Project funded by: Erasmus+ / Key Action 2

2020-1-HR01-KA226-HE-094713

O4 – Pedagogical strategy for female students in IT disciplines

November 2023

2020-1-HR01-KA226-HE-094713

CODEIN

Cloud cOmputing for Digital Education INnovation

Work Package:	**Intellectual Outputs**
Product/Deliverable:	**O4 - Pedagogical strategy for female students in IT disciplines**

Version:	**1**	**Date:**	**November, 2023**
Type:	**e-book**		
Distribution:	**Project Partners**		
Responsible Partner:	**University of Aveiro/ Šibenik University of Applied Science**		
Author:	**E.Pereira/A.Vukičević**		
Contributors:	**All Partners**		
Approved by:	**Quality Assurance Team**	**Date:**	

Identification Sheet

Project Code	**2020-1-HR01-KA226-HE-094713**
Project Acronym	**CODEIN**
Project Full Title	**Cloud cOmputing for Digital Education INnovation**

Keywords	IT technology, learning strategy, female students, stereotypes in computer science, positive motivation
Abstract	This document describes new pedagogical strategy for female students in IT disciplines through understanding stereotypes, cultural implications and finally through suggestions for inclusive IT education. While these strategies are especial relevant for supporting females in IT, many are also important approaches for males. Further, good lecturing in general together with positive reinforcement with students lays a crucial foundation for supporting all students in IT.
Disclaimer	This project has been funded with support from the European Commission. This publication reflects the author's views only, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Contents

1. INTRODUCTION

The need for Information Technology (IT) education is recognized as being of central relevance for meeting social and economic challenges, as well as for developing a scientifically, mathematically, and technologically literate citizenry. In many countries, however, there are gender differences in the participation and achievement of women in IT and Science, Technology, Engineering, and Mathematics (STEM) education and careers.

This document investigates the current situation at five European High Education Institutions (HEI) through the application of a questionnaire and based on the obtained results describes a new pedagogical strategy for female students in IT disciplines through understanding stereotypes, cultural implications, and finally through suggestions for inclusive IT education.

The remainder of this document is organized as follows. Section 2 presents and discusses the results of a survey on pedagogical strategy for teaching female students that was run among High Education Institutions' students on different levels of study distance learning coming from five different European countries. Starting from this, in Section 3 we describe the importance of understanding stereotypes of female students in IT; the importance of exposure to female role models, and supporting monitoring programs as some of the main challenges in distance learning. Next, in Section 4, we lay down the framework for female computer science students. In Section 5 we define some of the most common issues in STEM education, while Section 6 analyzes some of the gender differences in IT studies. Finally, we list some concluding remarks in Section 7.

2. A SURVEY ON PEDAGOGICAL STRATEGY FOR TEACHING FEMALE STUDENTS IN IT

Based on the literature review done previously, a questionnaire was designed and applied to the students of the five partner's HEI: University of Aveiro (Portugal), Šibenik University of Applied Science (Croatia), LUISS University (Italy), Tecnhological University of Lodz (Poland), Tecnologic University of Zilina (Slovakia).

The purpose of the survey is to identify and support pedagogical strategies to increase female students' active participation in Information and Communications Technology (ICT) courses, gender equality in an ICT career graduation, and contribute to women's engagement in the digital economy. The research was conducted among female and male students from four different levels of study: undergraduate, graduate, post-graduate, and post-doctoral students.

2.1. The results of the survey

The following paragraphs describe the results of the survey on pedagogical strategy for teaching female students in IT applied to higher education students in the five different European countries.

The respondents came from five different EU countries: Croatia (18%), Italy (26%), Poland (28%), Portugal (14%) and Slovakia (2%). The questionnaire contained 13 different statements, listed below. Respondents could express their degree of agreement/disagreement with each statement according to the scale: Strongly disagree; Disagree; Neither agree nor disagree; Agree; Strongly Agree.

Aneswered to the questionnaire 106 students. According to the level of studies (Q2) were 57% Undergraduate (1st cycle), 31% Graduate (2nd cycle), 7% Post-Graduate Studies (PhD or 3rd cycle) and 3% Post Doctoral studies.

The questions 3 to 12 and the obtained answers are presented in Table 2.1.

Table 2.1 – Obtained answers to Questions 3 to 12

Question	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Q3: Using mixed-ability, collaborative rather than competitive group work as preferred teaching method	3%	7%	24%	42%	22%
Q4: Providing diverse historical and contemporary female role model in IT and their work (guest speakers, class materials) is highly motivational	4%	5%	28%	38%	25%
Q5: Using gender is inclusive language when discussing occupational roles	10%	8%	28%	41%	11%
Q6. Using gender-inclusive teaching material will help challenge potential stereotypes about females in IT	14%	9%	29%	37%	9%
Q7: Offering non-integrated curricular courses (summer school, workshops, seminars) and out-of-contact hours (online training, seminars) will encourage female students to participate more in IT programs with peers	5%	6%	28%	44%	15%
Q8: Teaching female students by offering workshops can strengthen their own IT performance and participation	5%	3%	24%	43%	22%
Q9: Teachers should stay well informed of good local programs and events, contests, and other learning opportunities to promote	5%			53%	40%
Q10: Developing greater competence and confidence, as well as enthusiasm for teachers' own IT knowledge and skills is crucial for the teaching process		1%	10%	50%	37%
Q11: It is important for the High Educational Institution teachers to grow professionally by learning more about gender issues in IT disciplines	5%	8%	24%	39%	21%
Q12: Students feel well prepared about the obtained skills at the High Educational Institution to develop an equal career in the labor market	3%	11%	29%	43%	12%

