# THE IT GENDER GAP: Experience, Motivation and Differences in Undergraduate Studies of Computer Science

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## ABSTRACT

**This paper reports on progress and conclusions of two-year research of gender issues in studying computer science at Department of Mathematics and Informatics, Faculty of Science, University of Novi Sad. Using statistics on data gathered by a survey, the work presented here focused on identifying, understanding, and correlating both female and male students' performance, professional motivation, ambition, confidence level and attitudes towards differences, learning quality and nature of the field. Results show agreement with theoretical predictions and significant improvement over previous efforts; providing profound implications for future studies of gender-sensitive IT education in the region and beyond.**

**Keywords: Gender, Computer science, Job/Study satisfaction, Stereotyping**

## RELATED WORK AND RESEARCH

**Despite significant growth of IT professions in recent years [Beyer], women remain under-represented in occupations requiring knowledge of, or qualifications in the field of computer science. As stated by [Trauth], "it is ironic that at this time of unprecedented opportunity for IT professionals around the world, the field should be experiencing an IT skills crisis stemming from the shortage of qualified IT professionals". Since computers and IT play an increasingly pervasive role in education and careers, this underrepresentation is critical, not only for women whose potential may go unrealized, but also for a society crucially dependent on technology [Fisher].**

**For example, one study shows that women are only 29% of the science and technology labor force in Canada, compared to their overall labor force participation of 43% [Acker]. Although the exact extent, to which gender differences in performance or representation occur, varies from country to country [Hanna], and within countries - social differences complicate the picture [Oakes]; this shortage of female experts continues to be common everywhere in the world, and worthy of scientific attention and reaction. Therefore, gender issues occupy a place of considerable importance in the computer science education literature [Greening], in attempt to explore chronic stereotyping and demystify entrenched gender inequity.**

**Namely, the participation of women in computer science from high school to university is decreasing at an alarming rate. As stated by [Wilson], not only does this "brain drain" occur throughout school, it also continues in the academic faculty ranks, where participation of female computer science instructors at all levels, from assistant professor through full professor also decreases. This trend is often referred to as "pipeline shrinkage". According to [Putnik], Serbia is also facing this global problem, and it seems that the same situation is present in all other Balkan countries. The question in the minds**

**of those concerned with IT human resources and the development of qualified IT professionals is, "Why?". If research studies can identify causes of low female participation in the field, the issue could be addressed and some possible solutions offered.**

**In [Putnik] and [Ivanovic] it has been reported that women are more attracted to applications that benefit society than in core implementation procedure. Therefore, women tend to lose interest when this aspiration towards human aspects is neglected, often because they feel restricted by a somewhat abstract curriculum, claims [Fisher].**
**However, two main reasons for the non-significant number of women in CS are found to be negative stereotypes regarding the field, and low confidence [Beyer]. Females have *inaccurately* low confidence in so-called masculine domains, including mathematics, chemistry and CS. In fact, women in society often do not receive the same level of support that men receive for entering and persisting in the field [Cohoon]. Parents, friends, and classmates seldom encourage women to choose and continue in IT. According to [Paloheimo], social pressure is the biggest obstructing factor: "The society does not actually prevent girls from accessing computers, but it has failed to introduce computer science as a viable option for them", and as a result, information technology builds a strong image of the men's playground.**

**What is the consequence of low confidence? [Collis] identified what she called the "We can but I can't" paradox: girls would strongly defend the abilities of their sex in general terms, but hesitate about their own potential and choices. Positive self-perception greatly affects aspirations, educational choices, and a preference for challenging tasks. As stated by [Beyer], "stereotype threat occurs when targets of stereotypes implying intellectual inferiority are reminded of the possibility of confirming these stereotypes".**

**In addition, many authors dispute the reference to technical skills as being "gender blind". According to [Adam], "gender-technology studies are now moving away from essentialist models of technology, where the technology is portrayed as culturally neutral". Such authors propose that technology itself has a gendered nature which forms an inherent basis for which many women may be unattached to [Greening]. In fact, as this feeling is somewhat artificially conceived, we may conclude that it is possible to overcome it, by implementing proper strategies for actively recruiting and retaining women in computing majors at universities.**

**Having that motivation in mind, a gender-related research was initiated at our department in 2008. First study examined statistical data attached to enrollment distribution, and success rates achieved in the main technical and non-technical courses available at undergraduate studies of CS. In order to further explore several interesting points, 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; a new study was made in 2009, involving specifically female undergraduate students.**

