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Comparing Technologies used in the Swedish Software Industry and Education

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Comparing Technologies used in the Swedish Software Industry and Education

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***Abstract*—The Swedish software industry is seeing explosive growth and Swedish colleges and universities play a crucial part in supplying industry professionals with relevant education. Studies show an existing gap between what software engineering (SE) education teaches students and what the software industry needs. This study looked specifically at what technologies Swedish SE education used in its syllabuses compared to what technologies were in demand by the Swedish software industry to determine if any knowledge gaps existed. Course syllabuses and job posts were collected and compared through text analysis, highlighting keywords associated with different technologies. The result showed that the Swedish SE education overall aligned with industry demands with some minor exceptions. Conclusions were that some improvements could be made to meet the demand of technologies such as C#, TypeScript, Kubernetes, and Docker.**

***Index Terms*—Software Engineering Education, Swedish Software Industry, Software Technologies, Text Analysis, Education Gap**

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I. Introduction

The Swedish software industry is growing fast, and The Swedish Public Employment Service predicts software developers to have great employment opportunities in the foreseeable future [1]. This view is confirmed by an industry report predicting that the number of Swedish software developers will need to increase by 37% between 2020 and 2024 to keep up with industry growth [2]. The same report also shows that employers look for new hires to have post-secondary education and that academic background is highly preferred. This aligns with how The Swedish Standard Classification of Occupations categorizes the software developer as requiring an advanced level of higher education [3]. This indicates that Swedish colleges and universities play a central part in enabling industry growth by supplying new SE graduates to the workforce.

Several international studies have pointed out knowledge gaps between what is taught at universities and what students face once entering the industry [4]. If gaps exist, narrowing them should benefit a growing industry since it would shorten the time for recently graduated software engineers to become productive team members at a company. Looking at this problem from a Swedish point of view leads to the question: are there knowledge gaps between the Swedish SE education and industry as well? If so, what possible improvements can be made to ease the transition from student to industry professional?

Bodell [5] conducted a qualitative study on how well Swedish SE education matched the requirements of different stakeholders. The industry perspective was gathered through interviews with employees from 11 different Swedish companies and concluded that the overall curricula met industry expectations. Bodell acknowledged the need for more studies on the topic, preferably using quantitative methods. To collect larger amounts of data, several studies and reports have used job posts as a data source for analysing different aspects of the job market. A Swedish government-issued report looked at future needs for technical skills in the Swedish job market, by collecting historical job posts in search of possible trends [6]. Oguz and Oguz studied the knowledge gap in SE education from different stakeholder perspectives [7]. They also used job postings in their study to represent the industry perspective.

In job posts related to the SE field, the most occurring skills listed were technology-related e.g., programming languages and frameworks [7]. This might be related to findings in several studies that suggest that employers are more likely to hire candidates that know the company's tech stack [7]–[9]. Even though knowledge of a specific technology alone is not sufficient to make a candidate qualified, it might be extra beneficial for new graduates since they don't have any previous professional experience to lean on when faced with all the new things to learn when starting a new position.

During SE education students are taught a wide range of topics and often these are not linked to specific technologies. Colleges and universities could adjust what technologies are used in education without affecting the underlying teaching goals. This should provide an opportunity for educators to choose technologies relevant to the industry and reuse the same technology throughout courses to deepen the students' knowledge. Could it be possible for Swedish SE education to narrow a potential knowledge gap by choosing technologies that differ from what is currently being used?

There has not been any extensive research on knowledge gaps between Swedish SE education and the Swedish software industry, and to the author's knowledge, Bodell [5] is the only recent study done on the subject. This study aims to better understand if current technologies taught in Swedish SE Education contribute to the knowledge gap and if so, what changes might be done to narrow it. By utilizing text analysis and comparing job posts to education syllabuses the study seeks to better understand how well education and industry align. Additionally, by analysing historical job posts any upcoming technology trends might be identified.

II. Purpose and Contributions

The growth of the Swedish software industry will play a key role to keep the Swedish economy competitive on a global level [10], [11]. It currently faces challenges with growing at a fast rate and the need for new talent is high. Colleges and universities need to provide relevant education to make it easier for students to transition into productive industry professionals by limiting the gap that exists between education and industry.

SE topics covered in syllabuses are many times technology-independent making it possible for educators to choose what technologies to use and still fulfil the teaching objectives. This provides an opportunity for educators to choose technologies that are relevant to the industry when designing new syllabi or improving existing ones. Even though general programming knowledge is the most desired technical skill in the Swedish software industry [2], knowing a specific technology used by a hiring company increases the likelihood of getting hired [8]. It also helps decrease the knowledge gap by removing one more thing to learn once employed. To get a better understanding of how well the SE education and software industry in Sweden aligns, in their use of technologies, the following research questions have been constructed:

RQ1 What are the technologies taught in the SE program and course syllabus at universities?
RQ2 What technologies are requested by the SE industry?
RQ2.1 What technologies are seeing an increase in demand?
RQ3 What program and course improvements could be made to align them with industry needs?

This study will provide an overview and comparison of what technologies the Swedish software industry is currently using and how well this corresponds to what is being taught at Swedish colleges and universities. It will also indicate what technologies are seeing growth or decline in their usage. This will provide insights useful to academics when choosing what technologies to use when creating program and course syllabuses. The study will also provide a tool for fetching Swedish job posts and performing text analysis based on keywords to make it easier to collect and analyse large amounts of data.

The hypothesis is that technologies that have been high in demand for a long time in the Swedish software industry will also be well represented in SE education. However, technologies that in recent years have gained popularity throughout the industry are predicted to not be as widely adopted by universities and colleges.

III. Background

A. *The Computing Field*

Association for Computing Machinery [12] (ACM) and the Institute of Electrical and Electronics Engineers Computer Society [13] (IEEE-CS) have together created The Computing Curricula 2020 (CC2020) [14]. The report looks to give a clearer overview of the computing field and its knowledge areas as well as provide curricular guidelines for computing education. It separates the field into seven sub-fields and links each one to different knowledge areas. Table I lists the computing fields.

TABLE I: Computing sub-fields

Computer Engineering
Computer Science
Cybersecurity
Information Systems
Information Technology
Software Engineering
Data Science

B. *Software Engineering*

The SE field consists of 15 knowledge areas shown in Table II. CC2020 defines [14, p. 28] SE as ”an engineering discipline that focuses on the development and use of rigorous methods for designing and constructing software artefacts that will reliably perform specified tasks”. The focus is on the construction of software even though some parts of its knowledge areas overlap with other computing fields.

Software Engineering Body of Knowledge [15] (SWEBOK) notes that SE is a field that builds on top of computer science (CS) and has a dedicated knowledge area to cover the related parts called computer foundations. It covers some aspects of CS but not all its parts. The selected parts must have direct usefulness to SE and software construction. Software Engineering Education Knowledge (SEEK) states that SE draws its foundation not only from CS but also from other fields like mathematics, engineering, and project management [16].