In question 13, the students were questioned about their opinion about the main obstacles for female students in IT. 26% of the responders to this question were men. The majority identified as main obstacles as:

- Gender bias, discrimination in the workplace, a lack of female role models
- STEM studies are difficult for the majority of people
- Male peers are perceived as more skilled
- Lack of female followers
- Prejudices - IT is thought of as a male job area
- That it is a male-dominated field.
- Stereotypes about women, that they're more emotional than logical

2.2. Main findings from the survey

Most of the surveyed students believe that the main obstacles are the belief that IT is still perceived as a male dominated field, together with the fact there are not enough female followers or female role models in IT.

When discussing occupational roles the use of gender–inclusive language is more preferred among the students, as well as the fact that teachers should stay well informed of good local programs and events, contests, and other learning opportunities to promote. Surveys have shown that developing greater competence and confidence, as well as enthusiasm for teachers' own IT knowledge and skills is crucial for the teaching process and that students feel well prepared about the obtained skills at the HEI to develop an equal career in the labour market.

Another finding from the survey is that offering non-integrated curricular courses (summer school, workshops, seminars) and out-of-contact hours (online training, seminars) will encourage female students to participate more in IT programs with peers.

3. UNDERSTANDING STEREOTYPES OF FEMALE STUDENTS IN IT

The future is expected to be digital with labor market based on a next generation of jobs characterized by a huge increased demand for people with computational and problem-solving skills (Box, 2018; Spieler, Oates-Induchovà & Slany 2020).

The knowledge and learning about CS and digital technologies for young people is today imperative, and taking in account the underrepresentation of women in the computing industry is relevant to reinfornce these dimensions and improve the knowledge of yourn people in general,

Wing (2006), focused on reinforcing Computational Thinking (CT) skills among students and promoving coding as a mandatory skill, states that this is a a new way of thinking, problem-solving and critical thinking tasks in the classroom relevnt to advire competences for future works and jobs. These results were incorporated into the United States of America (US) curricula of many federal states of the US, in K-12 movements, and I by Barack Obama in 2016 in the "Computer Science For All" initiative (Spieler, Oates-Induchovà & Slany, 2020).

Nowadays, teaching and improving competencies in CT skills are very important. In Europe, many countries organize contests intending to help students of different age groups to develop CT skills, to boost interest in CS, to think about tricky tasks related to CS, to disseminate basic concepts of CS, and to promote diversity and empower girls (Spieler, Oates-Induchovà & Slany 2020). These authors state that this course's curriculum materials are designed to recruit, engage, and retain women and people of color and to share inspiring videos and role models; and that as a result of this the statistics of courses show a high amount of female participants. They also cite other institutions that bolster initiatives in CS for girls, such as the cases of GirlsWhoCode‡ or Codefirst: Girls§.

Spieler, Oates-Induchovà, and Slany (2020) also state the relevance of two trends that emerged around 2006, and that contributed to the success of teaching CT skills to all students:

> "*First, a number of block-based visual-oriented programming tools were introduced which should help novice programmers and young learners in their first programming steps (…). Second, the widespread use of smartphones can change how learning takes place in many disciplines and contexts. Mobile devices are more frequently used than computers or tablets and from the age of 12 almost all are online (Bitkom, 2019). They are already a part of our culture and for most adolescents, the smartphone performs several functions of their daily lives. As a result, a new generation of young digital natives emerged.*" (*Spieler, Oates-Induchovà, and Slany, 2020:473)*

Recent world statistics indicate that women's representation in Information and Communications Technology (ICT) professions and related university programs has not improved and women's employment in these occupations increased at a slower rate than men's employment in the past decade (European Statistics Eurostat, 2023). Jobs and university programs in ICT are clearly male-dominated were in 2022, with 81% male compared to 19% female working as ICT specialists (World Economic Forum Statistics, 2023). Further data gathered by the European Statistics Eurostat (2023) confirms a low percentage of 4% of graduates in the European Uninion in the ICT field , with t higher proportion of graduates in ICT in Estonia (10%) and Ireland (8%), in contrast to 2% in Italy and 3% in Portugal, Belgium and Cyprus. About women with a degree in ICT studies only 2% of female graduates had a degree in ICT, with Estonia (18%), Finland and Malta (both 14%) having the largest shares of ICT graduates among male graduates, while Estonia (5%), Ireland and Romania (both 4%) had the largest shares among female graduates (European Statistics Eurostat, 2023).

