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Software Engineering Students, Soft and Hard Skills Got through a University Software Company

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Abstract. This paper shows quantitative research regarding knowledge, soft & hard skills, and experience acquired by students hired by a University Software Development Company (USDC). Additionally, suggestions regarding how to set up a USDC in an academic environment, facing real customers, are shown. There have been good and bad experiences, both will be presented in this paper. Furthermore, students' perceptions will be discussed. To identify students' perceptions a questionnaire (survey) was applied. Its reliability was calculated through Cronbach's alpha coefficient (α =.89). Additionally, the Pearson correlation coefficient was calculated (r) in order to identify questions that should be deleted to increase the questionnaire's reliability. Outcomes could be useful when a software engineering faculty wishes to set up a USDC.

Keywords: software engineering students; soft skills; hard skills; student perceptions.

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Личностные и технические навыки студентов-программистов, полученные в университетской компании по разработке программного обеспечения

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Аннотация. В представленной статье описываются количественные исследования, касающиеся знаний, личностных и технических навыков и опыта, приобретенного студентами, нанятыми университетской компанией по разработке программного обеспечения (USDC). Показаны предложения по созданию компаний USDC в академической среде, работающих с реальными клиентами. В статье представлен ранее приобретенный опыт, как положительный, так и отрицательный. Описывается также восприятие сотрудничества с подобными компаниями учащимися. Для выявления восприятия учащихся был применен опрос и анкетирование участников. Надежность эксперимента вычислялась через альфа-коэффициент Кронбаха (α = .89). Кроме того, чтобы повысить надежность опроса и определить вопросы, которые лучше из него удалить, был рассчитан коэффициент корреляции Пирсона (r). Результаты могут быть полезны, если образовательная организация, ведущая обучения методам разработки программного обеспечения хочет создать USDC.

Ключевые слова: студенты программистских специальностей; личностные навыки; технические навыки; восприятие учащихся.

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1. Introduction

Software system development requires a set of knowledge, hard & soft skills, experience, and values [1-2]. Traditionally, software Engineering (SE) theory and values are acquired at Universities. Experience and skills (reinforcement) are acquired through real developments. Nowadays, universities and industries follow different strategies to help students gain SE skills and professional experience. Among others,

i) Students' mobility from academia to industry [3],
ii) Internships [4],
iii) Cooperative Education (Co-Op) programs [5],
iv) Capstone projects [6],
v) Open Source contributions [7].

Additionally, there are some efforts like,

a) Companies spend resources to train new personnel, who are not ready for different SE roles [8],
b) Industry and Academic Collaboration programs,
c) Workshops and panels organized in research conferences [9],

d) Industry proposing a set of real challenges to be solved by students (hackathons).

SE teaching should be more practical than theoretical. SE programs would need a USDC (University Software Development Company) to carry out R&D activities.

It is recommendable to look for strategies to increase students' professional hard & soft skills before they finish their professional careers. In this sense, a USDC (Luminisoft) was created, more than ten years ago, at the Information and Communication Technology Faculty (ICTF) at the UPAEP, a university in México. This paper shows outcomes related to students' perception regarding LuminiSoft, and gives some advice to universities interested in replicating this model.

The paper is structured as follows. Section 2 provides a research background. Section 3 describes the research methodology. Section 4 presents the results of the study. In section 5, the results are discussed in more detail. Section 6 summarizes the key findings obtained. Finally, section 7 outlines areas for future work.

2. Research background

SE Education plays an important role in keeping students updated with software technologies, processes, and practices, unfortunately, some authors [10] point out gaps between Industry and Education [11]. A good way to understand some topics is by working in a practical way, or "learning by doing" [12].

There are a few interesting cases of this approach. For example, [13] describes using agile practices on a large-scale project. In addition, the University of Sheffield has a module, Genesys Solutions, where the students run their own software company [14].

In [15], try exposing SE students to the latest industry practice and research with an industry-academia team teaching a course. In [16], students create a consulting company where they work with a corporate sponsor on a project.

