A NOTE ON PERFORMANCE AND SATISFACTION OF FEMALE STUDENTS STUDYING COMPUTER SCIENCE:

Note on Performance and Satisfaction of Female Students Studying Computer Science

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ABSTRACT

In this paper some gender related results are presented. They are taken from a survey conducted at Department of Mathematics and Informatics, Faculty of Science, University of Novi Sad. These results explore several interesting points regarding the female undergraduate students, such as: general success rate, professional confidence, interests and ambitions, level of satisfaction with the choice of studies, and attitudes and beliefs towards the gender issue. The analysis of a survey resulted in indicative statistical data, offering basis for some future work and discussion, towards the aim of narrowing the gender gap within the field of Computer Science.

Keywords: Performance; satisfaction; female students; computer science.

INTRODUCTION

Numerous research results have shown a significant lack of female students enrolled in Computer Science studies at the universities worldwide. A lot of recent research has been conducted in different domains of ICT, involving different levels of education – starting from elementary school to the faculty level in Davies et al (2000), Gharibyan (2006), Gunn et al (2003), Ilias et al (2006), McKenzie (2002), Paloheimo et al (2006), or Thai-Sheng Fan et al (2005).

It is also important to note that some of the recent researches are related to such new directions in education as: computer-mediated communication and computer-supported learning as in Dalampan (2006), Hughes (2002), or Prinsen et al (2007). Moreover, some authors go further and examine relations between outside school computer experiences, perceived social support for using computers, and self-efficacy and value beliefs about computer learning for elementary school boys and girls, like Vekiri et al (2008).

In the USA, for example, as stated in Kilgore et al (2006), from 1995 to 2004, only 20% of bachelor degrees in computer science were awarded to women. In addition, the percentage of female diplomas is continuously diminishing, despite the supporting acts made by the academic community and the overall growing amount of education options available. Similar situation is in other countries like Taiwan, presented in Thai-Sheng et al (2005), Australia, as stated in Miliszewska (2006), and most of European countries like Germany, Vosseberg et al (1999), Finland, Paloheimo (2006), Holland, Prinsen et al (2007), and Greece in Ilias et al (2006).

According to Putnik et al (2008), Serbia is also facing this global problem, while it seems that the same situation is present in all other Balkan countries.

Moreover, it is a recognized fact that those few women who stay in the field discontinue their studies more often than their male colleagues. This phenomenon is known as "the shrinking pipeline": even though young girls could be attracted by computer science, the higher level of education, the smaller is the proportion of female students, as stated in Paloheimo (2006). Consequently, this leads to inadequate involvement of women in the information-communication technology industry. Statistics show that only 22% of the employees in the science related fields are female, which clearly does not match their actual share in the work force in general Putnik et al (2008).

Some of the identified causes of this occurrence are the following:

- **Intimidation with the male dominated nature in the computer science field (similar situation is also in engineering and other technical domains);**
- **The absence of female role models;**
- **Lack of respect towards female professionals;**
- **Lack of confidence in the abilities of female professionals as stated in Gharibyan (2006);**
- **Social pressure not to study computer science, and**
- **Fear of combination of work and family life in information technology sector regarded as problematic in Paloheimo (2006).**

In addition, in Putnik et al (2008), and Ivanovic et al (2009) it has been reported that women are more attracted to applications that benefit society than in programming itself. Therefore, women tend to lose interest when this aspiration is not satisfied, often because they are feeling restricted by somewhat abstract curriculum, claims Fisher (2006).

On the other hand, historically observing female researchers and programmers have played a significant role in founding of computer science, as stated in Paloheimo (2006). For instance, women in their forties formed a majority of the first programmers during the World War II. In the fifties and sixties female researchers heavily contributed in, for example, the development of user interfaces as presented in Ngambeki et al (2006). Distinguished representative of that era is Grace Hopper, one of the most incisive futurists in the world of computing, the inventor of the compiler and programming language COBOL.

Another important figure of that time was Evelyn Granville, a pioneer in information technology who began her career in academia, went on to programming challenges at IBM and ultimately worked on the NASA space programme before returning to teach others; the first black woman to obtain PhD in Mathematics in 1949. Naturally, a question is posed: what has influenced such a serious deepening of the gender gap over the past few decades?