According to Spieler, Oates-Induchovà, and Slany (2020), the gender gap in ICT is not a universal constatation and does not verify a significative difference in Eastern Europe, like the cases of Romania, Bulgaria, or Latvia. This is based on the strong tradition of educational ideals on mathematics and sciences of the countries of communist regimes of the former Eastern Bloc, which prioritized hard sciences over social sciences and humanities (Sanders, 2005; Ciobanu, 2018; Oates-Indruchovà, 2020). So in this case, female students have role models that influence cultural stereotypes (Spieler, Oates-Induchovà & Slany, 2020).

Bell and White (2014), Beekhuyzen et al. (2008), and Spieler, Oates-Induchovà, and Slany (2020) also mention the cases of underrepresentation of women in ICT worldwide, referring that in the US women hold 11% of executive positions at Silicon Valley companies and white men dominate college CS departments. In 2017, in Australia, about 46.2% of women were in the workforce but only around 30% were in the roles of technology (Charleston, 2017). In developing countries, the digital gap is higher (Buskens & Webb, 2014) with men in Africa having almost twice as women to have access to the Internet, and in the sub-Saharan Africa regions, about 45% of the women have no Internet access (Spieler, Oates-Induchovà & Slany, 2020). On the other side, according to these authors, in Israel, 61% of the students in CS classes are female. However, Spieler, Oates-Induchovà, and Slany (2020) based on Stoet and Geary (2018) state that countries that have the most female college graduates in STEM and CS are also some of the least gender-equal countries.

Spieler, Oates-Induchovà and Slany (2020) cite the sentence of Ripley (2017) *"[A] boy doesn't* *need to study hard to have a good job. But a girl needs to work hard to get a respectable job*" and the World Bank statistics about the small proportion of female workforce across Middle East Arabic countries, of 16% in Saudi Arabia and 8% in Yemen. The statistics from Asia show mixed numbers, with 60% of female students in CS programs in Malaysia or around 50% (no gender gap) of female students in CS programs both at Chang Gung University in Taiwan and Mahidol University in Thailand (Ong, 2016). In the case of Japan, at Hiroshima University, only 4% of the students are female, which contrasts with India, where the problem women face is a barrier to entering in labor market (Oliver, 2017).

So, across countries, there are different realities in many cases related to the different cultures, and some of the countries empower women to choose the career they are interested in the most. However, it is well-recognized by many authors (Bers et al., 2014; Gabay-Egozi et al., 2015; Unfried et al., 2015; Zagami et al., 2015; Beyer, 2016; Khan & Luxton-Reilly, 2016; Ko & Davis, 2017; Spieler, Oates-Induchovà & Slany, 2020) that gender gaps in CS do not start at universities or industry or labor market, but between the ages of 12 to 15, or even earlier in childhood.

The seminar research developed by Margolis and Fisher (2002) examined the impacts at the college and high school level on young girls' motivation for CS and contributed to analyzing the gender gap in CS. On the other side, some research documented low competencies of girls towards computer sciences, which could be changed through the contact of girls with technology at an early age and before stereotyping discourages them (Carter, 2006; Sadler et al., 2012). Unfried et al. (2015) and Master et al. (2016) on their research concluded that female students do not feel motivated to learn about technology as well as they are not encouraged by friends or their family to it.

3.1. Exposure to female role models

Lockwood (2006) presents two studies that examined the importance of female role models for career choices in first-year female students. The results showed that i) women prefer female career role models to male ones, and ii) that they derive special benefits from gender-matched role models, by naming their achievements.

Women must see female role models who have succeeded and who promote positive beliefs regarding women's abilities, which demonstrates that this job field can suit them as well (Young, 2013). Since the technology sector is very male-dominated, most role models are also male.

However, the study emphasized that women who had to overcome gender stereotypes or are successful in traditionally male-dominated fields are most effective as role models.

Cheryan et al. (2011), based on experiments with female non-CS majors, argue that role models who were perceived as very stereotypical can have a negative influence on women's choices. They consider as examples of role models people who prefer stereotypical games or movies (for example he cases of Star Wars or Star Trek), a stereotypical appearance (for example the case of female computer scientist who wears glasses), or a role based in a supernatural genius in her field (for example a girl who started programming with a very early age). According to Spieler, Oates-Induchovà, and Slany (2020: 477) "*If role models are presented as somehow supernatural, it implies to girls that only outliers and geniuses would succeed in a field that is not typical for their gender"*.

Female role models perform particular importance in the choice of degrees and career aspirations and attitudes; and mostly refer to models at every stage from secondary school, college, or university professors in mathematics or science, female students, faculty members in higher education, and women working in STEM fields (Young et al., 2013). According to this author, female professors were viewed as more positive role models than male professors.

Some other authors developed research studying the repercussion of role models, steriotypes and attributes of girls choices based on gaming environment (Dele-Ajayi et al. , 2018) or on questionnais applied to high school girls (Semmens, Piech & Fried, 2015). Those attributes mentioned at the end of the course were more positive and less stereotypical.

3.2. Supporting monitoring programs

Mentoring programs have appeared in the last two decades. Mentors not only act as role models but additionally provide guidance, for example by increasing one's self-confidence during a task completion, or during the first semesters of university study.