For undergraduate students, to teach proper SE they developed a "mock software company" to create a microcosm and teach real lessons about SE [17].

3. Research methodology

An online questionnaire (survey) was applied. The questionnaire was based on CLEI (Computer Laboratory Environment Inventory), and ACCC (Attitude towards Computing and Computing Courses Questionnaire) tools.

Table 1. Characteristics of SE education approaches

Paper	Business Environment	Active Learning	Practical Experience	Focus on Real-world Competencies	Emphasis on Teamwork
[8]	✓ (working with corporate sponsor)	✓	✓	✓	✓
[9]	✓ (simulated)	✓	✓	✓	✓
[7]	✓	✓	✓	✓	-
[5]	✓ (simulated)	✓	✓	-	-
[6]	✓ (students run own company)	✓	✓	✓	-

3.1 Motivation

Some research questions arise: RQ1. What kind of skills can be acquired by students when they participate in a university software development company? RQ2. What are the main aspects to consider when a university software development company will be set in a university program?

RQ3. What are the main aspects to consider when students are hired at a university software development company? and RQ4. What kind of events were meaningful to increase students' experience?

3.2 Methodology

The methodology was based on a voluntary online survey applied to students who have been hired by USDC from 2010 to 2022. The survey instrument was divided into two sections to provide quantitative and qualitative data. The first section gathered demographic questions. The second section was based on CLEI [19] Scales: Cohesiveness (C), Open-mindedness (OM), Integration (I), Technology adequacy (TA), and Facility Availability (FA).

C. Extent to which students know, help, and are supportive of each other.

OM. The extent to which the USDC activities encourage an open-minded approach to the use of computers and troubleshooting.

I. The extent to which the USDC activities encourage learning new technologies in addition to the theory learned in classes.

TA. The extent to which the hardware and software are adequate for the tasks required.

FA. The extent to which the facilities are available for use.

Additionally, ACCC [20] scales were taken into account: Anxiety (A), Usefulness of computers (UC), and Usefulness of the USDC.

Anxiety.The extent to which the student feels comfortable or has experience using computers, software, development framework, and so on.

The usefulness of computers. The extent to which the students believe computers are useful.

The usefulness of the USDC. The extent to which the students found the USDC useful.

This section measured students' perception of participating in USDC. The variables were measured using a five-point Likert scale ranging from 1 to 5, (strongly disagree to strongly agree, respectively).

Attitudes, skills, and students' experiences were identified. Independent and dependent variables were defined.

Independent variable

1. Gender,
2. Career,
3. How long were you working at LuminiSoft?

The dependent variable, some of them are shown:

1. I have enough skills to use computers
2. I have enough skills to learn new software development frameworks

...

7. I have enough skills to use CASE tools*
8. My experience as a team member improved

…

19. When technology is new, Luminisoft pays for the time required to learn the new technology*

…..

21. LuminiSoft is a complement to academic preparation in order to increase professional experience.

(* these questions were deleted in order to increase questionnaire reliability)

3.3 Instrument

For this research study, a questionnaire was designed for analyzing students' attitudes, skills, and experience, among other constructors.

3.4 Data Collection and Analysis.

Data for developing this research were collected from students who signed a contract.

This research collected data from 36.66% of hired students. A sample of 11 students was collected. The results were significant because they show a high correlation, α = 0.917. The participants completed the questionnaire through google forms.

4. Results

First of all, the internal consistency of the questionnaire was assessed through Cronbach's alpha coefficient. The questionnaire was composed of 21 questions.

The Cronbach's alpha was computed. It was α = 0.87. After that, Questions: Q7, and Q19 were removed because of the Pearson correlation coefficient results, see Table 2.

