The Role of Software in Computer Science Majors' Career Choice

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Abstract
The shortage of highly-skilled ICT (information and communications technology) workers remains a serious and global concern. This paper reports on how to attract more computer science majors to job fields within ICT that are especially critical to economic growth, rather than how to solve the overall shortage. A qualitative preliminary study found that certain software-related aspects might play an important role when picking a job field. In order to generalize and validate these findings an online survey based on the Social Cognitive Career Theory was conducted. The data were analyzed and show that the software used in a prospective job does in fact have a positive influence on computer science majors' career choice when a technical usage of the software is pursued. A direct correlation exists between usage frequency of a software product and the willingness to take on a job in which the software is used. A modern user interface is an advantage when attracting computer science majors to specific job fields but other characteristics such as good functionalities and ease of learning seem to affect career choice much more. Further research will be required to determine which characteristics of a software are decisive.

Keywords: Career Choice, Role of Software, Usage Frequency, UI Design, Computer Science Majors, Information Technology, Career Decision Making, Factors, Influences, ICT Students, Student Attitudes, Survey, Social Cognitive Career Theory, SCCT

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Introduction

Many countries in the world, like Canada, China, Germany, India, Indonesia, Singapore and Thailand, currently face a shortage of highly-skilled workers in the field of information and communications technology (ICT). As digital technologies are further integrated into sectors across our economies, a process commonly known as "digitalization", the demand increases even more. There are several approaches to closing the skill gap in the ICT field, e. g. strengthening lifelong learning, offering work-based learning for students (dual course of studies) and developing gender equality schemes (Goel, 2020). These approaches and related research focus on how to increase the number of skilled workers in the ICT field in general in order to eliminate the shortage on the long run.

The focus of this research project is different in so far as it analyzes computer science majors' motivation to choose one ICT field over another. Understanding the causalities might not solve the overall skill shortage but can help attract more students to ICT fields that are critical to economic growth in the short term. To mention just one example: an aging workforce combined with offshoring in the mid-2000s currently leads to a significant shortage of experienced SAP experts. Skilled experts are crucial for the migration from SAPs enterprise resource planning system "ECC", which is the backbone of many mid- and large-sized companies, to its successor product "S/4HANA" until the end of the vendor's support deadline in 2025 (Prior, 2019).

A qualitative preliminary study conducted by the author suggests that certain software-related aspects may attract computer science majors to specific ICT fields. The purpose of this study is to first validate the correlation between software and career choice in general:
H1. The software that is used in a prospective job has a positive influence on computer science majors' decision to persue a career in the software's ecosystem.

In addition, the study's aim is to validate two generalized key findings of the preliminary study:
H2. The more contact with a software computer science majors have, the more likely they will persue a career in the software's ecosystem in the future.
H3. If a software has a modern user interface, more computer science majors will persue a career in the software's ecosystem.

In order to validate the hypothesis quantitative methods are applied. The research question is:

Do usage frequency and the user interface design of a software positively affect computer science majors' decision to persue a career in the software's ecosystem?

Related Work

Understanding Skill Shortage in ICT at a Granular Level

The shortage of highly-skilled ICT workers and its current and prospective negative impact on economical growth is a key driver for scientific research. A lot of the recent studies aim towards identifying the factors that determine whether or not scholars will pick an ICT-related education or decide to persue careers in information technology. Understanding the decisive factors is crucial for the derivation of appropriate measures to be taken to encourage scholars to start an ICT career in their future lifes. Typical research questions are:

- Who influenced a child's career choice? (Calitz, 2013)
- Did parents and teachers encourage their children to pursue careers in ICT? (Calitz, 2013)
- Which factors have the most influence on a student's choice to pursue ICT-related programs at university or college? (Ron et al, 2010)
- What motivates women (Hyrynsalmi et al, 2020) or minorities (KumarDas et al, 2019) to work in the ICT industry?