A study by Clarke-Midura et al. (2016) evaluated programs designed to encourage female high school students to volunteer for mentoring programs to help girls from middle school in CS to empower both age groups. This near-peer mentoring provided a positive experience for both groups in terms of interest and self-efficacy. Two studies by Ko and Davis (2017) investigated if mentoring enhances students' interest, beliefs, and engagement levels in CS. The results showed that students who had mentoring relationships with different kinds of people, including friends, parents, siblings, cousins, teachers, and even neighbors, were influenced positively. For example, they were more interested in computing (e.g., incorporating computing into their identities), had more positive beliefs about people working in CS (e.g., the associated attributes were "creative", "intelligent", or "hard-working"), and finally, felt more engaged in coding opportunities (e.g., encountering more programming languages).

The report by The Association for Women in Science (2017) identifies mentoring as being

> *"[A]mong the most effective ways to bring about change, because it reaches across institutions, fields, and even generations. Mentoring unifies women, validates their experience, provides inside information about the system's workings, trains groups of individuals to challenge the system, and provides the basis for generations of outsiders to both enter the system and, as insiders, demand needed change."*

In male-dominated fields, female students need encouragement. However, The Association for Women in Science report did not indicate if mentors must be women or if it is only important to have somebody who believes in them and encourages them.

4. FRAMEWORK IN FEMALE COMPUTER SCIENCE STUDENTS

The model of Cheryan et al. (2017) is based on three elements, that combine and interact to make certain fields unattractive or inhospitable for women: i) the masculine culture of these fields, ii) the lack of early exposure for women, and iii) women's lack of belief in their ability to succeed. However, this model does not aim to offer a comprehensive overview of the experiences of women in these fields, and there are some aspects of women's experiences in STEM that are not considered in the framework. According to Ayre et al. (2023) and Fouad et al. (2011), the framework does not cover the experiences of everyday sexism, microaggressions, and sexual harassment that women in STEM fields report as well not refer to women's struggle to see how to best navigate their careers within STEM fields (Yates & Skinner, 2021). So, all of these might be thought to contribute to an environment that is unwelcoming or hostile to women.

4.1. The masculine culture

The notion of a 'gendered organization' (Acker, 1990) has contributed to our understanding of women's experiences in STEM organizations and the barriers they face to career progression (Yates & Skinner, 2021). The term refers to organizational cultures that purport to be fair and meritocratic, assuming that all employees are held to the same standards and given the same opportunities, but which, in reality, favor men, through standards that are easier for men to reach and opportunities which are better suited to men.

A 'gendered classroom' extends this idea, referring to a classroom that is assumed to be gender-neutral but which is in reality tailored towards male students (Yates & Skinner, 2021). This concept of the gendered classroom has not been widely applied to computer science education, but the existing literature suggests that this might be a useful lens through which to understand the experiences of female computer science students.

Women are shown to be more likely to be motivated by communal goals and men by agentic goals, so a pedagogical style or a learning environment that appeals to agentic learners, and which is unappealing to communal learners, favors male students (Bakan, 1966; Eagly et al., 2000; Riegle-Crumb et al., 2019). Those motivated by communal goals are drawn to supportive relationships and collaboration and want to see a pro-social purpose to their endeavors. Those motivated by agentic goals are spurred on by competition, enjoy autonomy and independence, and are motivated to learn for their interest in the topic. Women and girls tend to prefer more communal learning environments (Brotman & Moore, 2008), characterized by supportive relationships (Meyers-Levy & Loken, 2015; Tamres et al., 2002), with clear guidance from tutors (Aylor, 2003; Frymier & Houser, 2000; Menekse et al., 2020), and where the curriculum is made explicitly meaningful (Giannakos et al., 2017). These communal needs, more often desired by women, may not always be well met in the typical computer science classroom.

STEM careers have been linked with more agentic goals (Diekman et al., 2010) and self-directed learning is a core skill that is desirable within the technology industry (Zander et al., 2012). Computer science courses therefore tend to foster agentic goals, with an explicit focus on autonomy, independence, and self-directed learning (McCartney et al., 2016; Thomas, 2013). Competitiveness, another aspect of an agentic self, is prevalent in STEM Education and Information Technologies (2022) classrooms, where individuals strive to demonstrate their superiority through intense work and long hours (Hirshfeld, 2010, 2015; Sallee, 2011).

Research from the US that has explored the environment of the computer science classroom adds weight to the idea that computer science classrooms provide limited support for communal learners. Barker and Garvin-Doxas (2004) in a major observation study in a computer science classroom found evidence of an impersonal and guarded environment and the formation of informal hierarchies which led to competitive behavior from the students (Barker & Garvin-Doxas, 2004; Östberg, 2003, Barker, 2016). They identified certain types of discourse that hindered the development of a supportive and collaborative culture within the classroom and described a strongly defensive climate, in which trust was low, and students did not feel safe to make mistakes without risking humiliation. One last factor that may contribute to an inhospitable environment for women in the computer science classroom comes from stereotypes: women and girls may feel that they are different from their own and other's perceptions of a typical computer scientist, and this can have an impact on their feelings of belonging and their choices.