**That was the first step in understanding relative significance of factors that have the greatest bearing on the confirmed low numbers of female students.**
**As stated in [Grurer], "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 our research results presented here, we focus on examining educational environment of both female and male students, aiming to widen the perspective, achieve greater objectivity through correlations, and form guidelines for creating favorable conditions at our department for recruiting and retaining female students. Intrigued by previous findings, we not only continued to monitor female students' population regarding gender**

**issues, but also reached for deeper insight into the situation by observing both "sides of the story", in order to verify or dispute some of our hypothesis presented in [Ivanovic].**

**The implicit goal of this study is to explore whether gender gap at our department, that have existed in the past, is now perhaps narrowing; and if not, how could it be influenced through potential gender-sensitive innovations in educational methods. It is important, as the educational system is where it all begins [Fisher], [Cohoon]; with a specific eye toward understanding the ambition and motivation factors and processes whereby they attach themselves or detach themselves from the field.**

**The next Section presents literature review, where we discuss different streams of research conducted by those concerned with the participation of women in IT. It is followed by a short overview of our own research at University of Novi Sad and presentation of the methodology of data collection used and a detailed content of the questionnaire. In Section 4 we concentrate on gathered statistical results of the study and their implications, interpreting them and comparing them to our previous efforts. At the end, Section 5 brings conclusions and final remarks and recommendations regarding possible future involvement and reaction strategies.**

## LITERATURE REVIEW

**Participation of women in IT has been reflected in recent literature from a variety of different theoretical viewpoints. At the highest level, these could be put into two categories: those that emphasize fundamental differences between the sexes, and those that de-emphasize them [Trauth]. Two streams of research derive from a view that male and female students have basic differences – but they elucidate truly confronted conclusions.**

**A stream of research in the United States assumes fundamental, psychological differences between the genders and links this presumed difference to the present gender gap in IT by looking at technology acceptance in the context of individual adoption and sustained usage of technology in working environment [Venkatesh]. It proposes that women typically display lower computer aptitude and higher level of computer anxiety than their male peers. This group of authors radically suggests there are inherent differences between genders which portray women as less capable, more insecure and more compliant than men, and therefore less willing to adopt and use technology. Since our everyday experience of successful women in IT worldwide testifies to the contrary by providing numerous counter examples, it is clear that those findings should be taken with doubt, and that answers should be sought elsewhere. Another stream of research starts from the same point of view, by assuming there are gender differences in acceptance of technology.**
**However, it reaches more flattering conclusions. It encourages work on recruitment of women in IT, because, as suggested in [Spender], "if more women held technical positions, such as that of a programmer, not only would IT's gendered nature disappear over time, but it would be transformed and improved by exposure to feminine values"; therefore bringing key benefit for both women and the IT world. Most feminist writers on technology support this paradigm, insisting on the value of contribution that a gender-sensitive approach could initiate [Greening]. For example, [Gunn] in her work on gender issues in computer supported learning, reports that female and male participants generally take different approaches to the use of technology, i.e. exploratory and developmental versus practical and instrumental. This supports popularized conception of "toy/tool" dichotomy [Kantrowitz], that "most males see computers as toys to play with, while most females use them as tools to do things with". Rather than proclaiming inherent differences between the sexes, another branch of research upon this subject goes down a different track. It focuses on gender socialization and pursues answers in the social construction of IT as a male domain. As [Nielsen] explains, "in order for women**

**to be successful in IT, they must adapt to this masculine domain", that has been construed.**

**An interesting study from this stream of research, [Trauth], investigated the influence of socio-cultural factors on gender in the Australian IT professions. The spotlight was on successful women in technology because it is this group that best challenges the assumption that women are inherently unsuited to work in technical fields such as IT. Data was collected through open-ended interviews, which aimed to specify framework of environmental factors such as parents, educators, policy makers and IT professionals and its influence. Three types of women emerged from these interviews – those who appeared more or less unfazed by being a woman in a male dominated field and did not reported to be operating on an uneven playing field. However, instances of an uneven playing field often crept into the interviews. Second group were the ones that accepted the inequity, with varying satisfaction levels. In the third group were women who have experienced discrimination and were willing to speak about it. Study took into account cultural backgrounds of participants, especially the experience of living abroad. One participant stated that "in Yugoslavia, during her university days and early career, it was totally acceptable for a woman to become an engineer".**