All of this research contributes to answering the question: what leads to the approval or rejection of an ICT-career in general? Few studies differentiate between specific working fields within information technology and the distinction is drawn on very abstract levels, e. g. the hierarchy level of the persued job or a generic job title (McKenzie et al, 2017).

Skill-shortage is not equally distributed among different ICT job profiles. In Germany, for example, there is a lack of IT-application consultants, software developers and electrical technicians whereas in Canada job positions for database administrators, IT support specialists, machine learning engineers and data scientists are difficult to fill. These differences illustrate the importance of understanding the shortage of talent at a more detailed level (Goel, 2020).

While some of the skill shortage in jobs related to emerging technologies like artificial intelligence (machine learning engineer, data scientist) can be attributed to the novelty of these job profiles, the explanation does not make sense for traditional jobs including database administrators and IT support specialists. This points to the possibility that additional factors at a granular level might play a role if specific jobs or jobs from a certain working field are rejected.

The qualitative preliminary study was conducted in order to identify those additional factors.

Preliminary Study: Computer Science Majors' Attitude Towards SAP Careers

The qualitative preliminary study investigated computer science majors' attitude towards SAP careers. The study focused exemplarily on the SAP ecosystem, because a broad variety of traditional job profiles is affected by skill shortage in this field, e. g. consultants, developers and project managers (Prior, 2019).

Three individual interviews were conducted with master's degree students of the University of Applied Sciences Wuerzburg-Schweinfurt with the field manual being based on SCCT (see next chapter). The interviews were recorded, transcripted and evaluated. The evaluation resulted in the following two findings that were derived from statements in the interview:

1. The more contact with SAP systems computer science majors have, the more likely they will persue a SAP career in the future.

A study among American teenage girls has examined how joining a computer science camp and receiving computer related trainings such as programming tutorials raised their motivation for pursuing a computer science related career (Hur et al, 2017). The results indicate a positive correlation between contact with computer science topics in general and the effect on career choice but did not show a direct correlation between the usage of a specific software and the willingness to start a career in the respective software ecosystem.

2. If SAP systems had a more modern user interface, more computer science majors would persue a SAP career.

According to a current research paper there is still a gap between user expectations and the quality of implementation of ERP user interfaces which correlates negatively with end users acceptance (Lambeck und Leyh, 2016). But the corresponding research neither considers the impact on expert users like computer science majors nor does it analyze if the acceptance issues correlate negatively with career choice.

The two software ecosystem-specific findings form the basis for further research reported in this paper.

Social Cognitive Career Theory

In the preliminary study Lent, Brown, and Hackett's social cognitive career theory (SCCT) (Lent et al, 1994), which has primarily been derived from Bandura's general social cognitive theory (Bandura, 1986), was applied. SCCT also serves as a theoretical model for this paper for the following reasons:

- Although developed in 1994 the SCCT is still a very prevalent theory and often cited in current academic career choice literature and research papers.
- Unless many other models such as Holland's Hexagon model (1997), SCCT does not focus on character-related aspects. An analysis of character traits may be helpful for the explanation of career choices on a general level, e. g. "rational thinking people prefer jobs in physics", but is less appropriate for a finer distinction of the motivations to pick specific working fields and jobs within ICT.

SCCT describes how learning experiences, influenced by personal factors (e. g. predispositions) and contextual factors (e. g. constraining or encouraging social support system), affect self-efficacy and outcome expectations. Both impact the formation of career-relevant interests and the setting of goals that eventually trigger career-related actions such as choosing a certain job.

According to SCCT learning experience is gained by:

- being exposed to activities of career relevance, e. g. an internship (personal experience)
- observing others or hearing about others performing various occupational tasks (image)

Personal experiences can form outcome expectations indirectly by (1) affecting self-efficacy; (2) the subjective perception of self-efficacy is assessed and leads to an adjustment of the outcome expectations. As an example, imagine a teenager trying to autodidactically learn a computer programming language. The experience of either success or failure (1) suggests whether to persue a job as a computer programmer in the future or not (2).