According to Yates and Plagnol (2021), based on Beyer (2008, 2014) and Cheryan et al., (2009) stereotypical computer scientists intent to reflect reality usually are male, clever, and obsessed with coding. These stereotypes are held by girls, boys, parents, teachers, and employers (Dickhäuser & Meyer, 2006; Vekiri, 2013), are entrenched from an early age (Master et al., 2017), and could make girls and women feel that they will not fit in with colleagues or be successful in the field of technology. Stereotype threat has also been shown in this field to have a negative impact on performance and has been shown to have an impact on levels of interest in some STEM subjects like engineering, and science and on girls' choices to study computer science or not at high school in the US (Yates & Plangol, 2021).

4.2. Early exposure to computer science

The second element of Cheryan et al.'s (2017) model is the lack of early exposure to the field. Many children become familiar with computers through games they play as children, but with many games characterized by their repetitive shooting, loud noises, and violent graphics, computer games are in large parts aimed at and played by boys (Hartmann & Klimmt, 2006; Dele-Ajayi et al, 2018;).

Recent evidence indicates that boys and girls spend similar amounts of time on screens throughout their adolescence but the nature of their engagement with technology is different: boys spend significantly more time playing video games and girls spend more time interacting with their friends on social media sites (Mullan, 2018). These differences have been shown to have an impact on career decisions, as evidence suggests that computer gaming is a significant positive predictor of interest and confidence in studying computer science (Sevin & DeCamp, 2016). This lack of early exposure has an impact. Girls who have been fortunate enough to have a greater degree of early exposure develop more computer self-efficacy (Master et al., 2017), and have more positive stereotypes associated with technology jobs (Cheryan et al., 2013). Some evidence show that countries that have more compulsory STEM coursework also have a better gender balance in STEM jobs (Charles et al, 2017).

4.2. Gender differences in self-efficacy

Cheryan et al. (2013) final explanation for the under-representation of women in STEM fields is their lower levels of computer self-efficacy. This trait has been widely examined, and Gürer and Camp (2002) in their review of the evidence suggest that this lack of confidence in their ability to accomplish computer-related tasks is the single most influential factor in the under-representation of women in computer science. Despite evidence that men and women tend to perform equally well in computer courses (Beyer, 1999, 2008; Georgiou et al., 2007), women consistently rate their computer ability as lower than men rate theirs (Lehman et al., 2016). This discrepancy is the result both of women underestimating their ability (Beyer, 2008) and men overestimating theirs (Bench et al., 2015). Women's lack of belief in their abilities has been shown to have an impact on their career plans (Beyer, 2014; Dempsey et al., 2015; Rosson et al., 2011), expectations of success in the technology industry (Appianing & Van Eck, 2015), the development of occupational identity (Carlone & Johnson, 2007; Dempsey et al., 2015), intention to study IT (information technology) at school (Sáinz & Eccles, 2012), and interest in the field (Margolis et al., 2000).

5. MOST COMMON ISSUES IN STEM EDUCATION

In the last decade, several studies investigated particular variables involving students' attitudes towards STEM education (Lane at al, 2022).

According to Falk et al. (2017), research findings assumes that females have lower interest levels in STEM compared to males Social inclusion factors are noted as a particular reason for lower interest. Means et al. (2021), according to Lane et al (2022), state a large-scale meta-analysis of the relationship between attendance at an inclusive STEM high school and a range of academic and motivational outcomes, because selecting students based on prior academic achievement, inclusive STEM high schools provide opportunities for underrepresented youth to develop STEM interests and talent.

The Means et al. (2021) research about metanalysis allow to conclusde that the students who attended an inclusive STEM high school compared with non-STEM schools report high interest in undertaking a graduate degree and in entering a STEM career, and this effect was also found for low-income and female students. These studies call on the need to focus on equity-oriented interventions that increase the social belongingness of students in STEM domains where there is unequal participation by gender to increase interest in STEM (Lane et al, 2022).

6. GENDER DIFFERENCES IN IT STUDIES

Blažev et al (2017) study the school pupils in Croatia shows that male students and those who had previous success in STEM subjects are more likely to hold stereotypical beliefs about STEM. Several factors have been proposed to positively impact stereotypical beliefs, such as the presence of females in a class (Gunderson et al., 2012; Master et al., 2016; Riegle-Crumb et al., 2017). Riegle-Crumb et al. (2017) conducted a study regarding the presence of females in high school classes. They reported that female peers had a positive impact in reducing male peers' stereotypical beliefs. The presence of female teachers seemed to have a similar impact: Master et al. (2016) found that female teachers reduced female students' concerns about being negatively stereotyped in classroom situations.

In contrast, Gunderson et al. (2012) reported that gender-biased stereotypes about females' mathematics capabilities are cultivated, rather than ameliorated, by teachers. Exposure to role models is often promoted as a way of overcoming negative stereotypical beliefs about STEM. Gladstone and Cimpian's (2021) systematic review in this field yielded four recommendations for maximizing the effectiveness of role models in STEM for motivating students from diverse gender and ethnic backgrounds: i) portray role models as being competent and successful, while avoiding extreme levels of success that might instead be alienating; ii)portray role models as being meaningfully similar to students; iii) prioritize exposure to role models from groups that are traditionally underrepresented in STEM; iv) portray role models' success as being attainable.