C. *Swedish Software Engineering Education*

Undergraduate degrees in Sweden, and some more parts of Europe, are obtained by completing three years of full-time studies. This differs from the American system, and similar ones, where an undergraduate degree is completed in four years. This is acknowledged in the CC2020 [14, p. 71] explaining that ”students do not begin a general degree and subsequently choose a specialization; they enroll from the

TABLE II: SE knowledge areas

Software Requirements
Software Design
Software Construction
Software Testing
Software Maintenance
Software Configuration Management
Software Engineering Management
Software Engineering Process
Software Engineering Models and Methods
Software Quality
Software Engineering Professional Practice
Software Engineering Economics
Computing Foundations
Mathematical Foundations
Engineering Foundations

outset in a specialist degree". The SEEK also addresses this and includes a model for a three-year curriculum.

Another important aspect when examining SE educational programs at Swedish Universities is cases of ambiguity in knowing what field a program belongs to compared to CC2020. Only looking at the program major is not sufficient since some programs have more than one field listed [17] and some list a different field than the program's actual content [18], [19]. A computing major in computer engineering (CE), translated from *datateknik*, indicates it would involve hardware topics such as circuits and electronics, signal processing, or embedded systems. But there are examples of programs with majors in CE that exclude hardware topics and examining the content of their curriculums shows that they relate more to the CC2020 definition of SE than CE [18], [19]. The differences in Swedish SE education compared to the CC2020 is an interesting topic that warrants a study of its own and a subject too big to fully examine in this thesis.

D. Current Industry Software Technologies

Stack Overflow is a site for posting and answering programming-related questions and has over 100 million monthly visitors [20]. Since 2011 they have conducted a developer survey about what software technologies are being used and the 2021 edition got responses from over 80 000 developers and about 58 000 of them were professionals [21]. The survey gives insight into what technologies are currently being used by developers worldwide and has been used by researchers to map IT industry roles to specific skills [22] and analyse directions of programming languages, databases, and job-seeking statuses of developers [23] to name a few. Figure 1 shows a summary of the top technologies from the 2021 survey categories: Programming, scripting, and markup languages, Web Frameworks, Other frameworks and libraries, and other tools. The category for databases was left out since four of the top five were SQL-based and SQL was already represented in the Programming, scripting, and markup languages category.

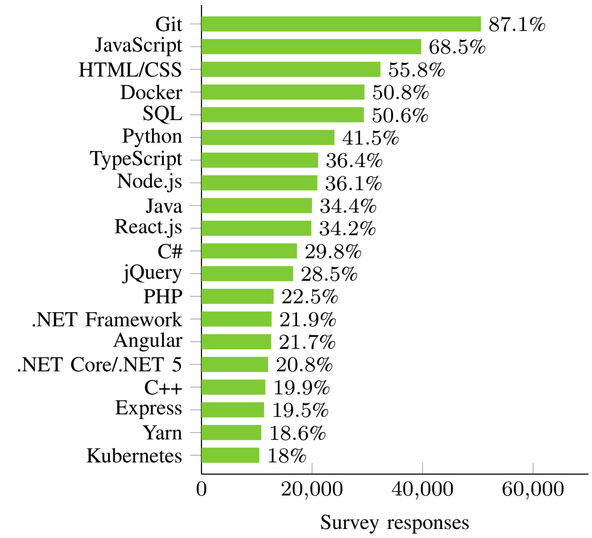

Fig. 1: Compilation of Stack Overflow Survey 2021 Source: Adapted from [21]

IV. Related Work

In this section, works related to this study are presented. They are grouped in subsections by the following topics:
Education gap - International works identifying knowledge gaps between SE education and the software industry.
Comparing Swedish SE education and the software industry - Works comparing Swedish SE education against the Swedish software industry looking at potential knowledge gaps.
Technology Needs In Swedish Software Industry - Recent reports on the state of technological needs in the Swedish Software Industry and future predictions.
Hiring Graduate Software Engineers - Works related to hiring recently graduated software engineers from different stakeholder perspectives.

A. Education gap

A systematic literature review on the knowledge gap between SE education and industry was conducted by Garousi et al. [4]. They collected 35 studies and 8 of them had measured, in quantitative terms, the knowledge gap. The results from these 8 papers were mapped against the knowledge areas defined in SWEBOK [15] and classified as having low or high gaps and of low or high importance. The results showed that 9 out of 15 knowledge areas had high gaps and were of high importance. When including only reports made in the last five years the areas showing high gap and high importance had grown to 11 indicating a widening of the gap.

B. Comparing Swedish SE education and the software industry

Bodell conducted a qualitative study looking at Swedish computing education from different perspectives focusing on software development [5]. A small sample of curricula from Swedish computing programs was compared to ACM and IEEE's curricula recommendations for the fields CE, CS, and SE [24]. Interviews were also conducted with representatives from the Swedish software industry to get their views on how well education lived up to the expectations. Conclusions were made that examined curricula did not entirely match the recommendations but lived up to the expectations of the industry. Bodell acknowledged the limited number of studies done comparing Swedish SE education with the Swedish Software Industry and recommended more research on the topic. He also highlighted the need for using quantitative methods.

C. Technology Needs In Swedish Software Industry

An initiative by the Swedish government looked at how the skills supply of technical competence could be sustained, short- and long-term. As a part of the initiative, The Swedish Agency for Economic and Regional Growth (SAERG) together with the Swedish Higher Education Authority (SHEA) created a report [6] that collected and analysed job posts from the Swedish Public Employment Service to map the demand for different technical competencies. Among other things it listed data on what software technologies in the Swedish software industry were in demand and trending up to and including the year 2020. The report's conclusions on the technologies most in demand for the year 2020 can be seen in Figure 2.

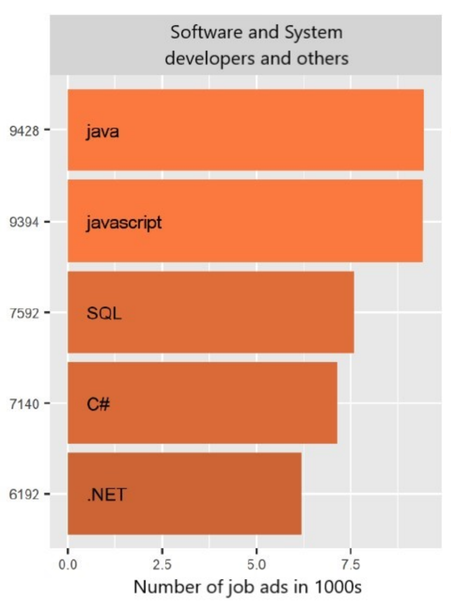

Fig. 2: Top programming languages 2020 Source: Adapted from [6]

They also looked at how the demand was changed between 2017-2020 to highlight technologies that were increasing as well as decreasing in popularity. Results on trending technologies for 2020 can be seen in Figure 3.