Personal experiences can also have a direct effect on outcome expectations when they depend on personal preferences rather than on (perceived) capabilities. An unappealing work environment, for instance, might lead to the rejection of a job regardless of the required skills.

The image of a job affects outcome expectations directly. As shown in the findings of Hellberg (2009) when forming output expectations a prospective jobs' image is compared with expectations towards an ideal job. An incongruity leads to a rejection of the prospective job–a corrective effect on outcome expectations.

Although mentioning both types of learning experiences, the image and personal experiences, SCCT does not put emphasis on a distinction. In the context of this research a clear distinction will be necessary because it contributes to a better understanding of whether actual or perceived software-related aspects influence career choice (Fig. 1).

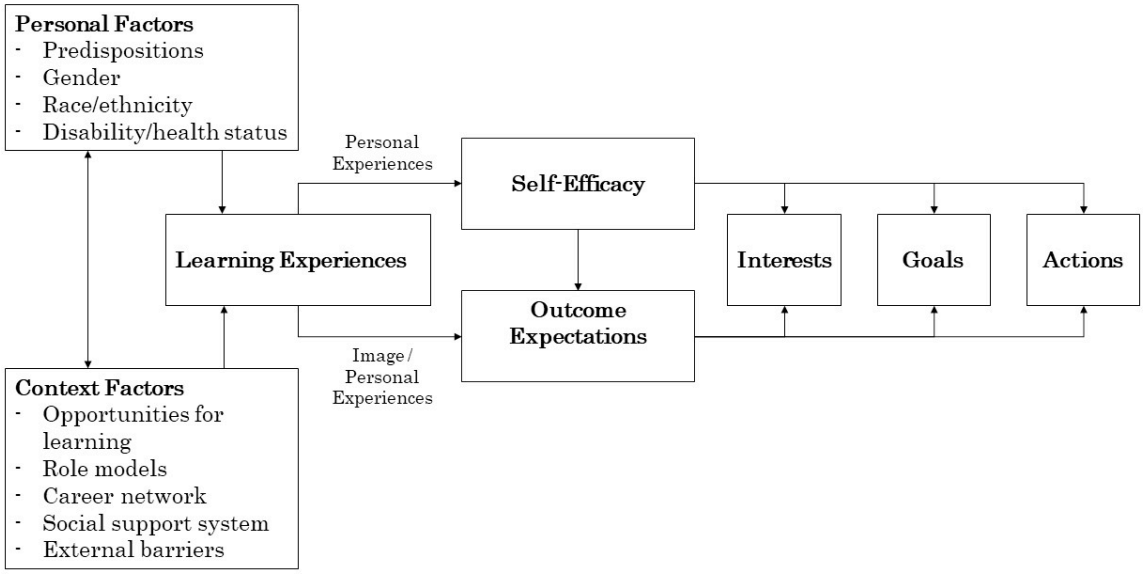

Figure 1: Social cognitive career theory (SCCT): Own representation based on Lent et al (1994) and Hellberg (2009).

Methods

Research Approach

In the qualitative preliminary study the findings were inductively derived from interviews with computer science majors based on SCCT. This complementary study focuses on a deductive generalization and validation of theses findings. The primary research approach was an online survey which was analysed quantitatively.

Sampling

The responses of the survey were anonymous with a total of n = 51 participants. They can be assigned to three participant groups the study was promoted amongst:

1. 18 master students of the studying course Information Systems, University of Applied Sciences Wuerzburg-Schweinfurt
2. 30 bachelor students of the studying course e-Commerce, University of Applied Sciences Wuerzburg-Schweinfurt
3. 3 students of diverse computer science major studying courses, diverse universities

An ideal sample would exhibit a balanced ratio of different computer science major studying courses. The large number of students in the sample who were enrolled in the studying course e-Commerce is therefore clearly relevant to the discussion that follows as it is an apparent bias. In contrast, the large number of master students in Information Systems can be neglected because students enrolled in the studying course have different backgrounds including educations and careers in informatics, business informatics and e-commerce. The produced bias is therefore low.