Some authors suggest that the key factor was the arrival of the home PCs in the early eighties: the computers became a very popular hobby, especially for the young boys. As explained in Paloheimo (2006), this led to the situation where, due to the boys' early involvement with computers, the female students enter introductory computer science classes with weaker programming skills and lack of computer related background. However, the situation is more complex.

According to Paloheimo (2006), social pressure is the most obstructing factor: "The society does not actually prevent girls from accessing computers, but it has failed to introduce computer science as a feasible option to them", and as a result, information technology built a strong image of the men's playground.

What finally brings women to the table? The following was suggested:

- **The continuous presence of computers in a way that women can comprehend the versatility of computer use;**
- **Support and encouragement by the female professionals in the field;**
- **Help in understanding different career possibilities in information technology, and**
- **Awakening of interest in mathematics and science from the early age, as suggested in Fisher (2006).**

In the light of these findings, the goal of this research was to explore gender influences on female undergraduate students at Department of Mathematics and Informatics, Faculty of Science, University of Novi Sad. The same situation is in whole Serbia, as well, and results obtained and presented here reflect the reality in the whole country.

The rest of the paper is organized as follows: Section 2 gives brief insight into gender related research, which addressed the above mentioned issues. Section 3 presents used methodology of data collection and detailed content of the questionnaire.

In Section 4 we concentrate on gathered results of the study, through analysis of causes and effects of the specific focus points. In the end, Section 5 brings conclusions and final remarks regarding possible future involvement and reaction strategies.

RELATED WORK AND RESEARCH

Beginning of the 21st century introduced a significant number of published research and expert papers associated to gender politics in various domains, as a first but very valuable step towards the adequate solutions in practice. Being regarded as distinctively male dominated fields, Engineering and Computer Science disciplines have been given a considerable amount of scientific attention in terms of efforts to encourage the necessary gender balance.

Most importantly, these actions would result in improvement of the quality of education. In Paloheimo (2006), the authors state that "students perform far better if their comfort level is high, and one of the factors in defining comfort level is how comfortable students are in presenting questions to other students and the course faculty". Students were divided into groups of female, male and mixed gender groups. The communication was observed, followed by a survey which explored their success rate throughout the course. The study reveals that in computer science classes "typical gender distribution (majority male) lowers the comfort level of all students in comparison to a case with even gender distribution", suggesting that both male and female students would benefit if more women studied computer science.

However, gender differences regarding the experiences and the ways of thinking indisputably exist. How to use them in a positive manner when it comes to engineering education? In Kilgore et al (2006), after surveying 40 male and female first-year students in the USA, authors remark: "A more detailed understanding of what distinguishes women as early successes in the possible engineering pathways provides empirical grounds for portraying engineering more broadly". It was found that "regardless of gender, students view math, science and other technical abilities as fundamental in engineering". Surprisingly, the research did not register differences in abilities nor ambitions between male and female students. Yet, gender differences were shown in the way the students view the practical nature of engineering as a field. "Men were more likely to discuss and be attracted to the hands-on possibilities:

trying out ideas in the real world", while women were more likely to commit to the "linking theory and practice: designing and creating". Consequently, teachers' acceptance of described gender differences in perception of what is required for engineering would lead to the better professional motivation of both male and female students.

Taking that objective into consideration, we can ask ourselves: "Which is the best way to motivate our students?" In order to motivate and correctly direct students during their higher education, it is of great relevance to recognize their life goals and attitudes towards profession, as suggested in Ngambeki et al (2006). Through numerous interviews, authors of the study analyzed personal and professional identity formation and attitudes towards learning amongst randomly selected groups of female engineering and non-engineering students of different years of college. The interviewers asked questions such as: "Where do you want to go in life and why; How does this relate to who you are now; Is your current field an important part of who you are; What have you learned in class that you feel really applies to your life; What impact does your field have on society; How and why did you choose your field; What does learning well mean to you?" They came to the conclusion that "students develop more sophisticated ideas about learning process and about their life goals as they progress through their undergraduate years, but the engineers have a clearer sense of professional identity than their non-engineering counterparts early and throughout their undergraduate careers".

Intriguing female students' motives for studying computer science have been reported in Gharibyan (2006), providing the completely different point of view. In the mentioned paper, the author explored factors which attract women in Armenia to the field of computer science. Namely, there are few countries, such as republics of the former Soviet Union that have well represented female population in computer science studies. The author explains this success with the following specifics: "In Armenian culture there is no emphasis on having a job that one loves; instead there is a determination to have a profession that will guarantee a good living". And moreover, as it is stated, "Armenians consider themselves to be very practical and reasonable, setting goals that are reachable within their talents, abilities and circumstances, and they do not have glamorized expectations of life, and therefore do not get disappointed easily and do not give up when things get difficult". As a result, computer science as a field is one of the most popular fields in Armenia. Could these findings be related to Serbia?