**A group of authors [Bryson] have described four discourses concerning gender and technology: *positivism/technicism*, *constructivism*, *critical approach to equity* and *postmodernism*.**

**Positivism aims, first and foremost, at public notions. It concentrates on encouraging women to increase their presence in technology by introducing innovations in education, e.g. altering textbooks and curriculum materials and providing role models and a better career guidance. This would result in higher level of motivation and public acceptance that IT is an appropriate place for females. This is considered to be a liberal feminist approach, as its goal is only to alter attitudes and diminish stereotypes, rather than to challenge fundamental wheels of social structures. [Acker] specifies three problems with this discourse: pure awake of interest among girls in IT, without actually enabling them to acquire certain skills and adopt learning strategies, could be counterproductive. Furthermore, "the nature and practice of science and technology may go unquestioned if the goal is simply to attract women into these fields". The third issue is that it implies that girls' choices are irrational and rooted in purely individual characteristics, rather than socially shaped, as modern research suggests [Cohoon].**

**Constructivism suggests more radical approach – it takes a task of reworking science and technology, challenging its establishment by enforcing "feminine ways" into the picture. Drawing attention to incompatibility between "female ways of knowing" and standard practices of technology, it relies on feminist accounts that women, regardless of whether nature or socialization, have a preference for cooperative, caring, connected approaches to learning and working. For example, girls are less interested than boys in imposing their "will over the machine" or competing to finish the task first [Bernhard].**

**Therefore, constructivism suggests interventions which would adapt practices in technology to these female needs. However, [Bryson] doubt that learning style alone could explain failure or alienation of a certain group, in this case, women. Another problem with this discourse is that it seems to create counter oppression, deepening the gender gap in science and technology by insisting on separations, instead of narrowing it by efforts towards overall common integration of the sexes with attention to differences.**

**The third discourse stated in [Bryson] is critical approach to equity. Here, gender and other social divisions are considered to be artificially produced and nurtured by such institutions as schools and universities. [Kessler] introduces a term of "gender regimes" to describe patterns of practices that define "acceptable" masculinity and femininity within the education system. These patterns are hegemonic, yet open to resistance and**

**change. Whether participation in science and technology is seen as a suitable part of gender expectations for young women would be a feature of a gender regime of a particular education system. [Acker] emphasize advantage of critical approach in its implication that education is no longer seen as necessarily positive or even neutral, while there still lays a power to intervene. Reflecting on the ideology of individual free choice, restraining factors must be taken into consideration by looking at responsibilities of institutions, workplaces, the scientific community, etc.**

**Finally, the postmodernist discourse is incompatible with the other three, and questions not only the dualism of gender, but the essentialist view of science and technology as well. As [Acker] explains, "identity is seen as constantly shifting, multiply positioned and influenced by complex inputs based on sex, race, class, age, sexual orientation, and so forth". This viewpoint came as a consequence of the contemporary social and cultural framework, bringing so far the greatest challenges for education innovators in science and technology.**

**One of the central issues concerning gender in science and technology remains the previously explained "pipeline shrinkage" [Greening], guiding worldwide research to focus on how to actively recruit and retain women. Studies have shown [Fisher], [Wilson], [Cohoon] that recruiting should be primarily aimed at raising self-confidence among potential female students; since their lack of participation in the field is considered not to be caused by lack of ability, but lack of support. More specifically in computer science, according to [Wilson], an area of research related to retention of women mainly focuses on the following influential aspects: previous computer experience, hostile environment and culture, attribution theory, comfort level and studies of self-efficiency. What are prospects for change *in practice*? [Cohoon] recommend methods for increasing female participation in undergraduate computer science that gave fruitful results when they were implemented.**

**Proposed recommendations aim to actively influence departments, community and institutional representatives, as well as internal policies and practices. Focus is on: public outreach, revision of curriculum and mentoring, careful marketing, interaction between various institutional groups at all levels of education system, development of community support and peer networks, promotion of female role models, career guidance.**

**Some inspiring early efforts towards achieving gender-sensitive educational climate were made at Carnegie Mellon University by [Fisher]. Four-year research involved both female and male students of computer science, from first-year to senior, examining their attitudes towards the studies and nature of the field in the light of gender differences, through open-ended interviews and surveys. Some of the conclusions are following:**