Luo et al. (2021) investigated upper primary students' stereotypical beliefs about STEM careers and found that these beliefs negatively predicted STEM self-efficacy and career-related outcome expectations. Their findings suggest that interventions targeting STEM career aspirations need to target STEM stereotypes, self-efficacy, and outcome expectations simultaneously.

7. CONCLUSIONS

Through this paper, we have shown the major research findings concerning pedagogical strategies for female students in IT strategies. Moreover, by conducting research among female students we were able to recommend a way for educators to support and encourage females in IT disciplines. While these strategies are especially relevant for supporting females in IT, many are also important approaches for males, Further, good lecturing in general together with positive reinforcement with students lays a crucial foundation for supporting all students in IT. Educators need to continue to grow professionally by widening their knowledge about gender issues in IT disciplines and learning the tools how to address issues effectively.

REFERENCES

Acker, J. (1990). Hierarchies, jobs, bodies: A theory of gendered organizations. *Gender & Society,* 4(2),139–158.

Ayre, M., Mills, J., & Gill, J. (2013). “Yes, I do belong”: The women who stay in engineering. *Engineering Studies*, 5 (3), 216-232.

Bakan, D. (1966). *The duality of human existence: An essay on psychology and religion*. Chicago: Rand McNally.

Barker, L. J. & Aspray, W. (2006). The state of research on girls and IT. In Cohoon, J.M. & Aspray, W (Eds.). *Women and Information Technology: Research on Underrepresentation,* Cambridge, Massachusetts Institute of Technology Press, 354.

Baker, M. (2016), “Women graduates and the workplace: continuing challenges for academic women”, *Studies in Higher Education,* 41 (5), 887-900.

Barker, L. J., & Aspray, W. (2006). The state of research on girls and IT. In J. M. Cohoon, & W. Aspray(Eds.), *Women and information technology: Research on underrepresentation* (pp. 3–54). Cambridge: The MIT Press.

Barker, L. J., & Garvin-Doxas, K. (2004). Making visible the behaviors that influence learning environment: A qualitative exploration of computer science classrooms. *Computer Science Education*, 4(2), 119–145.

Barker, L. J., McDowell, C., & Kalahar, K. (2009). Exploring factors that influence computer science introductory course students to persist in the major. *ACM SIGCSE Bulletin*, 41, 282–286. Cambridge, MA: MIT Press.

Barker, L. J., O'Neill, M., & Kazim, N. (2014). Framing classroom climate for student learning and retention in computer science. In Proceedings of the *45th ACM Technical Symposium on Computer Science Education* (pp. 319–324).

Beyer, S. (1999). Gender differences in the accuracy of grade expectancies and evaluations. *Sex Roles*, 41(3/4), 279–296.

Beyer, S. (2008). Predictors of female and male computer science students' grades. *Journal of Women and Minorities in Science and Engineering*, 14(4), 377–409.

Beyer, S. (2014). Why are women underrepresented in computer science? Gender differences in stereotypes, self-efficacy, values, and interests and predictors of future CS course-taking and grades. *Computer Science Education*, 24(2–3), 153–192.

Brotman, J. S., & Moore, F. M. (2008). Girls and science: A review of four themes in the science education literature. *Journal of Research in Science Teaching*, 45(9), 971–1002.

Bers, M., Flannery, L., Kazakoff, E., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers and Education* 72, 145–157.

Beekhuyzen, J. & Dorries, R. (2008). Tech Girls are Chic! (Not Just Geek!). tech2morrow, Brisbane. Bell, D. A. & White, S. S. (2014). *Gender Diversity in Silicon Valley: A Comparison of Silicon Valley Public Companies and Large Public Companie*s. Fenwick & West LLP.

Bell, D. A. & White, S. S. (2014). *Gender Diversity in Silicon Valley: A Comparison of Silicon Valley Public Companies and Large Public Companies.* Fenwick & West LLP.

Bers, M., Flannery, L., Kazakoff, E., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers and Education,* 72, 145–157.

Blažev, M., Karabegović, M., Burušić, J., and Selimbegović, L. (2017). Predicting gender-STEM stereotyped beliefs among boys and girls from prior school achievement and interest in STEM school subjects. *Soc. Psychol. Educ.* 20, 831–847.

Beyer, S. (2016). *Women in CS: Deterrents. Encyclopedia of Computer Science and Technology Edition: 2ndChapter: Women in CS: Deterrents*, Publisher: CRC Group Editors: P. A. Laplante.

Box, S. (2018). *Digital transformation must focus on women and girls*. Policy Options Politiques, Retrieved 20th October, 2023, from http://policyoptions.irpp.org/magazines/november-2018/digital-transformation-must-focus-women-girls/

Buskens, I. & Webb, A. (2014). *Women and ICT in Africa and the Middle East: Changing Selves, Changing Societies*. In Zed Books.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching,* 44(8), 1187– 1218.

Carter, L. (2006). Why students with an apparent aptitude for computer science don't choose to major in computer science? *Proceedings of the 37th SIGCSE Technical Symposium on Computer Science Education*, 27–31.