Although the gender related study made recently at our Department by Putnik et al (2008) gives no answer to this question, let us briefly refer to it. This paper compared past three years success rates and enrollment data of both freshmen and the last year male and female students. Its findings reveal a somewhat surprising fact: when it comes to the technically-oriented courses whose representatives were "Introduction to Programming" and "Software Engineering", it is stated that: "there is no significant difference gender wise". On the other hand, when it comes to the business-oriented courses, such as "Computer Ethics" and "Software Project Management", there has even been noted a slight difference in women's favor.

However, female students did show an inclination towards prejudices to some extent. Namely, the analysis of recent gender related enrollment data for our Department, given in Putnik et al (2008), reports that a constant number of females did enroll into "Business Informatics" direction, while their number at "Theoretical Informatics" direction is steadily decreasing each year. Also, there has not been a single female student enrolled into "Teacher of Informatics" direction in the past three years. In addition, the gender related data provided by Putnik et al (2008) and Ivanovic et al.

(2009), now regarding students who reached the final year of studies at our Department, indicates that female percentage in enrollment was about 10% higher during the previous years, whilst, in comparison, the overall number of students preserves status quo. Evidence from around the world also suggests that women are reluctant to pursue studies in information-communication technology at postgraduate level, as stated in Miliszewska (2006).

A FEW NOTIONS ON THE METHODOLOGY QUESTIONNAIRE AND DATA COLLECTION

The research presented here was conducted during June 2008, and involves 116 female students of all four years of undergraduate studies of Computer Science at Department of Mathematics and Informatics, Faculty of Science, University of Novi Sad (Table: 1).

Table: 1 Number of female undergraduate students involved in the survey

	1st year	2nd year	3rd year	4th year
Number of participants	36	38	24	18

The data was collected in the form of questionnaire, which consisted of 20 questions, focusing on the following topics:

- **General studies success rate;**
- **Satisfaction with the choice of studies;**
- **Professional confidence, interests and ambitions, and**
- **Attitudes and beliefs towards the gender issue.**

The focus selection has been made taking into consideration presented research goals, as well as the examples of previous studies, given in Section 2. Various examination techniques were combined in order to gather the most referring and inclusive feedback data. Survey was conducted as anonymous.

Firstly, the participants were asked to provide some education related basic information, such as year of studies and average mark. The next part of the questionnaire included descriptive questions:

- **How do you imagine your job position after the completion of your studies?**
- **On which job position do you see yourself in 10 years from now?**

The participants were then asked to name the most liked and most disliked subjects they have experienced during their studies, depending strictly on the course content. This was followed by three questions which required circling the preferred answer and a brief elaboration:

- **What had mainly influenced your choice of studies?**
- **Is information technology a suitable field for women?**
- **Is it possible to have both successful career and family?**

Finally, nine questions were given in the form of statements and participants responded according to the Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree), covering three key points of the research: expression of personal ambitions

regarding career; expression of individual attitude towards curriculum; and expression of attitudes towards the gender issue.

In Section 4, the exact preview of the questionnaire is given, together with its results. The "Variety of Questions" approach proved effective, offering a wide spectrum of data, which consequently reflected on the research results in the most positive manner. The statistics were calculated using the Origin 7.0 computer program.

RESULTS OF THE ANALYSIS AND DISCUSSION

This Section summarizes the results which were gathered by the survey, and classified by the focus points of the research.

General Success Rate

General success rate of the population observed is given in Table 2. Generations enrolled in 2nd and 4th year prove to be more competitive ones, which match the results provided by the previous study made at our Department in Putnik et al (2008). Grading system for higher education in Serbia is established in a form of a scale from 5 (failed) to 10 (outstanding excellence). Bologna education system, introduced at our Department in 2006, resulted in the significantly higher passing rate and higher average success rate.

Table: 2
Average success rate.