- **There was a significant gender gap between male and female prior experience in computing, and a correlation was found between female students' sense of feeling less prepared and their actual experience prior to the studies of CS.**
- **Prior experience in computing is shown not to be a guarantee for academic success.**
- **Confidence gap between female and male students narrows significantly as they progress through the studies.**
- **There is confirmed importance of family influence on students' exposure to, and interest in CS in their early years.**
- **While most of the male students describe an early and persistent attraction between themselves and computers, women often link their computer science interest to a larger social framework and their interest seems to grow stronger over time.**
- **Male students seem to suffer far less from a mismatch with the dominant culture of being a "geek" than do women. Most of CS students, male and**

**female equally, feel they do not support the stereotype: their interests are varied and not isolated to IT.**

- **Almost all male students stated interest in computers as their primary reason to study computer science; while female students, beside it, find class experiences and the sense of promise of the field of equal importance. Interestingly, among international female students prevails pragmatic factor, e.g. employability, prospects of high income. Male students also mention computer games as an influence, which was not once cited among females. Furthermore, females mention peer interactions as a positive driver far less than their male colleagues. These findings were confirmed in our own study [Ivanovic], within the scope of examination of female students' motivation.**
- **Senior students, both male and female, report that not before their final years of studies, they realized computer science is not just programming and express relief at that. Especially female students emphasized that they would be more attracted to the field if they knew about this misconception earlier.**

**Lessons learned were applied to the design of pedagogical, administrative and social methods that aimed at recruiting and retaining female students. New interdisciplinary courses and new faculty marketing policies were introduced with confirmed outstanding success, reflecting in enrollment and graduation rates [Fisher].**
**A more recent study upon the subject of gender differences, involving both male and female CS students, was made by [Beyer]. Confirming theoretical predictions that women more incline to teamwork, female participants reported stronger interpersonal attachment with others than did males. Female participants also showed significantly lower level of professional confidence, putting a shadow of doubt at the findings that participants, equally male and female, stated they noticed no gender discrimination. Moreover, there were no significant gender differences in reports upon the following aspects: beliefs about the compatibility of family life and career in CS, personal self-esteem, and comfort level, satisfaction with the choice and quality of studies; while men had significantly higher educational aspirations than did women. Finally, looking at enrollment rates, the study confirms the presence of "pipeline shrinkage" effect. Our own results in [Ivanovic] implied similar conclusions.**

**This phenomenon was also noted in a study by [Miliszewska], where she argues: "Sweet was the knowledge that the students, both male and female, found their learning environment gender neutral; bitter was the realization that if gender bias did not drive females away from computing course, then something else did".**

**Therefore, we may presume that areas, such as student demographics, learning environments, educational theories, professional requirements and technology itself, are nevertheless influenced by gender issues. Learning styles, educational and individual backgrounds and capabilities should not be treated in isolation from the gender context.**

## SOME EXPERIENCES, METHODOLOGY AND QUESTIONNEIRE

**The first initiative to examine this subject at Department of Mathematics and Informatics, Faculty of Science by [Putnik] compared success rates and enrollment data of both freshmen and the last-year male and female students throughout a three-year period. Results reveal a somewhat surprising fact: when it comes to the technically-oriented courses, represented by "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 soft-skills courses, such as "Computer Ethics" and "Software Project Management", there has even been noted a slight difference in women's favor.**

**The gender gap proved to be nevertheless present. Namely, a constant number of females enroll into "Business Informatics" major of the department, while their number at "Theoretical Informatics" major continues to significantly decrease. Also, there has not**

**been a single female student enrolled into "Teacher of Informatics" direction in the past four years. Moreover, the gender related data provided by [Putnik], 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. These findings denote gender issues which required further research.**

## Some experiences

**In order to address the issue through reaching for deeper understanding of female students, a new study was made by [Ivanovic]. The data was collected in the form of questionnaire, focusing on the following aspects:**

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

**The survey revealed that the female students of computer science show a surprisingly high level of gender self-awareness and confidence. The participants expressed serious 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. What is more, girls tend to firmly diminish the presence of the gender issue, although statistics and the literature point to the contrary. Therefore, we concluded that these factors are worth further observation, not only towards the aim of finding proofs for potential narrowing of the gender gap, but to also ensure constant quality assessment of the programs and learning environment we offer.**

**Secondly, results of [Ivanovic] open a question of a certain lack of ambition, in contrast with confidence in professional capabilities which female students expressed. Most popular career 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. It was noticed that, when describing their future goals, almost none of the girls in senior years used the term "programmer" in their answers, while the term "software engineering" is mentioned only once. Hence, the reason for such attitudes has been one of the aspects explored in the work that followed.**