Table 2. Lower Mean

Questions	Mean	Std. Dev.	K
Q1. I have enough skills to use computers	4.7	0.516	6
Q7. I have enough skills to use CASE tool	3.8	0.752	6
Q9. I like to share my knowledge with others at LuminiSoft	4.5	0.547	6
Q10. I should have to learn new technologies at LuminiSoft	4.5	0.836	6
Q19. When it was necessary, LiminiSoft paid the required time to learn new technologies	3.7	1.211	6

Table 3 shows the correlation matrix. When question 7 was analyzed, low correlations were identified, indeed some of them were negative. Hence, question Q7 and Q19 were removed.

After this action, the Cronbach's alpha coefficient increases from 0.87 to α =0.89, see Fig. 1.

Table 3. Pearson correlation Matrix

Qs	1		3	4	5	6	7	...	21
1	1	0.67082	0.751779	0.833333	0.67082	0.833333	0.180021	...	0.388889
2	0.67082	1	0.263117	0.559017	1	0.804984	-0.06901	...	0.67082
3	0.751779	0.263117	1	0.86618	0.263117	0.470679	0.015131	...	0.392232
4	0.833333	0.559017	0.86618	1	0.559017	0.816667	-0.03858	...	0.527778
5	0.67082	1	0.263117	0.559017	1	0.804984	-0.06901	...	0.67082
6	0.833333	0.804984	0.470679	0.816667	0.804984	1	0.046291	...	0.466667
7	0.180021	-0.06901	0.015131	-0.03858	-0.06901	0.046291	1	...	-0.10287
...	...	...	...	...	...	...	...	...	...
19	-0.24721	0	-0.43633	-0.43633	0	0	-0.3433	...	0
20	0.240563	0.516398	0.198148	0.288675	0.516398	0.288675	0.111359		0.7698
21	0.388889	0.67082	0.392232	0.527778	0.67082	0.466667	-0.10287		1

5. Discussion

Regarding demographic results, there have been more male participants than female participants, see Fig. 2.

There are more male students than female students enrolled in ICTF. That's the reason for this situation.

Regarding how long hired students remain working at LuminiSoft. Usually, they spend more than one year, see Fig. 3. Hired students receive payment and gain professional experience, hence it is very common that they spend more than one year working as developers at LuminiSoft.

Subject	Q1	Q2	Q3	Q4	Q5	...	Q21
1	4	4	4	3	4	...	4
2	5	5	5	5	5	...	5
3	4	5	3	3	5	...	5
4	5	5	5	5	5	...	5
5	5	5	5	4	5	...	5
6	5	5	5	5	5	...	5
7	5	5	5	5	5	...	5
8	5	5	5	5	5	...	5
9	5	5	4	4	5	...	4
10	5	5	4	4	5	...	5
11	5	5	5	5	5	...	5
Mode	5	5	5	5	5	...	5
Mean	4.8	4.9	4.5	4.4	4.9	...	4.8
Median	5	5	5	5	5	...	5

Cronbach's alpha-->	0.89

Fig. 1. Cronbach's alpha coefficient after some questions were deleted

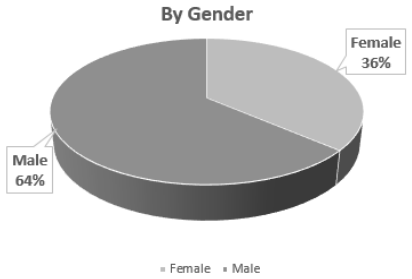

Fig. 2. Developers by gender

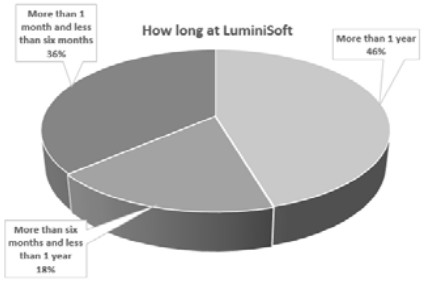

Fig. 3. How long working at LuminiSoft

Regarding attitudes towards computing, developing frameworks, sharing knowledge, hard & soft skills, and experience gained while participants worked at LuminiSoft, research questions were answered. These questions were answered taking into account CLEI and ACCC scales. The next paragraphs describe the outcomes.