A report by The Swedish IT & Telecom Industries looked at what future competencies would be needed and sent out

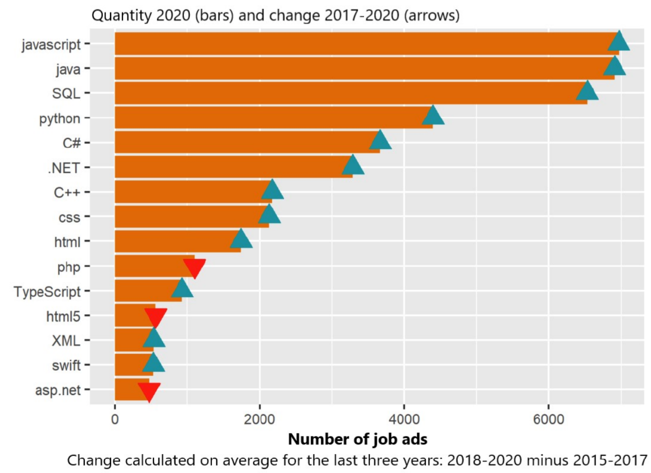

Fig. 3: Programming languages trend 2017-2020. Source: Adapted from [6]

surveys to recruiters and business owners [2]. One part of the survey asked what specific programming languages, database technologies, and other digital tools would be in demand for the next 3-5 years and the result can be seen in Figure 4.

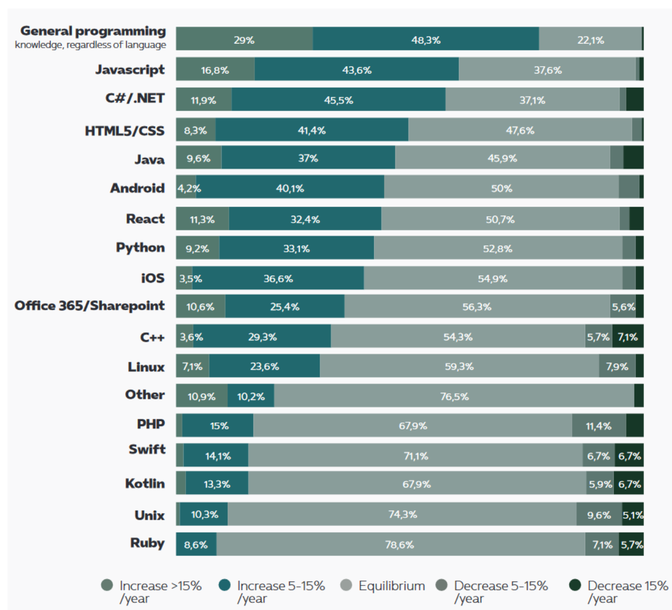

Fig. 4: Predictions made by survey respondents 2020 looking 3-5 years into the future. Source: Adapted from [2]

Both reports were done in 2020 and even though they used different methods some common conclusions could be drawn. Javascript, Java, and C#/.NET were technologies in the top-5 in all diagrams showing that they were in demand during the year 2020, trending, and predicted to increase in demand.

D. Hiring Graduate Software Engineers

To get an up-to-date view of what employers look for when hiring CS graduates Stepanova et al. conducted a study by sending surveys to recruiters [8]. Software developers were highest in demand, and they listed experience, GPA, projects, and skills as the four most important areas that employers looked at on a resume. The skills category is the only one directly related to the education syllabus, including programming languages and other technical skills.

Oguz and Oguz took a broader look at the problem from the perspectives of all involved parties [7]. They were students and recent graduates, academics, and the software industry. The first two groups, students and recent graduates, and academics were sent questionnaires and participated in interviews. The conclusion was that students were experiencing a knowledge gap when moving to a job in the industry since working on real-life projects was different from working on smaller school assignments. Soft skills such as teamwork and communication were also mentioned as part of the gap. It was through experience that the gap was closed. From the software industry perspective, they gathered job posts and analysed them to see what companies were looking for in new hires. The only requirements that were mentioned in all job posts were skills in different programming languages and the requirement of at least an undergraduate degree in SE or related fields.

E. Relations to this study

None of the reports in the study by Garousi et al. [4] had any data collected from Sweden and to the best of the author's knowledge, Bodell [5] is the only study to date to explore any knowledge gap between Swedish SE education and the software industry. Due to the limitations of the qualitative research method used in the study, Bodell suggested future research use quantitative methods to measure any knowledge gap. This study intends to address the lack of research on the topic by using quantitative methods to collect and analyse job posts to find out industry needs. A similar method was used by SAERG and SHEA [6], and Oguz and Oguz [7] to enable access to larger data sets than qualitative methods. Oguz and Oguz [7], and Stepanova et al. [8] showed that technical skills are important when hiring software engineers and this study will look at potential knowledge gaps in technical skills that might exist between SE undergraduate programs and the software industry in Sweden.

V. Research Methodology

The research methodology was divided into four steps: tool construction, data collection, defining skills and keywords, and measuring results. An overview of the method can be seen in Figure 5.

A. Tool Construction

A software artefact called Job Market Analyser (JMAR)[1] was constructed to import data and perform text analysis. This section describes the different features of the tool and an overview of the tool can be seen in Figure 6.

1) Data import: The data for analysing could be imported by two different methods. The first method was to connect to publicly available APIs created by JobTech to access job post data from the Swedish Public Employment Service. Two different APIs were used, the JobSeach API [25] and the Historical ads API [26]. Both APIs accepted HTTP requests and returned search responses as JSON data. The APIs had a limitation of returning a maximum of 2000 posts, this could be overcome by sorting posts by date and creating a new search from the date of the last post in the previous search. The second method of import was by loading locally stored PDF files and both methods placed data in a table to enable multiple imports to be analysed as one data set.

2) Skill definition: A table was implemented for specifying and mapping keywords and skill pairs. This enabled alternative keywords to be used to identify a skill e.g., both keywords HTML and HTML5 in the text should map to the skill HTML. The keyword and skill table could be saved and loaded as CSV files. This method was adapted from the report by SAERG and SHEA [6] where they also used alternative keywords mapped to the same skill to improve the result. The skill definition was implemented to be imported from correctly formatted CSV files.

3) Text analysis: Performing text analysis on the data set was done by searching the text for any occurrences of each keyword specified in the keyword skill table. When a keyword was encountered, it was added to the counter for the related skill and only counted once per entry in the data set. To minimize false-positive results from keywords e.g., JavaScript returning a hit on Java, a method of adding a prefix and suffix to the keyword was used. This meant that many actual Strings were generated for each keyword, one for each possible combination of prefix, keyword, and suffix. An illustration of the method can be seen in Figure 7. The method was developed through testing and analysing search results to identify suitable suffixes and prefixes to use. Once all keywords had been searched for the analysis generated a table showing the number of times a skill appeared in the data set.