**Another point is related to female students' relationship with curriculum. Authors in [Fisher] suggested that girls are more inclined to mathematical than informatics related subjects. The results obtained in [Ivanovic] indicate differently, but they are not strongly convincing. When participants were asked to list the most preferred and the least preferred courses from their studies, mathematical courses often take place in the list of less popular. This claim also deserved further investigation.**

**Finally, inspired by these conclusions, we decided to conduct a new survey, which involved both female and male students of CS. This enabled us not only to keep track of our female students, but also to make comparison and correlations with the findings for male students from wider perspective.**

## METHODOLOGY

**During the summer semester 2009, there was around 300 students (about 200 male, and about 100 female students) enrolled in three directions of computer science at Department of Mathematics and Informatics, Faculty of Science, University of Novi Sad (approximately 46 000 student population). In a survey voluntarily participated 108 students, out of which 42 were female students and 66 were male students. The following percentages represent how the sample was classified by year in school: 40% freshmen, 30% second-year, 10% third-year and 20% fourth-year. Data was collected in May 2009 using a questionnaire as an instrument. One group of questions was given in the form of statements and participants responded according to the Likert scale from 1 (*Strongly Disagree*) to 5 (*Strongly Agree*); while the other group of questions required a "yes/no" choice. This methodology was also successfully applied in [Sumak], [Greening], [Beyer]. The questionnaire consisted of overall 33 questions, sorted in three categories according to their goals: General data, Motivation and Ambition. Three key points of the research were addressed:**

- **General success rate**
- **Students' motivation and ambition regarding career**
- **Students' attitudes towards the gender issue**

**Calculations were performed using *Minitab 15* statistics software. Data was analyzed through descriptive statistics and a series of Two sample t-tests with standard signifycance level of 0.05, in order to prove or dispute specific hypotheses about correlations between female and male students' opinions. Assumption of the t-test is that two groups of samples are of equal cardinality, and therefore male population sample was each time randomly split to fit the number of female answers, followed by normality check where needed. Mann-Whitney U test was used on certain features to further confirm whether there was divergence by gender.**

## DATA ANALYSIS, RESULTS 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

**Grading system for higher education in Serbia is established in a form of a scale from 5 (failed) to 10 (outstanding excellence). General success rate of the population observed is given in Table 1. There seems to be no gender difference ($p = 0.438$), while female students show no changes in their performance, evaluated in the previous studies [Putnik], [Ivanovic]. Bologna education system, introduced at our Department in 2006, resulted in the significantly higher passing rate and higher average success rate [Putnik]. When asked whether they feel more comfortable with CS-related, than with math-related courses, both female and male students answered affirmatively (70.00%, 87.88%, respectively). Authors in [Fisher] suggested that girls are more inclined to mathematical than informatics-related subjects, but we see that is not the case at our department.**

**Table: 1**
**Average success rate by gender**

| May 2009 average mark | female [%] | male [%] |
|---|---|---|
| 6.00-7.00 | 7.32 | 7.94 |
| 7.00-8.00 | 36.57 | 41.27 |
| 8.00-9.00 | 43.90 | 38.10 |
| > 9.00 | 12.21 | 12.69 |

## Professional motivation, ambition and confidence

**Participants responded to the question: "How did the following factors influence your decision to enroll this faculty?", according to the Likert scale from 1 (*Not at all*) to 5 (*Very much*). Statistics are summarized in Table: 2.**

**Table: 2**
**Motivation for the choice of studies**

| Factors of influence | Female [Mean value, St. dev.] | | Male [Mean Value, St. dev.] | |
|---|---|---|---|---|
| Interest in computers | 4.051 | 1.050 | 4.588 | 0.833 |
| Parents | 1.700 | 1.114 | 1.627 | 0.967 |
| Potential financial security | 3.100 | 1.355 | 2.716 | 1.289 |
| High income | 3.075 | 1.403 | 2.642 | 1.356 |
| Perspective profession for the future | 4.250 | 0.981 | 4.209 | 0.897 |
| Possibility of making progress | 4.325 | 0.888 | 4.186 | 0.839 |
| Possibility of working alone, independently | 4.075 | 1.141 | 4.045 | 0.919 |
| Low risk of unemployment | 4.025 | 0.974 | 3.471 | 1.263 |
| Flexible working hours | 3.625 | 1.079 | 3.627 | 1.099 |
| Variety of employment options | 4.175 | 0.958 | 4.206 | 0.907 |
| Usage of up-to-date technologies | 4.282 | 0.916 | 4.375 | 0.845 |
| Possibility of employment abroad | 3.225 | 1.577 | 3.955 | 1.342 |