The CLEI scales assessed were: C, OM, I, and TA. C, the extent to which hired students by LuminiSoft, help, and are supportive of each other. To answer this question, one question was asked: "I like to share my knowledge with others at LuminSoft". OM is the extent to which the USDC activities encourage an open-minded approach to the use of computers and troubleshooting by themselves. To answer this question, one question was asked: "If there should be a problem to solve in a software system, where I am programming, I will try to solve it". I, the extent to which the USDC activities encourage learning new technologies in addition to the theory learned in classes. To answer this question some questions were asked, one of them: "I should have to learn new development frameworks at LuminiSoft". TA is the extent to which the hardware and software are adequate for the tasks required. To answer this question, one question was asked: "When it is necessary, Luminisoft provides me with technology to develop a software project". FA is the extent to which the facilities and resources are available for use. To answer this question, one question was asked: "Luminisoft provides facilities to develop a software project".

The ACCC scales assessed were: Anxiety, the extent to which the student feels comfortable or has experience using computers, software, development framework, and so on. To answer this question, some questions were asked, one of them being: "I feel comfortable when developing a software System". The usefulness of computers, the extent to which the students believe computers are useful. To answer this question, one question was asked: "I believe software systems and computers are essential in our lives". The usefulness of the USDC, and the extent to which the students found the USDC useful. To answer this question, some questions were asked, one of them: "Participating in LuminiSoft was useful to my professional development".

RQ1, this question was answered by taking into account. ACCC Scales: C, OM, and I. Usually, hired students share knowledge among themselves, mainly tacit knowledge through face-to-face interaction or virtual interaction; additionally, pair programming is applied when junior developers are required to learn from senior developers. Students working at LuminiSoft enjoy sharing their knowledge. This is true because the question related to this information had a mean equal to 4, and the standard deviation = 0.54. It means they agreed to share their knowledge. Additionally, students working at LuminiSoft get skills by themselves, when they try to solve problems, when software projects generate a new problem, the problem has to be solved in order to reach a successful project. There are different kinds of problems. There are technical and social problems. When technical problems arise, they are solved by the whole team. Social problems are related to communication, interaction, support, and so on. To solve it, the team has to establish communication ways and has to design strategies in order to increase commitment among team members. The questions related to this aspect had a mean equal to 4.2, and the standard deviation = 0.40. It means they agreed to look for a solution when troubles arise. Students working at LuminiSoft felt encouraged to learn new technologies during their stay. This action provides them with new hard skills. This scenery was associated with: Learning new technologies, increasing software development experience, learning new development frameworks, and participating in training activities, among others. It was evident because questions related to this had an average mean equal to 4.6 and a standard deviation = 0.66.

RQ2, this question was answered by taking into account, CLEI Scales: TA, and FA. LuminiSoft is economically self-sustaining. It means the USDC does not receive economic support either from the ICTF or from the University, hence, Luminisoft must generate its own economic resources. Customers pay for developments. These economic resources are used to pay salaries and to buy software and hardware needed to develop software. This is the main reason students face real situations. When money is not involved, the situation is not real, when budgets to develop a software system are negotiated with customers, they are expecting to receive the system they have paid for.

Hence, in order to provide technology to develop a software system, the USDC must generate its economic resources by itself. Additionally, facilities must be provided by the USDC. Hence, if a University or Faculty wishes to establish a USDC, facilities must be provided.