As shown in figure 2 the age of the participants shows no gross deviation from the expected Gaussian normal distribution with a mean at the approximate age of 23 (female) and 24 (male). Females were underrepresented in the survey, a fact that can be attributed to a general underrepresentation of females in science and technology (Stoet and Geary, 2018).

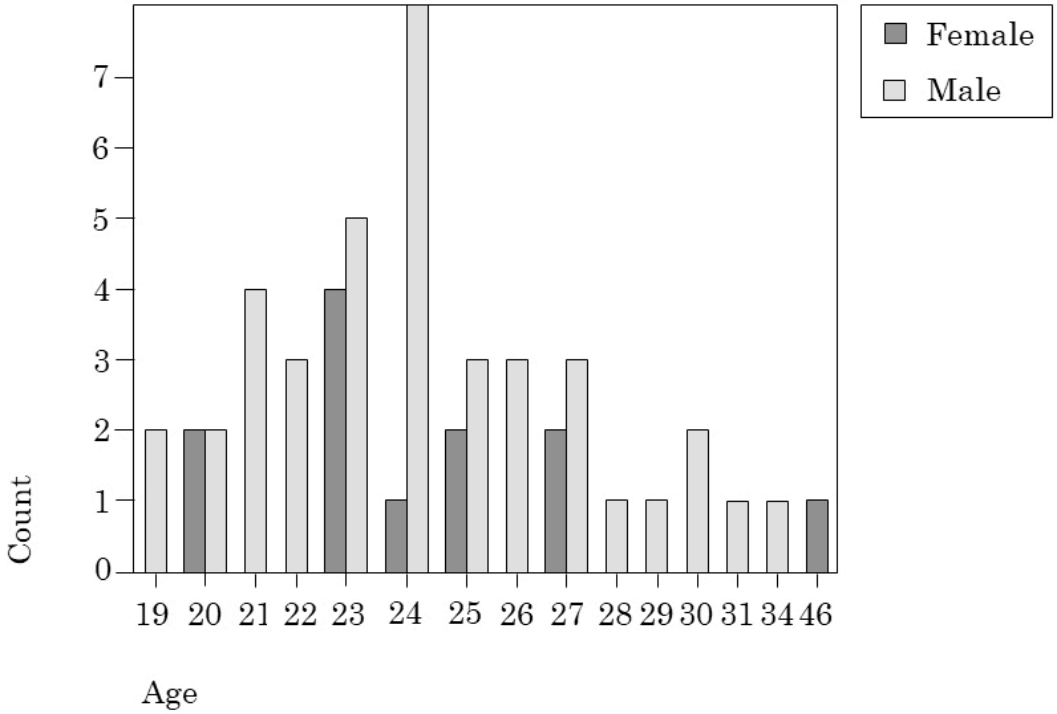

Figure 2: Survey Participant's Age and Gender

Study Design and Measurements

The survey was conducted online using the student's survey platform empirio.de. Participants were invited to take part in the survey via instant messaging (participant group 1) or personally (group 2). Group 3 joined on their own initiative. The data for the survey were collected between November 6, 2020 and November 11, 2020.

The survey's questionnaire was designed in order to directly or indirectly measure variables derived from SCCT and related to the hypothesis respectively.

Participants were first requested to name a software they would favor to use in a prospective job. Naming a specific favored product helped creating a mental picture that participants could refer to when answering subsequent questions.

Both software usage frequency and a modern user interface do not necessarily impact career choices as long as software in general is not considered as a decisive factor in career choice processes. The participants were therefore asked to rank the perceived overall importance of software regarding a prospective job on a Likert scale from 1 (not important) to 5 (very important). The ranking was used as an indirect measure for the variable "influence of a software's perceived importance on career choice". The more important software is ranked, the higher the influence.