**Statistics showed that there is divergence by gender when interest in computers is considered as an influence factor on the choice of studies ($p = 0.008$), which supports claims by [Fisher], explained in Section 2. Moreover, male students expressed significantly higher interest in going abroad ($p = 0.017$). On the other hand, female students expressed greater fear of unemployment ($p = 0.012$). Examining the other factors, no significant gender difference was observed ($p > 0.05$). Influence of parents is lower than predicted by related research [Fisher]. Next, students were asked about the role models who possibly inspired them to choose computer science as their profession to be. They were given options, which they rated upon the volume of influence, according to the Likert scale from 1 (*Not at all*) to 5 (*Very much*).**

**Table: 3**
**Role models which inspired students' choice of studies of CS**

| Role-models | Female [Mean value, St. dev.] | | Male [Mean Value, St. dev.] | |
|---|---|---|---|---|
| Female teachers and professors | 1.974 | 1.442 | 1.565 | 1.906 |
| Male teachers and professors | 1.692 | 1.151 | 1.871 | 1.349 |
| Parents | 1.526 | 1.133 | 2.028 | 1.610 |
| Older female colleagues | 1.410 | 0.910 | 1.607 | 1.320 |
| Older male colleagues | 1.872 | 1.341 | 2.213 | 1.603 |

**No significant divergence by gender of sample was noted ($p > 0.05$). However, when parents as role models are considered, there is a slight difference in favor of men ($p = 0.061$), predicted also by research of [Fisher]. Interestingly, it also seems that students did not have role models from the field of CS before coming to university. We may pose a question – does that change over time? The reactions are given in Table 4.**

**Table: 4**
**Ratings of professional expertise from representatives of the following groups, by what students have experienced during the studies**

| Groups | Female [Mean value, St. dev.] | | Male [Mean Value, St. dev.] | |
|---|---|---|---|---|
| Female teachers and professors | 4.310 | 0.811 | 3.469 | 1.112 |
| Male Teachers and professors | 4.477 | 0.762 | 4.109 | 0.758 |
| Parents | 2.023 | 1.123 | 1.687 | 0.924 |
| Older female colleagues | 3.643 | 1.144 | 2.909 | 1.199 |
| Older male colleagues | 3.767 | 1.088 | 3.554 | 1.275 |

**Firstly, here we can notice that female students have significantly more positive opinion about both female and male teachers than their male peers do ($p < 0.001$, $p = 0.015$, respectively). Students agree upon that their parents are not very skillful regarding IT, which might point to the issue of general low level of computer literacy in Serbia.**

**There was a significant divergence by gender in observation of professional skills of female students of higher years ($p = 0.002$), where male students assessed their older female colleagues in studying more negatively in average than their female peers. Taken into account general success rate presented, where we see there is no gender difference noted in performance, we may conclude this is a clear sign of discrimination. On the other hand, expertise of male students of higher years was equally overall positively rated.**

**If we observe the answers taking gender of role models into consideration, we may conclude that male students generally think their female teachers are less skillful than male teachers, as well as that female students of higher years are less competent than their male peers ($p < 0.001$, $p = 0.002$, respectively). On the other hand, female students perceive teachers and their older colleagues in studying in no correlation to gender ($p > 0.05$). These findings may be noted as another discrimination issue.**

**Next, on a question "Overall, are grades important to you"? students answered in different manner observed by gender. Marks are high priority for 52.22% of female students, and only 36.37% of male students. Results for female students match the prediction from [Ivanovic].**

**When asked whether they plan to continue their education through master degree studies, a great majority of both female and male students answered affirmatively. More data about their ambitions regarding their future academic career is summarized in Table 5. Analysis showed no distribution difference between female and male answers ($p = 0.904$).**

**Table: 5**
**Ambitions regarding graduate studies**

| "When in position to choose, where would you enroll master studies?" | female [%] | male [%] |
|---|---|---|
| At the same faculty/department | 55.10 | 48.72 |
| At some other faculty/department in the country, staying in the field of CS | 4.08 | 8.98 |
| At faculty abroad, staying in the field of CS | 28.58 | 33.33 |
| At faculty abroad, in some other scientific field | 4.08 | 2.56 |
| No need for master degree, there is enough learned during bachelor studies | 8.16 | 6.41 |