June 2008 Year / Average mark	6.00-7.00	7.00-8.00	8.00-9.00	9.00-10.00	Unknown
1st year	11.11%	27.78%	33.33%	5.56%	22.22%
2nd year	-	-	68.42%	31.58%	-
3rd year	-	64.29%	35.71%	-	-
4th year	-	33.33%	44.44%	22.22%	-

Notice that the 22.22% in the category "Unknown" for the 1st year students is due to the fact that research was conducted in June, before their first summer exam period, after which the average mark is commonly calculated by the Students' Office. Those who provided data referred to the outcome of the winter exam period, but it is understandable that some could not precisely recall the information.

The Level of Satisfaction with The Choice of Studies

The students responded to the statements given according to the Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree). These statements are presented in Table 3, together with the results.

Table: 3
Expression of attitude towards curriculum.

Statement	Mean value	Standard Deviation
I am generally satisfied with my choice of studies.	4.27	0.86
I feel more comfortable with mathematical courses, rather than with computer science courses.	2.87	1.59
Studies positively effected my intellectual development and interests.	4.29	0.95

By this set of questions we tried to determine the comfort level in studying, asking female students to review effects of the studies on their intellectual development and interests, that is, our indirect influence as an education institution. Results report it to be highly positive. To our relief, they have also shown general satisfaction with the choice of studies. Answers to both of the statements representing these points are with low standard deviation, which is even more encouraging. Authors in Fisher (2006) suggested that girls are more inclined to mathematical than informatics related subjects. The results obtained at our Department indicate differently, but they are not strongly convincing.

Namely, mean value is just about the middle (2.87), with high standard deviation (1.59).To support these claims, Table: 4 illustrates expressed interest in taken courses, where mathematical courses often take place in the list of less popular.

Table: 4
Interest in taken courses: the least preferred courses and the most preferred courses.

	1st year	2nd year	3rd year	4th year
The least preferred courses	**Math. Logic and Algebra, Analysis, Financial Mathematics**	**Data Structures and Algorithms, Math. Logic and Algebra, Analysis, Linear Algebra**	**Data Structures and Algorithms, Numerical Analysis**	**Differential Equations, Linear Algebra**
The most preferred courses	**Web design, Introduction to E-business, Data Structures and Algorithms, Introduction to Programming**	**Computer Organization, Object-Oriented Programming, Data Structures and Algorithms, Web Design, Data Bases**	**Data Bases, Web Design, E-learning, Information systems**	**Data Bases, Information Systems, Object-Oriented Programming**

To avoid confusion, let us mention that some of the courses are chosen on different study years, because the question was related to the least/most preferred courses from the studies as a whole, and not just for the current year. This way it was possible to list, for example, "Data Structures and Algorithms" as "the least preferred" course both for second and third year students, and at the same time as "the most preferred" course for the students of the first and second year. Similarly, some other courses were also mentioned as both "the least" and "the most" preferred. When asked about the motives for their choice of studies, the participants answered as presented in Figure: 1.

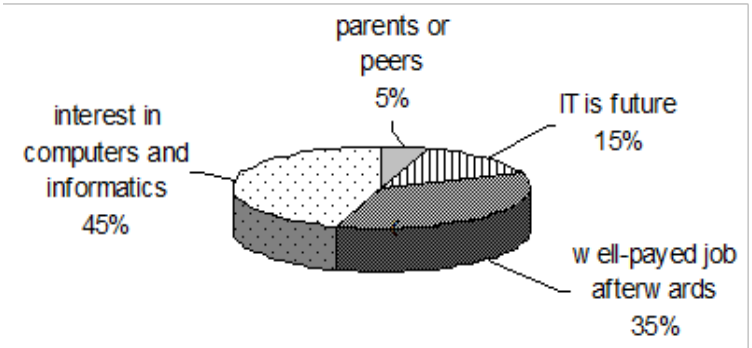

Figure: 1
Resulting answers to the question:
"What had the most influence on your choice of studies?"

When compared to the results of the study made in Armenia by Gharibyan (2006), it could be noticed that a motive of finding a well-paid job after the studies is as influential as in this former Soviet Union republic. We also detected a lower significance of the parents' or peers' influence.

Professional Confidence, Interests and Ambitions of Students

An insight into the students' points of view regarding their professional future is given in Table 5. Marks seem to be of lower priority than expected, if compared to the previous research conducted in Putnik et al (2008), and high general success rate. Students also seem to be very confident in the realization of their career objectives and professional security and integrity.

Table: 5
Expression of personal ambitions regarding career.