The participants were asked to rate the desirability of different ways of using their favored software in a prospective job, e. g. "I could imagine to implement/install the software". For the rating a Likert scale from 1 (disagree) to 5 (strongly agree) was provided. The answers allowed a more detailed analysis of the correlation between favored software usage–which stands for the pursued job field–and the perceived importance of software. The variable "software usage frequency" refers to the favored software product and had to be ranked on a Likert scale ranging from 1 (hardly or never used) to 5 (used very often). The ranking was used to determine the number of personal learning experiences. According to SCCT, learning experiences affect selfefficacy (proficiency in working with the software), the outcome expectation (own proficiency level is [not] appropriate to professionally work with the software) and the goal-setting (choose/reject professions in the software's ecosystem).

In order to measure the influence of a modern user interface the participants were given a set of different reasons why they had chosen their favored software. Besides "modern user interface" alternative options such as "good functionalities and interfaces", "quick and easy to learn" and "software vendor is likeable" were provided. The alternative options were not derived from the preliminary study but only placed for distraction. Each option was to be ranked on a Likert scale between 1 (disagree) to 5 (strongly agree).

An additional filtering question "Have you ever worked with the favored software?" was placed to distinguish between personal learning experiences and the mere image of a software product. If the question was answered with "no" the related record was not considered when calculating the variable "modern user interface's contribution to picking favored software". The filtering ensured that only personal experiences were considered rather than biased rankings based on distorted images participants might have of a software.

Analysis

All analysis were performed using the statistics tool PSPP. For significance evaluation a onesample student's t-test was used with X being the sample mean, μ_0 the population mean, s_D the sample standard deviation and n the number of observations (equal to the number of participants):

$$t = \frac{\bar{X} - \mu_0}{\frac{s_D}{\sqrt{n}}}$$

For correlation tests between ordinal variables the Spearman's correlation coefficient was applied.

Results

Perceived Importance of Software in Career Choice

A well-balanced ratio between participants favored software products to work with in a prospective jobs was found (Figure 3). Three software products were stated more often: Wordpress (17.6 %; n = 9), Linux (13.7 %; n = 7) and SAP (9.8 %; n = 5). Other software product namings were in the lower single-digit percentage range.

Figure 3: Favored Software Product Computer Science Majors Could Imagine to Work with in a Prospective Job

The perceived importance of a software to be used in a prospective job was rated with a mean score of $X = 3.43$ and a standard deviation of $s_D = 1.17$. The result of the one-sample t-test ($\mu_0 = 3$; $n = 51$; $df = 50$) gave a t-value of 2.62, p-value of 0.0058 and significance level at $\alpha = 0.010$. These results indicate a high statistical significance.

The correlation between the favored usage of software–as an equivalent to the pursued job field–and the perceived importance of software in career choice was measured (Table 1). The results indicate a very weak ("implement/install" and "program") to weak ("administrate/configure" and "support/offer consulting for") positive correlation regarding the more technical usages and a weak negative correlation regarding other ways of usage which includes the use of a software as an end user.

Favored usage: I could imagine to ... a specific software in my job	Avg. rating[a]	$s_D\pm$	Correlation between favored usage and perceived importance of software r_s[b]
implement/install	3.76	1.38	0.12
administrate/configure	3.43	1.28	0.34
program	2.75	1.48	0.13
support/offer consulting for	3.25	1.51	0.35
use in another way	4.43	0.81	-0.27

[a] Participant rating from 1 (disagree) to 5 (strongly agree)
[b] Spearman's correlation coefficient

Table 1: Computer Science Majors Favored Software Usage and Correlation between Favored Usage and Perceived Overall Importance of the Software Used in a Prospective Job

Influence of Software Usage Frequency on Career Choice

The usage frequency of the participant's favored software to be used in a prospective job was rated with a mean score of $X = 3.33$. The standard deviation was $s_D = 1.41$ and the result of the one-sample t-test ($\mu_0 = 3$; $n = 51$; $df = 50$) gave a t-value of 1.69, p-value of 0.0485 and significance level at $\alpha = 0.050$. The result indicates a statistical significance.