**In order to explore students' ambitions in more detail, participants were asked first to describe on which job position they expect to find after completion of studies (Table 6). After that, they were asked to express their expectations about their career and job position in 10 years from now (Table 7). They answered according to the Likert scale from 1 (*Not likely*) to 5 (*Most likely*).**

**Female students expressed significantly higher ambition to become professors after their graduation, comparing to their male peers ($p = 0.030$). Generally, female students appear more ambitious in comparison to results presented in [Ivanovic]. Considering other career options, there was no difference between female and male students' points of view ($p > 0.05$). General option of being a programmer seems to be the most preferred, while there is overall significantly lower interest in job positions in education than it was reported in [Ivanovic]. In the assessment of job perspectives in the next ten years, students showed no divergence by gender in terms of their ambitions ($p > 0.05$).**

**Table: 6**
**Job perspectives after completion of studies**

| "On which job position do you see yourself after completion of studies?" | Female [Mean value, St. dev.] | | Male [Mean Value, St. dev.] | |
|---|---|---|---|---|
| Programmer, project developer of IS, system administrator, computer networks | 4.366 | 0.859 | 4.060 | 1.071 |
| Team leader at some IT department | 3.827 | 1.264 | 3.833 | 1.158 |
| Manager of some software development unit | 3.349 | 1.207 | 3.591 | 1.176 |
| Owner of a software development company | 3.325 | 1.457 | 3.738 | 1.253 |
| Professor | 2.878 | 1.503 | 2.234 | 1.521 |
| Not in the field of CS | 2.049 | 1.341 | 1.939 | 1.346 |
| Basically, anything abroad | 1.625 | 1.079 | 1.879 | 1.183 |

**Table: 7**
**Job perspectives in the next ten years**

| "Being realistic, on which job position do you see yourself in 10 years?" | Female [Mean value, St. dev.] | | Male [Mean Value, St. dev.] | |
|---|---|---|---|---|
| Programmer, project developer of IS, system administrator, computer networks | 4.049 | 1.182 | 3.621 | 1.237 |
| Team leader at some IT department | 3.642 | 1.317 | 3.191 | 1.296 |
| Manager of some software development unit | 3.225 | 1.143 | 3.045 | 1.261 |
| Owner of a software development company | 3.075 | 1.403 | 3.091 | 1.389 |
| Professor | 2.780 | 1.458 | 2.273 | 1.342 |
| Not in the field of CS | 2.026 | 1.305 | 2.227 | 1.444 |
| Basically, anything abroad | 1.850 | 1.312 | 2.000 | 1.177 |

**However, a very interesting conclusion comes from a comparison of Table 6 and Table 7. Namely, it is noticed that the ambitions of both female and male students regarding their career decrease over time, which is somewhat a paradox.**

**Table: 8**
**General future expectations regarding career**

| "How do you professionally see yourself in the future?" | Female [Mean value, St. dev.] | | Male [Mean Value, St. dev.] | |
|---|---|---|---|---|
| Being socially acknowledged | 3.750 | 0.899 | 3.697 | 1.095 |
| Being confident in your professional skills | 4.025 | 1.025 | 4.091 | 0.972 |
| Being ready for life-long learning and | 4.350 | 1.001 | 4.258 | 0.882 |

| | | | | |
|---|---|---|---|---|
| aquiring new skills | | | | |
| Being up-to-date with technology | 3.821 | 0.997 | 4.123 | 0.739 |
| Expecting fair relationships with colleagues | 4.200 | 1.403 | 3.703 | 0.937 |
| Expecting that colleagues will share their knowledge and experience | 3.925 | 1.141 | 3.455 | 1.205 |
| You will share your knowledge and experience with younger colleagues | 4.175 | 1.059 | 3.909 | 1.173 |

We may presume that it would be reasonable to personally expect better positions during the time of the age of thirties, instead of during the period just after the graduation, while one is yet at the beginning of his/her professional life. In order to further investigate students' professional confidence, we focused on their expectations of personal future career capabilities, by asking them "How do you professionally see yourself in the future?" and providing them certain possible answers to rate. Results are summarized in Table 8.