Statement	Mean value	Standard Deviation
Marks during studies are important to me.	3.66	1.05
I believe I am about to have a successful career.	4.31	0.78
I am worried about further course of my career after I complete my studies.	2.44	1.26

In order to explore these ambitions in more detail, participants were asked to describe first on which job position they see themselves after completion of studies (Table 6), and then, in comparison, where they imagine themselves 10 years from now.

Table: 6
Personal ambitions after completion of studies.

Typical answers	1st year	2nd year	3rd year	4th year
Working in education	4	12	-	-
Working in private business	2	4	2	2
Programmer, code writing	8	-	4	2
Working in a bank	4	2	10	4
Related to Data Bases	-	4	6	4
Related to Web programming	2	4	-	2
Manager	-	2	2	-
Researcher	-	2	-	2
Going abroad	-	4	-	-
Related to SE	-	-	-	2
Unknown	16	14	6	2
Total number of participants	36	38	24	18

Most popular options seem to be an employment in a bank and working with data bases. It seems that, as a consequence of the existence of a rather conservative, male-oriented society in Serbia, only few participants mentioned in their answers terms such as "taking over leading positions", "multidisciplinary approach", "possibility of further education and professional growth".

We also reported a very low interest in research. The reason for such attitudes could be a focus on a future work at our Department.

Another interesting point is that a surprisingly high number of the participants in this research expressed a wish to work as a teacher, while, as already mentioned, none of them is enrolled in "Professor of Informatics" direction. The main reason for that can, again, be found in the current situation in Serbian society.

Teachers' positions, especially in elementary and secondary schools, are rather low-paid, but, on the other hand, very secure and somehow protected. As such, they are most appropriate for women who plan to have family and children. Also, it can be noticed that, when describing their future goals, almost none of the girls in senior years used the term "programmer" in their answers.

Moreover, the term "software engineering" is mentioned only once. A group of answers classified in "Unknown" includes such statements as "it is too early to think that far". It is comforting that the number of such responses is decreasing with the year of studies. Fig.2 presents how our students see themselves 10 years from now.

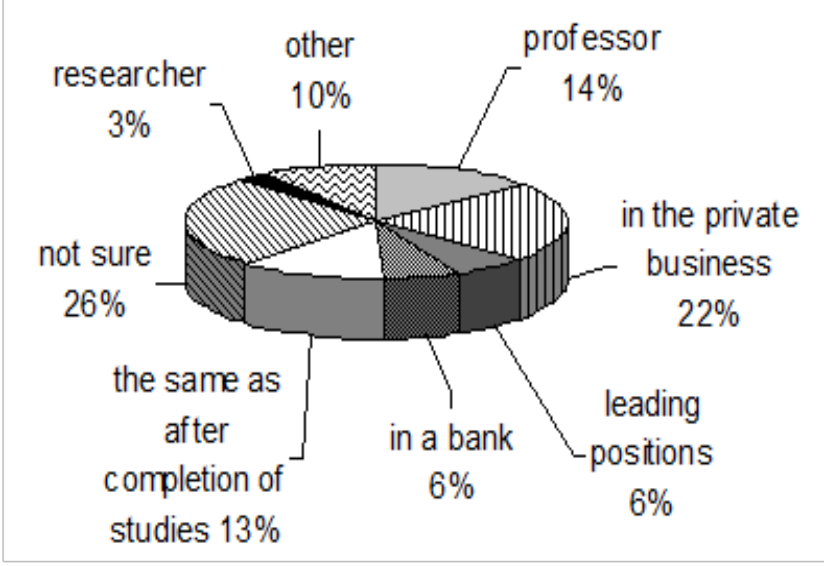

Figure: 2
Resulting answers to the question
"On which job position do you see yourself 10 years from now?"

Again, a rather low number of students (12.7%) gave the answer: "the same as after the completion of studies", which supports another claim stated in Gharibyan (2006): by business owners, women are seen as more loyal, dedicated and less ambitious, "female professionals are happy where they are and do not like to change their job frequently".

Additionally, this can be interpreted as a consequence of a somewhat conservative society, where the majority of women is rather family-oriented then career-oriented.

Attitudes and Beliefs Towards The Gender Issue

Figure: 3 shows that 81.7% of the participants believe that it is possible to combine the career in information technology and family life, and not a single one responded negatively. This is somewhat contrary to the previously obtained answers and slightly non-ambitious as far as the further advancement in professional life and the continuation of education are concerned.