[1] https://github.com/kristian-angelin/JMAR

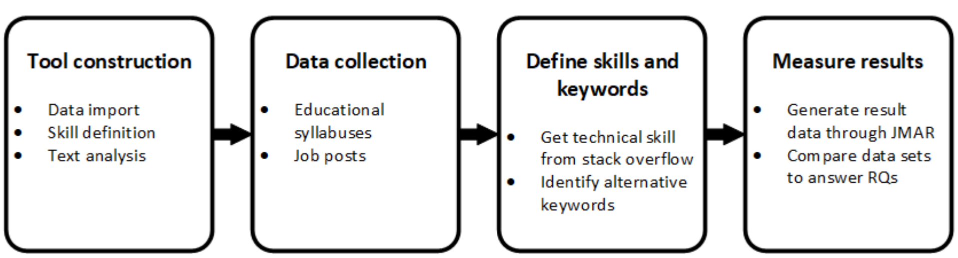

Fig. 5: Method overview

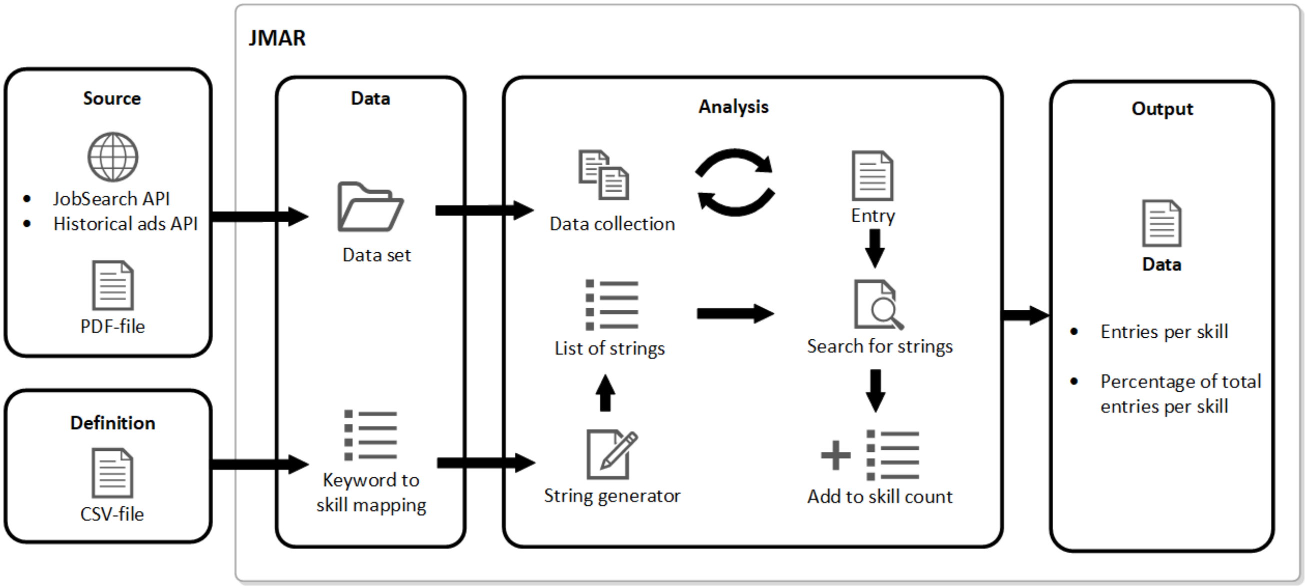

Fig. 6: Visual representation of JMAR functionality

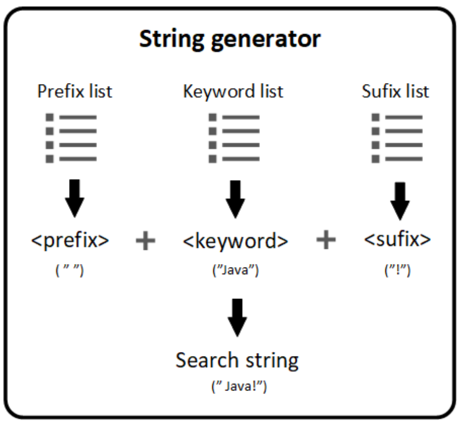

Fig. 7: Visual representation of string generator

B. Data collection

1) Educational syllabuses: SE syllabuses from colleges and universities were collected manually since no centralized database or common structure of their websites existed for easy access. Since Sweden's higher education consists of around 50 universities and colleges, each website was visited, and relevant educational programs were selected based on the following criteria:

1) Programs with majors in SE, CS or CE
2) Removed any programs not a 3-year undergraduate degree program
3) Removed CE programs containing courses in electronics and hardware topics

The following section describes the reasoning behind the selection criteria. The CC2020 [14] lists SE, CS, and CE to be the three areas in computing that have capabilities in SE, and therefore programs with majors in those fields were included. It could be argued that only majors within SE should qualify but it would result in only a handful of programs, and in reality, SE and CS graduates many times compete for the same jobs in the industry as well as some CE graduates. Then all programs not being a 3-year undergraduate degree programs were removed. This was to align with what Oguz and Oguz pointed out in their study, that all analysed job posts required at least an undergraduate degree [7]. Programs of longer duration were also removed such as civil engineering education since they usually last five years. The reasoning was that they could be compared to an undergraduate degree combined with a master's degree. The third criteria was to remove any CE programs that were teaching electronics and hardware-related courses. While SE and CS fields are concerned about software, CE generally is about both software and hardware. There are however a few CE programs that are only focused on software, and they were included in the study.

A total of 17 educational programs were gathered to represent the Swedish SE education. The gathered educational programs can be seen in Table III.

2) Job posts: The Swedish Public Employment Service job posting site Platsbanken [27] was used as a source for collecting job posts since it is one of the largest in Sweden. It has several publicly available APIs allowing access to databases of currently listed job postings [25] as well as historical ones [26]. Other sources such as LinkedIn [28], Indeed [29] and Carrerjet [30] were considered since they offered a large number of job posts, but none were selected due to the lack of APIs to extract the data. Since Platsbanken contains job posts written in both Swedish and English, words and phrases from both languages were used to get the search results. The used search phrases can be seen in Table IV.