Statistics show that there was a significant difference between female and male students' expectations of fair relationships with colleagues; as well as expectations that colleagues will share their knowledge and experience with others. Female students incline to more positive opinion about professional cooperation ($p = 0.016$, $p = 0.047$, respectively). This might be considered as a little bit odd, because of the noted discrimination towards women in IT (Table 4). Otherwise, no divergence by gender could be reported considering factors given in Table 8.

**Table: 9**
**General expectations regarding the field of CS in the future**

| "Please point out which fields of CS, in your opinion, overall promise the most?" | Female [Mean value, St. dev.] | | Male [Mean Value, St. dev.] | |
|---|---|---|---|---|
| Programming | 4.341 | 0.883 | 4.169 | 1.009 |
| System analysis | 3.512 | 0.779 | 3.308 | 0.983 |
| Project development | 4.025 | 0.862 | 3.800 | 0.887 |
| Software maintenance | 4.100 | 0.871 | 3.627 | 1.071 |
| Hardware maintenance | 3.625 | 0.897 | 3.417 | 1.242 |
| Developing help systems/user manuals | 2.950 | 0.783 | 2.540 | 1.119 |
| Creating user interface | 3.854 | 0.937 | 3.922 | 1.028 |

Students were asked to elaborate about siginificance of different types of activities in CS in the future. Results, which are presented in Table 9, show that female students are more interested in software maintenance and development of help systems and user manuals than their male colleagues ($p = 0.014$, $p = 0.031$, respectively). Students share the opinion regarding the other areas of CS that were questioned ($p > 0.05$), including programming. Biggest interest was awaken by the fields of programming, software maintenance and project development. Female participants generally gave more affirmative answers, with less variation.

### Attitudes towards the gender issue

Students' attitudes and beliefs towards the gender differences were expressed through reactions on the statements which are quoted together with percentages of "Yes" and "No" answers in Table: 10

**Table: 10**
**Attitudes towards gender issues**

| Statement | female Y/N [%] | | male Y/N [%] | |
|---|---|---|---|---|
| CS is a good field for women. | 88.10 | 11.90 | 73.44 | 26.56 |
| CS is a good field for men. | 100.00 | 0.00 | 100.00 | 0.00 |
| There is a lack of women in CS. | 73.18 | 26.82 | 46.15 | 53.85 |
| Stereotypes about women in CS are unjustified. | 85.71 | 14.29 | 70.76 | 29.23 |
| Stereotypes about men in CS are unjustified. | 73.18 | 26.82 | 71.21 | 28.79 |

**. While in average they do agree that CS is a good field for women, there was absolutely no doubt that CS is a good field for men (100% of positive answers, both male and female). Female students seem to be more aware about the lack of women in CS than in the previous studies made at the department [Ivanovic], but preserve the high level of confidence, refusing the stereotypes.**

**Participants were also asked to further elaborate about their views on the subject of women in IT, by rating on Likert scale from 1 (Not at all) to 5 (Very much) the opinions given in Table 11. These results reveal the highest variations in the survey between male and female students' opinions. The only point they agree upon is that women do not tend to be ready to sacrifice family life in favor of career ($p > 0.05$). Otherwise, female students showed far greater belief in capabilities of women in CS than their male colleagues ($p < 0.001$). It remains unclear whether that is so because male students see no gender differences, or because they do not appreciate enough the potential of their female colleagues.**

**Table: 11**
**Women in CS**

| In CS, women tend to be: | Female [Mean value, St. dev.] | | Male [Mean Value, St. dev.] | |
|---|---|---|---|---|
| More careful than men | 3.925 | 1.366 | 2.857 | 1.390 |
| More skillful than men | 3.075 | 0.927 | 1.935 | 0.939 |
| Ready to sacrifice family life in favor of career | 2.725 | 1.329 | 2.334 | 1.277 |
| Better workers than men | 3.025 | 1.250 | 1.984 | 1.138 |

## 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 levels of:**

- **Ambition,**
- **Motivation,**
- **Interest,**
- **Comfort,**
- **Confidence,**
- **Success**

**among both female and male undergraduate students of all computer science directions.**

**The research confirmed most of our previous findings [Ivanovic], that the female students of computer science at our department show a surprisingly high level of gender self-awareness and confidence. The female 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 hypothesis 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].**

**However, results reveal gender differences in opinions about women in IT, where male students expressed serious doubts about capabilities of female computer scientists and a general lack of role models.**

**Therefore, we may conclude that in the aim of narrowing the gender gap and deprivation of discrimination in IT, both male and female students must be influenced through gender-sensitive education strategies. 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 graduate level. 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.**

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