Cheryan, S., Plaut, V. C., Davies, P. G., & Steele, C. M. (2009). Ambient belonging: How stereotypical cues impact gender participation in computer science. *Journal of Personality and Social Psychology*, 97(6), 1045–1060.

Cheryan, S., Plaut, V. C., Handron, C., & Hudso, L. (2013). *The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women*. Springer Science & Business Media, 69(1-2), 58–71.

Cheryan, S., Siy, J. O., Vichayapai, M., Drury, B. J., & Kim, S. (2011). Do female and male role models who embody STEM stereotypes hinder women's anticipated success in STEM? , *Social Psychological and Personality Science*, 2(6), 656–664.

Cheryan, S., Plaut, V., Davies, P., & Steele, C. (2009). Ambient belonging: How stereotypical cues impact gender participation in computer science. *Journal of Personality and* Social Psychology, 97(6), 1045–1060.

Cheryan, S., Siy, J. O., Vichayapai, M., Drury, B. J., & Kim, S. (2011). Do female and male role models who embody STEM stereotypes hinder women's anticipated success in STEM? *Social Psychological and Personality Science*, 2(6), 656–664.

Cheryan, S., Plaut, V. C., Handron, C., & Hudson, L. (2013). The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women. Sex Roles, 69(1–2), 58–71.

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender-balanced than others? *Psychological Bulletin*, 143(1), 1–35.

Ciobanu, C. (2018*). Eastern Europe, is heaven for women in tech.* News Mavens, Central & Eastern Europe. Retrieved 19th November 2023 from https://newsmavens.com/news/aha-moments/1326/eastern-europe-heaven-for-women-in-tech.

Clarke-Midura, J., Allan, V., & Close, K. (2016). Investigating the Role of Being a Mentor as a Way of Increasing Interest in CS. *Proceedings of the 47th ACM Technical Symposium on Computing Science Education*, 297–302.

Dele-Ajayi, O., Emembolu, I., Peers, M., Shimwell, J., & Strachan, B. (2018). *Exploring Digital Careers, Stereotypes and Diversity with Young People through Game Design and Implementation, i*n 2018 IEEE Global Engineering Education Conference (EDUCON) IEEE.

Dickhäuser, O., & Meyer, W.-U. (2006). Gender differences in young children's math ability attributions. *Psychology Science*, 48(1), 3–16.

Diekman, A. B., Brown, E. R., Johnston, A. M., & Clark, E. K. (2010). Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers. *Psychological Science*, 21(8), 1051–1057.

European Statistics Eurostat (2023), *Digitalisation in Europe*, from https://ec.europa.eu/eurostat/web/interactive-publications/digitalisation-2023, Accessed in 6 November 2023.

European Statistics Eurostat (2019). Hard-to-fill ICT vacancies: how countries compare, Retrieved September 21, 2019, from https://ec.europa.eu/eurostat/de/web/products-eurostat-news/-/DDN-20190327-1 European Statistics Eurostat (2019b). ICT specialists are predominantly male, Retrieved from https://ec.europa.eu/eurostat/de/web/products-eurostat-news/-/DDN-20190513-1

European Statistics Eurostat (2018a) Women in science and technology,https://ec.europa.eu/eurostat/web/products-eurostat-news/-/EDN-20180210-1?inheritRedirect=true.

European Statistics Eurostat (2018b). Girls and women under-represented in ICT, Retrieved in

19th November from https://ec.europa.eu/eurostat/de/web/products-eurostat-news/-/EDN-20180425-1

Falk N. A., Rottinghaus P. J., Casanova T. N., Borgen F. H., Betz N. E. (2017). Expanding women's participation in STEM: insights from parallel measures of self-efficacy and interests. *J. Career Assess*. 25, 571–584.

Fouad, N., Fitzpatrick, M., & Liu, J. P. (2011). Persistence of women in engineering careers: A qualitative study of current and former female engineers. *Journal of Women and Minorities in Science and Engineering*, 17(1), 69–96.

Gabay-Egozi, L., Shavit, Y., & Yaish, M. (2015). Gender Differences in Fields of Study: The Role of Significant Others and Rational Choice Motivations. *European Sociological Review*. 31(3), 284–297.

Giannakos, M. N., Pappas, I. O., Jaccheri, L., & Sampson, D. G. (2017). Understanding student retention in computer science education: The role of environment, gains, barriers, and usefulness. *Education and Information Technologies,* 22(5), 2365–2382.

Lane, C., Kaya-Capocci, S., Kelly, R., O'Connell, T. & Goos, M (2022), Fascinating or dull? Female students' attitudes towards STEM subjects and careers, *Front Psychol.* 13: 959972.

Lockwood, P. (2006). "Someone Like Me Can Be Successful": Do College Students Need Same-Gender Role Models? *Psychology of Women Quarterly*, 30(1), 36–46.

Khan, N. Z. & Luxton-Reilly, A. (2016). Is computing for social good the solution to closing the gender gap in computer science? *Proceedings of the Australasian Computer Science Week Multiconference*, Paper 17, 1–5.

Ko, A. J. & Davis, K. (2017). Computing Mentorship in a Software Boomtown: Relationships to Adolescent Interest and Beliefs. *Proceedings of the 2017 ACM Conference on International Computing Education Research*, 236–244.