Using JMAR as a tool for collecting job posts both active and historical posts were collected and saved for analysis. The

TABLE III: Educational programs examined in this study

Educational Institution	Educational program, 180 credits
Blekinge Institute of Technology	Software Engineering
Blekinge Institute of Technology	Web Programming
Jönköping University	Computer Engineering: Software Engineering and Mobile Platforms
Karlstad University	Bachelor Programme in Computer Science
Kristianstad University	Bachelor Programme in Software Development
Linnaeus University	Software Engineering Programme
Linnaeus University	Software Technology Programme
Linnaeus University	Web Development Programme
Malmö University	Computer Systems Developer
Mid Sweden University	Computer Science
Mid Sweden University	Software Engineering
Mälardalen University	Bachelor's programme in computer science
Stockholm University	Bachelor's Programme in Computer Science and Software Engineering
Umeå University	Bachelor Of Science Programme in Computing Science
University of Gothenburg	Software Engineering and Management
University of Gävle	Study Programme in Computer Science
Uppsala University	Bachelor's programme in computer science

TABLE IV: Search phrases

software engineer
software developer
systemutvecklare
mjukvaruutvecklare
programmerare

currently active job posts were gathered on 2022-05-22 and the historical posts were collected at six-month intervals starting in 2016 and ending at the end of 2021. A summary of the number of returned job posts per search can be seen in Figure 8.

C. Defining Skills and Keywords

To identify technological skills to search for, the Stack Overflow developer survey [21] was used as a base for skill and keyword pairs. All technologies in the Most popular technologies section listed in the following categories were included:

- Programming, scripting, and markup languages
- Databases

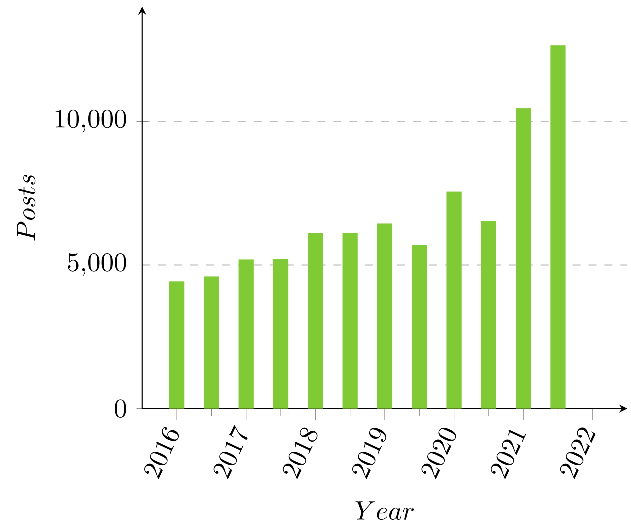

Fig. 8: Number of job posts gathered between 2016-2022

- Web frameworks
- Other frameworks and libraries
- Other tools

The list was examined and, in the cases, where alternative keywords could be identified, they were added to increase the chances of correctly identifying skills. Single letter technologies such as C and R were excluded from the skill and keyword list since they resulted in many false positives. Go, Chef, Flow, and Julia were also removed since the names gave false positives on common words and names in English and Swedish languages. Furthermore, the database category was examined and split into keywords divided between the skills SQL and NoSQL. This was to avoid SQL appearing in the results together with a specific technology utilizing it.

D. Measure result

To answer RQ1 and RQ2 the same method was applied to the respective data sets of program syllabuses and job posts. Entries for each data set were analysed for skills and added to the count of each skill found. Then a percentage was calculated to show how much of the whole set the skill was found in. This gave a list containing all skill keywords identified sorted by how many entries they were found in.

To answer RQ2.1 the previous method was applied to job data in six-month intervals between 2016-01-01 and 2021-12-31. This created a timeline for each skill and to detect trend change, a line was calculated using least squares regression. The equation for the line can be seen below, where m is the slope of the line and b is the intercept:

$$y = mx + b$$

$$m = \frac{N\sum(xy) - \sum x \sum y}{N\sum(x^2) - (\sum x)^2}$$

$$b = \frac{\sum y - m\sum x}{N}$$

The values were measured in percentages of the total amount of job posts for the interval. The slope value was used to determine the trend of each skill, showing if it was increasing or decreasing in demand compared to the overall SE job market. If the value were 0 it meant that the skill was trending equally to the overall SE job market. A positive number meant a skill was trending more and a negative number that it was trending less than the job market. The value also showed how significant the trend was with higher or lower values. RQ3 was answered by analysing the result from RQ1 and RQ2 to identify any variations in skills taught at educational programs compared to industry demands. A balanced supply and demand for a certain skill would mean that the same percentage of programs were teaching it as the percentage of job posts requiring that skill.

VI. Results

To explore the gaps between Swedish SE education and the Swedish software industry from a technical skills perspective, job posts and syllabuses from educational programs were analysed and compared. Syllabuses were manually collected while the constructed tool was used to collect job posts and to process the data through text analysis. The following subsections address the results related to each research question.

A. ***RQ1*** *What are the technologies taught in the SE program and course syllabus at universities?*

Syllabuses were collected and analysed from 17 educational programs and a total of 33 different technologies could be identified through text analysis. Figure 9 shows all identified technologies taught and listed by the number of programs teaching them. SQL was the only identified technology taught at every program. About one-third of the technologies could only be identified as being taught in one program.

B. ***RQ2*** *What technologies are requested by the SE industry?*

To find out what technology skills are demanded by the industry a total of 24 498 job posts were collected from the period between 2021-04-01 and 2022-03-31 using JMAR. Figure 10 show the 24 technologies that were the most requested for the period and identified in more than 500 posts each.

C. ***RQ2.1*** *What technologies are seeing an increase in demand?*

To find out what technologies are seeing an increase in demand, JMAR was used to collect job posts between 2016 to the end of 2021 in six-month intervals. Collected job posts for each skill that were listed in Figure 9 were included and the result can be seen in Table V together with the total amount of collected SE job posts. Results from trend analysis using the least square regression measurement can be seen in Figure 11 showing trend values for each skill during the measured period. Even if a trend number showed a negative value, it should be noted that all skills saw an increase in demand looking at the number of posts at the start of the timeline compared to the end of it.