Influence of Modern User Interface on Career Choice

Participants of the survey were required to rate different reasons for choosing their favored software including "it has a modern user interface" and further options placed for distraction. For every option a one-sample student's t-test was conducted (Table 2).

The analysis was conducted with only $n = 44$ of the total number of $n = 51$ records. $n = 7$ records were discarded in this analysis in order to consider only answers which were based on actual experience with the software.

The t-test indicates a statistical significance for the reason "it has a modern user interface" and a high statistical significance for "it has good functionalities and interfaces", "it is innovative", "it is quick and easy to learn" and "it is easy to find a job in the software's ecosystem".

Favored software: I picked this software product, because ...	Avg. rating[a]	$s_D\pm$	t[b]	p[b]	α[c]
it has good functionalities and interfaces	4.27	0.76	11.08	<0.0000	<0.000
it is innovative	3.34	0.96	2.35	0.0117	0.025
it has a modern user interface	3.36	1.26	1.90	0.0324	0.050
the software vendor is likeable	2.77	1.29	-1.18	-0.1217	-0.125
it is quick and easy to learn	3.66	1.24	3.53	0.0005	0.001
it is easy to find a job in the software's ecosystem	3.61	1.06	3.82	0.0002	0.001
of other reasons	3.23	1.26	1.21	0.1163	0.125

[a] Participant rating from 1 (disagree) to 5 (strongly agree)
[b] One-sample t-test conducted with $\mu_0 = 3$, $df = 43$ and $n = 44$
$n = 7$ records of the original $n = 51$ (cases in which participant has stated to never have personally used the favored software) were discarded in this analysis
[c] Significance level according to t-test

Table 2: Reasons for Picking a Favored Software in the Survey: Computer Science Majors' Ratings and Statistical Significance.

Discussion

Perceived Importance of Software in Career Choice

H1. The software that is used in a prospective job has a positive influence on computer science majors' decision to persue a career in the software's ecosystem.

It was found that computer science majors generally consider the software used in a prospective job as very important in career choice. The null hypothesis is therefore rejected, hypothesis H1 is accepted.

The well-balanced ratio of software stated as favored by the participants shows that the findings are independent of a specific software product. Only software that is very dominant in certain job fields was mentioned more often: Wordpress (web design and development), Linux (server operation) and SAP (business software). The result was to be expected as higher popularity of a software leads to a higher probability the software is mentioned in the survey.

The data suggest that there are differences between the perceived importance depending on the way the software is used. Technical usages such as implementation, administration and programming show a weak correlation with the perceived importance of software whereas "use in another way"–a category that includes rare technical ways of usage but especially the use as an end user–correlates even negatively. This could be a hint that computer science majors consider the software product being less important when they pursue rare technical ways of usage in their job or the use as an end user. Further research will be needed in order to have a distinct result.

The question "Overall, how important do you consider the software to work with in a prospective job?" was placed at the end of the questionnaire. The intention behind it was to first let participants reflect on a variety of aspects of software. All of them could be considered by the participants when answering the final question rather than rating the overall experience based on just one or two aspects that come to their mind quickly when being asked the question at the begin of the survey.

At the same time, answering the question after having already answered a lot of software-related questions before tends to result in a subjective overestimation of the importance of software–an effect commonly known as "priming" (Bargh et al, 1996). Placing the question at the end of the questionnaire is therefore a tradeoff between receiving a well-founded answer biased by priming effects on the one hand and receiving an unthinkingly answer on the other hand. As the biased results show a high significance it can be expected that the unbiased result would still be significant, only to a lower extend.

Influence of Software Usage Frequency on Career Choice

H2. The more contact with a software computer science majors have, the more likely they will persue a career in the software's ecosystem in the future.