RQ3, this question was answered taking into account, Scales: Anxiety, OM, I, and TA. Some hard skills (technical skills) include coding, database knowledge, modeling techniques, algorithms building, testing methodologies, operating systems, development IDEs, documentation techniques, and so on. Soft skills (social skills) needed, among others, are verbal communication, written communication, logical thinking, OM, teamwork, collaboration, organization, problem-solving, critical thinking, accountability, good attitude, and emotional intelligence. Some of them are required before students are hired. Hard skills are required but are not imperative because these skills are gained through practice. Soft skills are more important than hard skills when students are hired. Soft skills are difficult to acquire because they are intrinsic to each person. A strategy to reinforce these kinds of skills should be developed in academic programs. There were some indirect questions related to Soft Skills (SS) and Hard Skills (HS). For instance, I have enough skills to use computers (HS & SS), I feel comfortable using computers (HS & SS), I feel comfortable using development frameworks (HS & SS), I feel comfortable when developing a software System (HS & SS), I have enough skills to learn new software development frameworks (HS & SS), If there should be a problem to solve in a software system where I am programming, I try to solve it (SS), I like to share my knowledge with others at LuminSoft (SS), I should have to learn new technologies at LuminiSoft (HS), I increase my software development experience at Luminisoft (SS), I should have to learn new development frameworks at LuminiSoft (HS), My experience as a team member improve (SS). Questions directly related to RQ3 had an $\dot{X} = 4.6$ and a $\sigma = 0.66$. Hence, they were appropriately assessed by the participants. It means participants realized they are acquiring HS and SS.

RQ4, this question was answered by taking into account ACCC Scales, and the usefulness of the USDC. It means the extent to which the students found the USDC useful. Questions related to this scale were: "My experience as a team member improved, I like to participate in software development projects, participating in LuminiSoft was useful to my professional development, and LuminiSoft is a complement to academic preparation in order to increase professional experience". These questions had an $\dot{X} = 4.67$ and a $\sigma = 0.5$. The significant events to increase students' experience are, among others, direct contact with customers when they describe problems, they want to solve through a software system (elicitation requirements meetings), when students participate in delivery meetings (sprint review meetings) when students face requirements change request (RCR) because they have to evaluate time and money impact before they accept the RCR. Indirectly, these events were assessed with 5 questions.

As can be seen, almost all information is regarding good experiences, but there have been some bad experiences, mainly events related to staff turnover. Staff turnover must be taken into account because it is a common phenomenon. When students receive an offer from an external company they will resign from LuminiSoft. It is good and bad at the same time. It is good because students have gained enough experience to be hired by an external company. It is a little bad for LuminiSoft because the knowledge worker will be lost. In order to minimize the negative impact on Luminisoft, a knowledge database has to be maintained constantly. It means all time processes, methodologies, and solution troubles have to be documented. Knowledge wikis, and Frequently Technical Questions have to be kept up to date. Additionally, senior developers have to share their tacit knowledge with junior staff and code their tacit knowledge into explicit knowledge. Setting up a Knowledge management framework is suggested.

6. Conclusion

When the SE discipline is taught in Universities, it would be a good idea to set up a University Software Development Company for it. Mainly, because theory plus real practices are required when software engineers are formed. SE cannot be taught exclusively with theory, and academic practices. Students should be exposed to real-world situations where they can engage with customers,

understand their problems, and work to provide solutions that help maintain the customers' competitive advantage. This approach allows students to gain both hard and soft skills before graduating from university.

This research has shown, the students increased their experience, got technical knowledge, and reinforced their hard and soft skills. Additionally, Students gained the confidence to lead or participate in team works as team members or leaders.

Our USDC allowed students to face real situations before they finish their careers. It is useful because a considerable quantity of companies requires young people with professional experience, but how could Students meet this requirement? The answer can be simple, setting up an internal company in universities.

Regarding the questionnaire applied, it was reliable because Cronbach's alpha coefficient was equal to 0.89.

RQ1 to RQ4, analyzed in section 5 have shown that having a USDC is useful to increase students' professional experience, hence it is recommended to set up a USDC at universities or faculties when it is possible.

7. Future work

The same questionnaire will be applied to more hired students, at least 50% has to be reached in order to have additional information to be analyzed and compared actual outcomes with future outcomes. The USDC will try to increase student participation. Transversal capstones will be configured; several courses will be involved in each of them a single SDLC will be tackled. Additionally, a marketing department will be set up in order to increase real software development projects. So far, no marketing department exists and the Knowledge management framework must be tuned.

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