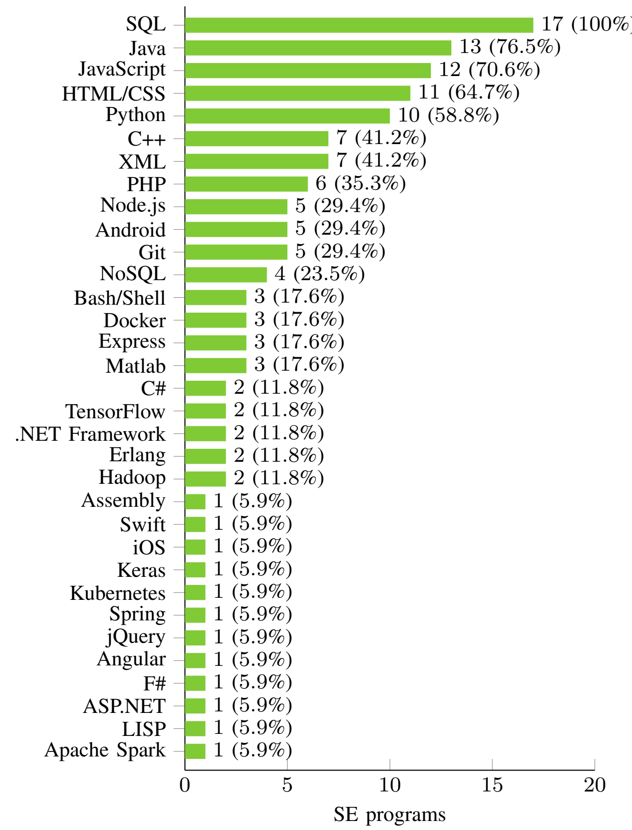

Fig. 9: Technical skills taught at educational programs

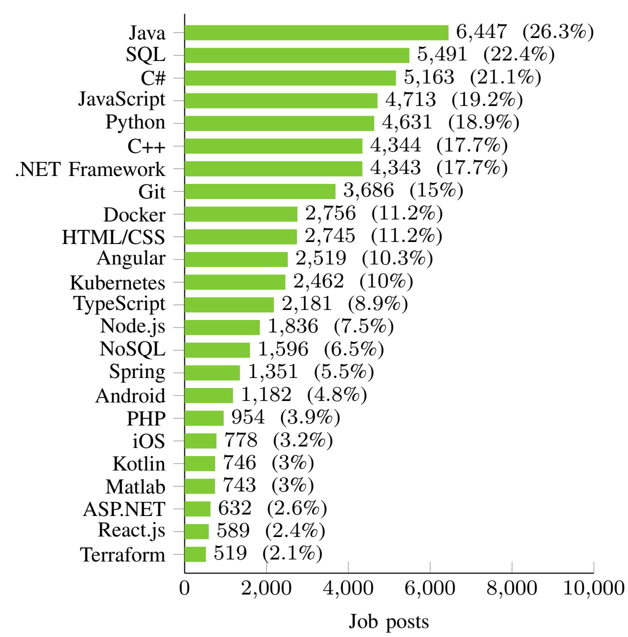

Fig. 10: Skills contained in job posts collected during a one year period between 2021-04-01 and 2022-03-31. Only skills found in 500 or more posts are displayed

TABLE V: Job posts per six months

Technology	1st 2016	2nd 2016	1st 2017	2nd 2017	1st 2018	2nd 2018	1st 2019	2nd 2019	1st 2020	2nd 2020	1st 2021	2nd 2021
Java	1182	1313	1506	1523	1510	1544	1731	1612	1872	1760	2871	3364
C#	1201	1244	1491	1436	1477	1566	1746	1554	1518	1467	2200	2660
SQL	1209	1182	1359	1213	1320	1271	1459	1216	1563	1551	2348	2854
JavaScript	1089	1300	1339	1172	1211	1266	1513	1312	1674	1483	2154	2567
Python	430	531	676	749	690	756	887	967	1143	1158	2002	2307
C++	910	1034	1176	1193	1285	1265	1441	1269	1171	1167	1903	2162
.NET Framework	935	987	1187	1049	1244	1206	1395	1233	1311	1248	1866	2237
Git	467	537	625	702	800	787	889	821	1032	894	1537	1932
Docker	99	152	194	208	274	345	419	492	616	601	1074	1459
HTML/CSS	930	985	979	858	846	908	1038	909	995	893	1183	1492
Angular	238	318	403	460	466	491	580	546	791	755	1032	1361
Kubernetes	3	6	16	35	69	146	230	244	394	443	970	1291
TypeScript	25	60	120	127	202	226	273	295	384	446	844	1163
Node.js	160	228	235	248	250	316	318	382	509	541	853	990
NoSQL	194	214	262	220	261	261	266	286	382	373	770	800
Spring	160	158	176	186	191	202	253	234	350	345	530	723
Android	334	346	360	460	412	353	469	384	359	339	566	648
PHP	368	400	377	287	307	292	309	246	376	346	429	553
iOS	265	296	262	310	278	209	290	287	274	255	399	423
Kotlin	0	1	8	33	64	67	141	115	138	142	392	452
Matlab	134	169	153	168	162	195	204	211	182	148	310	365
ASP.NET	263	266	278	238	222	260	316	277	242	202	252	342
React.js	65	69	85	103	70	95	106	104	132	141	238	312
Terraform	7	8	13	8	9	8	17	22	69	62	162	277
Posted SE jobs	4429	4601	5193	5200	6112	6115	6446	5700	7558	6537	10457	12649

D. ***RQ3*** *What program and course improvements could be made to align them with industry needs?:*

To answer the question of supply and demand the approach was taken to measure the difference between education and industry. All technical skills from Figure 9 and Figure 10 were compared and can be seen in Figure 12. The comparison showed in many cases big differences in supply and demand. The cases when the education supply exceeded the demand by more than double were in 24 out of 37 skills. There were four cases where the industry demand exceeded the supply by more than double and it was in technologies that weren't identified in any of the educational programs. The result of this comparison warrants some further analysis in the discussion section.

VII. Discussion

In this section, we discuss the results from the previous section and what they mean to the research questions. Comparisons are also made to related studies. Threats to validity are also discussed as well as social and ethical aspects of this study. Future work is also considered.

A. Answering research questions

1) ***RQ1*** *What are the technologies taught in the SE program and course syllabus at universities?:*
Bodell [5] looked at the content of Swedish SE Education from the perspective of SWEBOK knowledge areas and to the best of the author's knowledge was the only study done on the topic. Therefore, no previous study has looked at what technical skills are taught in Swedish SE education. Looking at the results it is important to have in mind that educational programs primarily don't teach the technologies themselves but the underlying concepts that the technologies are built around. The results show a perfect example of this in SQL being the most taught technology and included by every single program. Since databases are widely used and a part of the computing foundations knowledge area in SWEBOK [15] it is arguably needed to be included in all SE programs for them to be relevant. Looking at other widely taught technologies