Our personal opinion is that most of the participants have in mind that it is possible to have both a family and an average career.

Most of them are not aware of the fact that it proved to be extremely complicated to devote enough time to successfully start and maintain a family as well as an extraordinary career.

When asked "Is information technology a suitable field for women?" almost none of the participants gave a negative answer (Fig. 4).

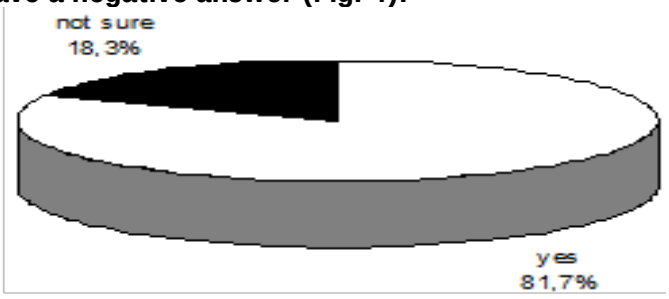

Figure: 3
Resulting answers to the question
"Is it possible to combine career in IT and family life?"

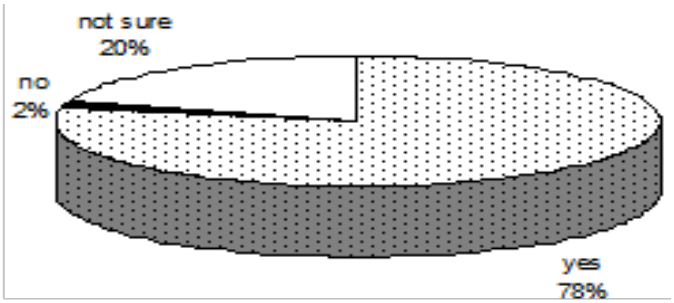

Figure: 4
Resulting answers to the question
"Is information technology a suitable field for women?"

More surprising data is shown in Table: 7, where girls tend to diminish the presence of the gender issue, although the statistics very argumentatively indicate the opposite in Putnik et al (2008).

Table: 7
Expression of attitude towards the gender issue.

Statement	Mean value	Standard Deviation
Professionally, I feel completely equal to my male colleagues.	4.37	0.91
Concern regarding the lack of women in information technology is justified.	2.62	1.33
Stereotypes regarding women in information technology do not manifest in real life.	4.04	1.21

These numbers reveal a remarkably high level of confidence, comfort and gender self-awareness related to professional skills amongst the participants.

CONCLUSION

This paper presented results that reflect the gender climate at the Department of Mathematics and Informatics at Faculty of Science, University of Novi Sad, but also in whole Serbia, with the focus on:

- **• The comfort level;**
- **• The confidence level, and**
- **• The success level**
- **amongst the undergraduate female students of all computer science directions.**

The research revealed that the female students of computer science show a surprisingly high level of gender self-awareness and confidence. The participants expressed serious and ambitious attitudes regarding their career objectives, feeling professionally equal to their male colleagues, with their grades to prove those claims. The comfort level considering their studies and the future professional growth has also reached a very satisfactory level. Even though the number of female students at our Department is dropping each year, those who manage to complete their studies prove to be as competitive and skillful as their male colleagues.This could partially be explained by the fact that the technical skills are gender-blind, and as a consequence, computer science as such "bears more promises for equity between genders in opportunities, positions and finally salary, than the other fields" as stated in Putnik et al (2008). However, the majority still tends to reject the idea of necessity of the gender related acts, although the statistics and the research, previously described in Section 2, have shown there are reasons for concern and care.

From that point of view, as stated in Grurer (2002), "it is important to understand a student's sense of identity both personally and with respect to the profession and gender, and to determine what students find to be most relevant and meaningful as they connect learning with life goals". In that manner, it becomes possible to employ various pedagogies more effectively and have more influence on the students' interest, motivation and performance. In turn, one of the aims of this research was to provide support for pedagogies in practice at computer science studies at Department of Mathematics and Informatics, Faculty of Science, University of Novi Sad, which poses as a potential focus for the future work and analysis. As the first step, it is planned that male students are included in some wider survey, and those results are to be compared and correlated with the findings for female students.

To conclude, our findings show that it is necessary to make an effort to improve education politics and attract more female students at undergraduate level, and especially at postgraduate level. There is still plenty of space for the improvements and new goals.

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