The survey has shown that computer science majors favor software in a prospective job that they have frequently used before. Combined with the finding that software plays an important role in career choice (H1) it can be postulated that more contact with a specific software leads to a higher probability that a job in the software's ecosystem will be taken on. The null hypothesis is therefore rejected, hypothesis H2 is accepted.

The credibility of this finding is supported by the fact that only $n = 7$ of a total of $n = 51$ survey participants answered the question "Have you ever worked with the favored software?" with "no". It also appears counterintuitive to consider software in general as very

important in terms of career choice but still choose a job no matter if the software used in the job has ever been tried out before.

There is a lack of information if participant's perception and behaviour are consistent, i. e. if they will actually choose a job depending on their experience with a software product or if this aspect is neglected when making a real decision lateron. A long-term study conducted before and after selecting a job could contribute to a better understanding whether expectations and actions always match.

Influence of Modern User Interface on Career Choice

H3. If a software has a modern user interface, more computer science majors will persue a career in the software's ecosystem.

It can be derived from the data of the survey that participants put significant emphasis on a modern user interface when picking their favorite software used in a prospective job. Considering that software plays an important role in computer science majors career choice (H1) it can be assumed that the modern user interface of a favored software affects career choice as well. The null hypothesis is therefore rejected, hypothesis H3 is accepted.

Obviously, other possible reasons for picking a favorite software, which were only placed in the survey for distraction, seem to play a more significant role than the user interface. While "it has a modern user interface" was rated as being important with a significance level at only $\alpha = 0.050$, "it is innovative" was rated with a higher significance of $\alpha = 0.025$. Other reasons were even highly statistically significant, e. g. "it is quick and easy to learn" and "it is easy to find a job in the software's ecosystem" ($\alpha = 0.001$); "it has good functionalities" ($\alpha < 0.001$).

These findings raise further questions that should be answered by additional research. Especially the fact that many participants gave a high ranking to the reason "it is easy to find a job in the software's ecosystem" seems contradictory. If staff shortage in a specific job was a decisive factor in career choice then the ICT job market should be completely self-regulating.

It also has to be considered that students of the studying course e-Commerce were overrepresented in the study with a total number of $n = 30$–more than half of the participants. Students from design-oriented studying courses might tend to emphasize visual aspects much more than students from other computer science major studying courses. Taking this strong bias into account, a modern user interface could therefore still play a role in career choice but to a lower extend than the data suggest.

Conclusion

This study has shown that software plays an important role in computer science majors' career choice when a technical usage in the job is pursued. Software products are not only the core of everyday business in ICT jobs, they are already very dominant in university education where they have a strong impact on students' learning experiences. These learning experiences form computer science majors' picture of a prospective job where the software is used. It is plausible that the quality of the experiences is a decisive factor when students–later in life–actually choose to take on a job or reject it.

Understanding the importance of software can help employers to prevent ICT shortage in their companies by picking products that are popular among computer science majors and skilled ICT workers. When choosing a software product, companies often focus on the end user acceptance and disregard the needs of qualified staff that is necessary to operate, maintain and program the application. This eventually results in a lack of qualified staff, vacant ICT jobs, long-winded recruiting processes and–in the worst case–the necessity to postpone projects important to growth.

It was found in the study that a high usage frequency of a software will increase computer science majors' willingness to pick a job in the software's ecosystem. In principle, this finding is already well-known as "force of habit" but the knowledge is not yet consequently applied. Some software vendors do already cooperate with universities and offer discounts for their products. But being even more present, e. g. by actively offering more free-of-charge tutorials for students, would further increase the number of learning experiences and as a consequence positively affect career choice.

The data of the study suggest–with a low confidence–that a modern user interface could be an advantage when attracting computer science majors to specific job fields. But other characteristics such as good functionalities and ease of learning seem to have much more impact on career choice. Some further research will be needed in order to validate these findings and understand which characteristics of a software other than the user interface computer science majors put emphasis on.

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