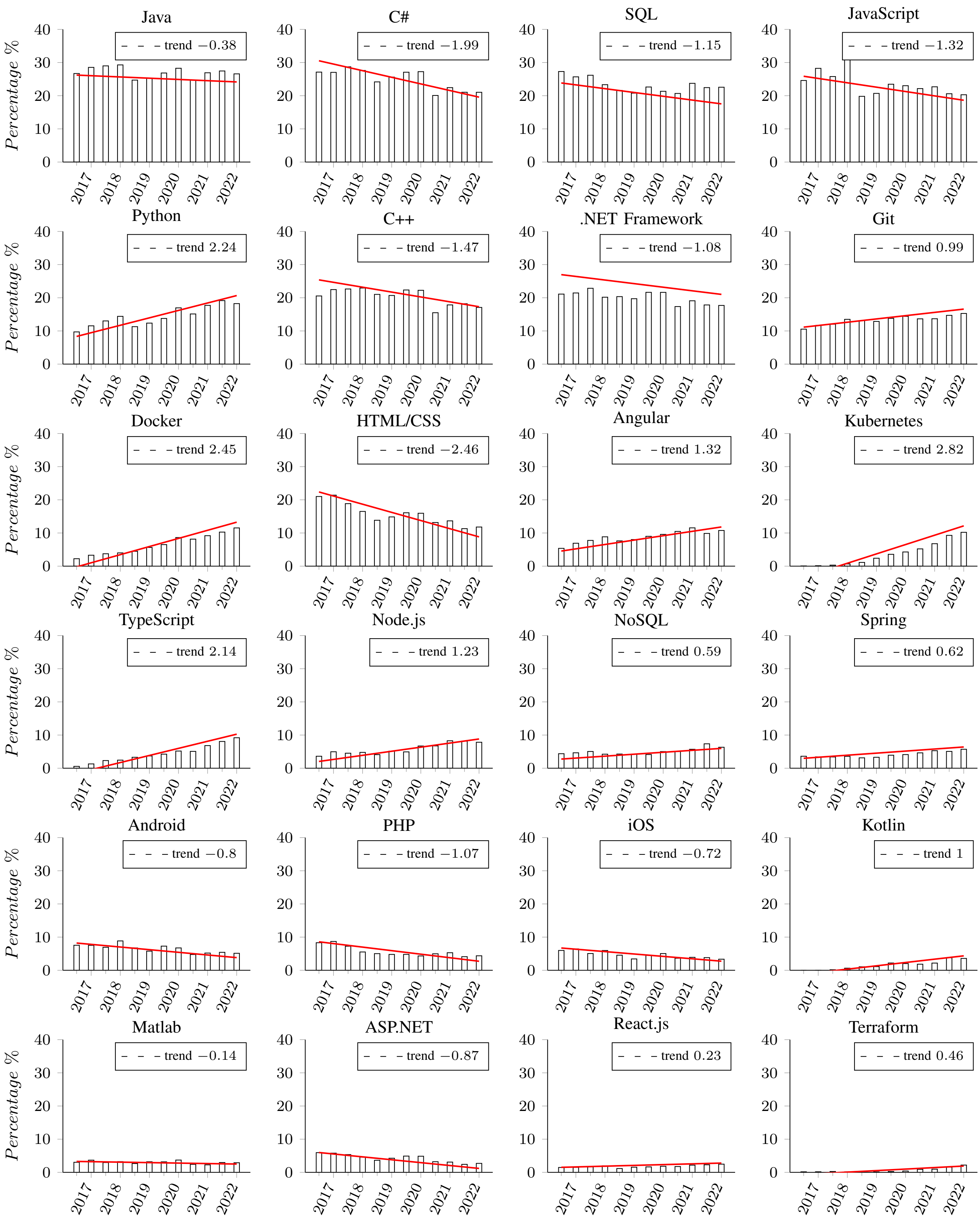

Fig. 11: Technology skills as a percentage of total job posts in six-month intervals. The linear regression line gives a trend value on the percentage change on a yearly basis.

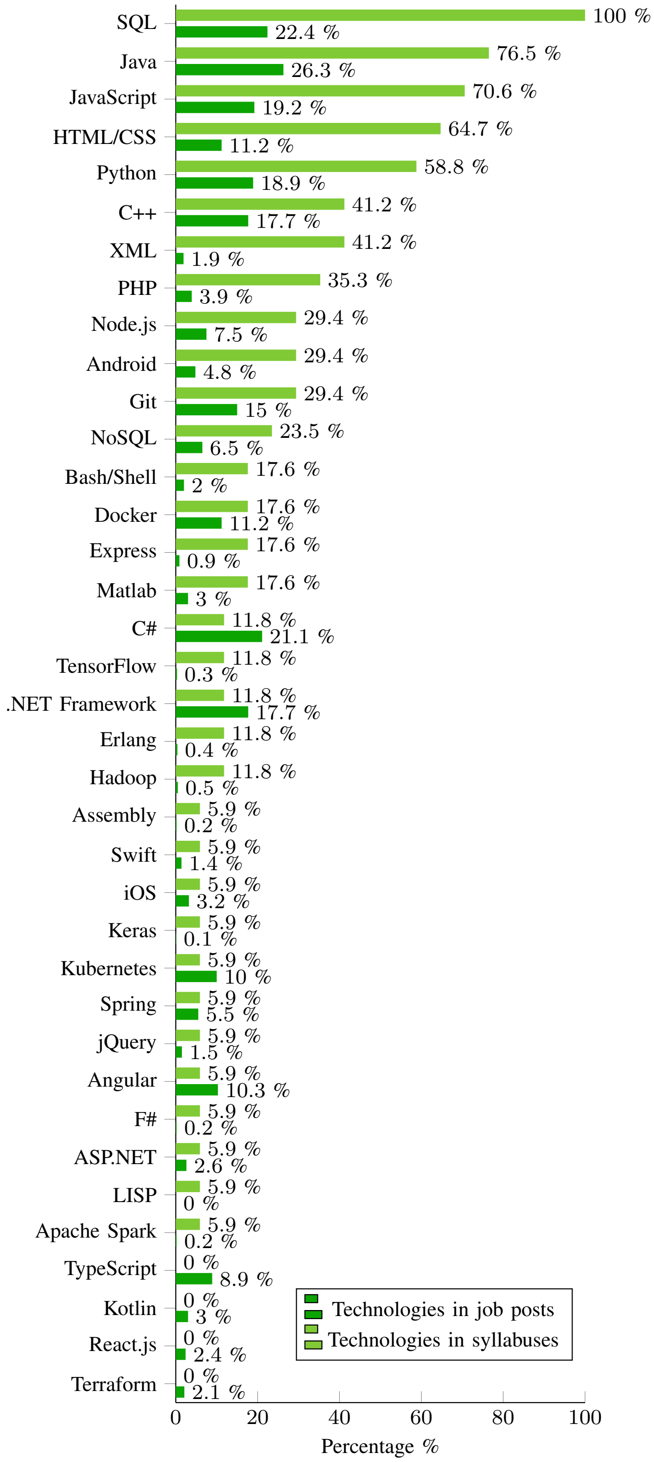

Fig. 12: Comparison of technical skills taught at educational programs compared to industry needs between 2021-04-01 and 2022-03-31

from this perspective shows that object-oriented languages (Java, C++), web technologies(HTML/CSS, JavaScript), and data storage (XML) all are placed at the top. This indicates that most programs seek to teach SE students a wide range of concepts and topics to be prepared for the industry.