Margolis, J., & Fisher, A. (2002). *Unlocking the clubhouse: Women in computing. Boston*: MIT Press.

Margolis, J., Fisher, A., & Miller, F. (2000). The anatomy of interest: Women in undergraduate comp Margolis J. & Fisher, A. (2003). Unlocking the clubhouse: Women in computing. MIT Press, Cambridge, MA. Master, A., Sapna, C., & Meltzoff, A. N. (2016). Computing Whether She Belongs:

Stereotypes Undermine Girls' Interest and Sense of Belonging in Computer Science. Journal of Educational Psychology, 108(3), 424–437.

Master, A., Cheryan, S., Moscatelli, A., & Meltzoff, A. N. (2017). Programming experience promotes higher STEM motivation among first-grade girls. *Journal of Experimental Child Psychology,* 160, 92–106.

Master, A., Sapna, C., & Meltzoff, A. N. (2016). Computing Whether She Belongs: Stereotypes Undermine Girls' Interest and Sense of Belonging in Computer Science. *Journal of Educational Psychology,* 108(3), 424–437.

Meyers-Levy, J., & Loken, B. (2015). Revisiting gender differences: What we know and what lies ahead. Journal of Consumer Psychology, 25(1), 129–149.

Mullan, K. (2018). Technology and children's screen-based activities in the UK: The story of the millennium so far. Child Indicators Research, 11(6), 1781–1800.

Oates-Indruchová, L. (2020). *Censorship in Czech and Hungarian Academic Publishing*, 1969-89: Snakes and Ladders. London: Bloomsbury Academic.

Oliver, T. (2017). *An In-Depth Look At The Gender Gap in the Tech Industry.* Retrieved 19th November, 2023, from https://www.technicallycompatible.com/an-in-depth-look-at-the-gender-gap-in-the-tech-industry/

Ong, P. (2016). *Tides are turning in favour of women in tech. Here's why. Tech in Asia*, Retrieved 19th November, 2023, from https://www.techinasia.com/talk/programming-brighter-future-women-tech

Ripley, A. (2017). Boys Are Not Defective. The Atlantic, Retrieved on 19th November, 2023, from https://www. theatlantic.com/education/archive/2017/09/boys-are-not-defective/540204/

Sanders, J. (2005). Gender and technology in education: what the research tells us*. Proceedings of the international symposium on Women and ICT: Creating Global Transformation. (*CWIT '05), Claudia Morrell and Jo Sanders (Eds.). 6.

Semmens, R., Piech, C., & Friend, M. (2015). Who Are You? We Really Wanna Know... Especially If You Think You'reLike a Computer Scientist. *Proceedings of the Third Conference on GenderIT (GenderIT '15)*, 40 – 43.

Sevin, R., & DeCamp, W. (2016). From playing to programming: The effect of video game play on confidence with computers and an interest in computer science. *Sociological Research Online,* 21(3), 14–23.

Spieler, B; Oates-Induchovà, L.; and Slany, W. (2020) Female Teenagers in Computer Science Education: Understanding Stereotypes, Negative Impacts, and Positive Motivation. *Journal of Women and Minorities in Science and Engineering*. 26 (5), 473-510.

Stoet, G. & Geary, D. C. (2018). The Gender-Equality Paradox in Science, Technology, Engineering, and Mathematics Education, *Psychological Science*. 29(4), 581–593.

Unfried, A., Da Faber, M., Stanhope, D. S., & Wiebe, E. (2015). The Development and Validation of a Measure of Student Attitudes Toward Science, Technology, Engineering, and Math (S-STEM). *Journal of Psychoeducational Assessment,* 33(7), 622–639.

Vichayapai, M., Drury, B. J., & Kim, S. (2011). Do female and male role models who embody STEM stereotypes hinder women's anticipated success in STEM?, *Social Psychological and Personality Science*, 2(6), 656–664.

Wing, J. (2006). Computational thinking. *Communications of the ACM*, 49(3), 33–35.

World Economic Forum Statistics (2023), *This is the state of digitalization in Europe in 2023 – Eurostat report,* Retrieved 19th October, 2023, from https://www.weforum.org/agenda/2023/09/digitalization-europe-eurostat-report/#:~:text=More%20than%209%20million%20people%20in%20EU%20member,skewed%2C%20with%2081%25%20male%20compared%20to%2019%25%20female.

Yates, J., & Skinner, S. (2021). How do female engineers conceptualise career advancement in engineering: a template analysis. *Career Development International,* 26 (5).

Yates, K. Plagnol, a.C. (2022). Female computer science students: A qualitative exploration of women experiences studying computer science at university in the UK. *Education and Information Technologies*, 3080-3105.

Young, D. M., Rudman, L. A., Buettner, H. M., & McLean, M. C. (2013). The Influence of Female Role Models on Women's Implicit Science Cognitions. *Psychology of Women Quarterly*, 37(3), 283–292.

Zagami, J., Boden, M., Keane, T., Moreton, B., & Schulz, K. (2015). Girls and computing: Female participation in computing in schools. *Australian Educational Computing*, 30(2), 1–14.