it is defined by HKR. While WIL has a stronger weight at the perspective of an education's learning objectives, than WBL, it is probably motivated to put HKR's WBL-concept closer to Atkinson's WIL than the corresponding WBL. Still, in any case WBL and WIL are generally tightly coupled to a workplace and engaged workplace-based supervisors, even though Atkinson also opens up for cases of university-based simulations of real-world occurrences. In that specific context, CDIO may be seen as WIL, but with a loose coupling between student and external part. Furthermore, preparing students for future Remote Work, such as proposed by Einarson & Klonowska (2021), brings new values to the discussion where the physical workplace no longer have the same meaning and significance.

At Computer Science, at HKR, two courses have been selected to include WBL elements, that is, *Systems Engineering,* and *Software Engineering.* Both courses, on 15 credits, have today developed contacts with industry and other organizations, to represent industry-related projects and processes ((Frisk, Klonowska & Einarson, 2022), (Teljega & Einarson, 2022)). Externals participate online, at a distance, where they have recurring meetings with student groups. This contributes to contacts between students and industry representatives, at the same time as valuable exchanges are made between teachers and these external representatives. Here, the industry representatives do not have actual supervisor roles, nor do they have to devote too many demanding resources to participate. In a modern context with the requirements and limitations that exist, this can be seen as a valuable contribution to WBL within a course, and within an educational program. The connection between student and workplace is loose but significant WBL-values can still be seen.

Regardless of which form of WBL is chosen, the learning objectives are essential to motivate the activities, as has been discussed. Articles that address WBL as well as Remote Work for students (e.g., (Einarson & Klonowska, 2021)), can be a guide in finding suitable learning objectives. Emphasis is especially on significant generic skills such as *Communication*, *Teamwork*, and *Planning skills*. These, together with other significant learning objectives, thus,

become those that substantiate the syllabus, and the manifestation of the syllabus through a suitable WBL-model. Moreover, through the loose coupling, full examination is performed by university teachers, where this e.g., is manifested through mandatory meetings, reflection reports, and presentations.

Additional aspects that have emerged from surveys of other universities, companies and students lead to inspiration to shed light on several values for a new type of WBL-based course. Such aspects include study visits to give students a sense of a physical work environment, invitations to recruitment companies to respond to employment opportunities in the WBL, and guest lecturers from the IT industry to contribute expertise in selected subjects.

This leads to a summary of a possible WBL-based course with an approach based on the following aspects:

1. A smaller number of company representatives are invited to follow the students during their projects. The company representatives have a knowledge-significant role in the project.
2. The course has elements of remote education
    a. This trains students in a future remote work situation
    b. Business representatives can minimize their efforts in terms of resources needed
3. The course project has a sufficiently high degree of complexity, according to CDIO's principles
    a. Process models that are used are established both scientifically and within IT companies
    b. Appropriate generic skills are emphasized, where these are to be examined as part of the course
4. Invitations of additional company representatives
    a. Recruitment companies are invited to open up for employment opportunities for students
    b. Additional representatives from the industry (or other organizations) are invited to give guest lectures on valuable topics

In a perspective of HKR's definition of WBL, it can be seen that the main aspects of that definition are fulfilled. Furthermore, it can be understood that problems, that traditionally are present in WBL for computer science education programs, decrease. One point remains and is not met, the one that concerns external participants acting as supervisors. In this case, supervision, examination, and grading falls entirely on the teachers at the university. In fact, this can be seen as a consequence of that the students not being physically present at a company but rather following the educational structures in a more traditional way.

From the point of view of the courses in specific focus of this study, that is, S*ystems Engineering*, and *Software Engineering*, revisions have already started and furthermore been implemented. The points 1 - 3 are currently in large met, while point 4 needs to be further developed. Moreover, point 3 b is typically a point of further future need to be reflected on, and where CDIO learning objectives may be clearly contributing.

CONCLUSIONS

This contribution proposes a new form of WBL that strives after meeting problems seen in WBL in computer science education. For example, it is difficult to engage a sufficient number of industry representatives in general to act in WBL, and especially in the supervision of students with limited resources, and where the highly specialized activities are not suitable for students on a shorter course. By instead involving a few external company participants in the educations where they participate online on a smaller number of occasions, there still are WBL-values, such as, contacts between student and industry, as well as between teachers in academia, and industry. Furthermore, the new form of WBL takes inspiration from the need to train students in Remote Work, which is pointed out by many as the new way of working in the IT industry.

However, the primary importance, also within WBL, is still to meet the learning objectives that are included in a course and within an educational program, and that must clearly be considered. In this paper, it is argued that learning objectives, such as, regarding *Communication*, *Teamwork* and *Planning Ability*, among others, are essential and should be examined through the WBL-activities. In the proposed WBL-approach, the examination lies entirely on the teachers who controls it in appropriate ways.

The argumentation for this paper is seen from a perspective of two Computer Science courses at Kristianstad University, *Systems Engineering*, and *Software Engineering*, where the proposed WBL-approach has been partly developed and is seen as potential for the Computer Science educations, not least because it also trains students in future distance-based working methods. Further WBL-values, such as meeting points for possible employments, and study visits, have also been proposed, and will be seen as important and interesting elements of WBL-based activities of such courses.

For future work: While the concept of WBL traditionally relates to a physical workplace to achieve some positive values, the core of those values must be further elaborated on. What is here considered WBL, and what is not? Is an appropriate guest lecture considered WBL? Must there be one course in a study programme that has the WBL to make the progamme WBL-like, or can different possible WBL elements be spread over a study programme's different courses, to together meet the amount of required WBL elements? Future studies are clearly needed in the context of WBL (or WIL) to shed light on the understanding of the concept.

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