*2) **RQ2** What technologies are requested by the SE industry?:*
The top three technologies were Java, SQL, and C#. Both Java and C# have a wide range of applications such as desktop and web development. It makes sense that technologies with a wide range of use cases end up in a lot of companies' tech stacks. The third most requested skill was SQL, and this highlight the fact that databases are a fundamental part of SE, and SQL seems to be the industry standard. The report by SAERG and SHEA [6] showed Java, JavaScript, SQL, C# and .NET were the topmost requested technologies for the period 2018-2020. This is like what was found in this study for the period of 2021-04-01 to 2022-03-31 where the top technologies were Java, SQL, C#, JavaScript, and Python. Most of the highest in-demand technologies have all been around for more than 20 years, some much longer, and this might affect how widely used the technologies are. The benefits are that it will be more widespread, easier to hire talent, easier to get support and it might also have been a part of the company's tech stack for some time, creating a technical debt that might cost more than what can be gained by replacing it.

*3) **RQ2.1** What technologies are seeing an increase in demand?:*
As noted in the results section all measured technologies saw an increase in the number of job posts listing it as a desired skill. But looking at the trends in relation to the increase in the overall SE job posts the top five technologies, Java, C#, SQL, and JavaScript, with the exception of Python saw a decreasing trend for the period 2016-2021. It might be that the acceleration of technologies like Python, TypeScript, Angular, and Node.js is taking over some use cases, but further research would be needed to draw any conclusions. The two technologies that saw the most uptrend during the period were both container technologies, Docker, and Kubernetes. Comparing technologies predicted to increase in demand by Swedish IT & Telecom Industries [2] the most increase in technology skill needs were JavaScript, C#/NET, HTML5/CSS, Java, and Android. However, their findings only account for the increase in percentage per technology and did not consider the actual number of job posts. As the results of this study show, Android is ranked as the 17th most demanded tech with only 452 job postings, in the second half of 2021, compared to Python which ranked fifth for the same period with 2307 job posts. This shows the benefit of the method used in this thesis since it takes more data into account.

Looking at the total amount of SE job posts collected through the period 2016-2021 a huge increase in jobs can be observed starting in 2021. This could partly correspond to the growth predictions made in the industry report by the Swedish IT & Telecom Industries [2]. However, the Covid-19 outbreak has probably been the main catalyst in accelerating the growth due to the increased digitization following the social distancing rules imposed during the pandemic.

*4) **RQ3** What program and course improvements could be made to align them with industry needs?:*
Just looking at Figure 12 and comparing the supply and

demand of technological skills is not enough to draw any conclusions when making changes to educational syllabuses. As discussed in RQ1 the educational program's goal of teaching concepts rather than technologies must be considered firsthand to teach SE students the necessary skills. However, some interesting findings deserve to be highlighted. C# is the third most requested skill in the industry (21.1%) but only taught at two SE programs (11.8%) compared to Java which was most in-demand (26.3%) and taught at 13 SE programs (76.5%). Here there is room for improvements in the educational programs to help supply the demand from the industry. Also, the increased usage of container technologies in the industry suggests that it also could be an area of improvement since Kubernetes is only included in one SE program. Some of the lesser taught technologies were even less in demand by the industry such as LISP, F#, Erlang, and Hadoop to name a few. Educational programs might consider replacing them. TypeScript was a technology seeing both an increase in demand and ranked 13th highest in demand in the industry but was not taught at any SE program.

B. Overall discussion

Even if the educational program's primary goal is to teach a broader range of concepts and topics, it does not exclude the benefits of carefully considering what technology to use. As a part of Bodell's study, the industry's perspective on the gap concluded that a lot of what new hires need to know they learn on the job. Knowing the right technology from the start will benefit both the new hire as well as the company since the employee will take less time to become productive and be under less pressure in the early stages of their new job.

C. Threats to validity

The technique of comparing supply and demand between SE educational programs and job postings suffered from some limitations due to the consideration education needs to take when designing syllabuses for a program.

The job posts gathered do not take into consideration that recruiters might not be familiar with the classifications made by the CC2020. As discussed in the backgrounds section there is confusion regarding terminology both in Swedish education and the software industry. This might create instances where a SE position might be within embedded systems requiring knowledge of electronics that more relates to the CE field, or a software engineer position working with machine learning being more related to a CS degree. This is also a concern when looking at what major an educational program has since the Swedish educational system does not rely on the definition from The Computing Curricula 2020 [14]. This might create the issues that not all relevant educational programs have been collected in this study.

The technique used to perform text analysis with keywords might not be able to catch all edge cases since it does not take into consideration any spelling errors that might creep into a job post. This is however somewhat mitigated in that texts might repeat keywords several times and it only takes one correct match for a job post to count. There might be other cases that have not been considered by the author.

The thesis only looked at education from universities and colleges and some of the highlighted technology needs might be full filled by other types of higher education.

D. Social and Ethical aspects

JMAR has been created with the intent to conduct research by collecting publicly available job posts and running text analysis on its content. The source code is publicly available for anyone to recreate the research. Hopefully, the tool can aid similar research, in other fields, to analyse job posts and highlight any knowledge gaps. Going from a student to a professional can be stressful especially if knowledge gaps exist. Closing such gaps could help decrease stress and in the long run, provide benefits to the well-being of newly graduates just starting their careers. The results of this study do not pose any ethical dilemmas, it only looks to improve upon any existing knowledge gaps between SE education and industry.

VIII. Conclusions

In this study, the author used a method of collecting job posts and educational syllabuses to measure any technical skill gap between Swedish SE education and the software industry. The result showed that the most requested technological skills by the industry were supplied by education. C# is the exception since it was the third most sought-after skill but only taught at two of the educational programs included in this study. Other technologies such as TypeScript, Kubernetes, and Docker saw an increase in demand but were not taught at many SE programs. It was also concluded that the method of simply analysing the supply and demand of skills to compare the SE education and industry was not sufficient to conclude any changes needed in the syllabus. The perspective and goals of the educational programs also needed to be considered.

Future work might consider using job posts to analyse any existing knowledge gaps in other types of SE skills such as soft skills or investigate if general programming concepts could be represented better in SE job posts. JMAR could serve as a starting point for further development of the method used in this thesis.

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Appendix 1: Time Plan

TABLE VI: Initial plan

Activity/week	1	2	3	4	5	6	7	8	9	10	11
Research and planning											
Write introduction, purpose and contributions											
Write background and related work											
Collecting syllabuses and job posts											
Coding artifact and measure results											
Write results, discussion and conclusions											
Prepare and submit video presentation											
Finalize and submit thesis											

TABLE VII: Actual plan

Activity/week	1	2	3	4	5	6	7	8	9	10	11
Research and planning											
Write introduction, purpose and contributions											
Write background and related work											
Collecting syllabuses and job posts											
Coding artifact and measure results											
Write results, discussion and conclusions											
Prepare and submit video presentation											
Finalize and submit thesis											