Empowering Persistence: The Impact of Mentoring on Women's Sense of Belonging in Computing Education

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Abstract. The computing field is suffering from a diversity crisis, as most of its workforce falls within a tight demographic. Homogeneous groups are proven to be less productive and less able to produce technology that meets the needs of a wide range of users. Therefore, increasing diversity by, for instance, employing more women in technology is a shared interest. Studies have shown that mentoring is one of the key success factors for recruiting marginalized groups, such as women in computing, because through its structured support it provides them with role models and makes the field more attractive. At the same time, much less research has focused on how and with what efficiency mentoring can be used to ensure that the women who are already enrolled in computing courses actually stay in the program and later in the profession, amidst significant dropout rates. Not only recruiting but also retaining women is an important prerequisite for increasing gender balance in the computing sector. The objective of this article is to present and evaluate a mentoring program that provided mentoring opportunities to female university students at three European universities in 2024-2025 with the intention of increasing their self-efficacy within various STEM fields, primarily computing. We collected data through two questionnaires – one before the mentorship program began, and then one after it finished – and examined whether mentoring had a positive impact on women's perception of their ability and willingness to complete their studies and stay in the profession. The results show that mentoring can most effectively help women by increasing their sense of belonging in the field. Even though without longitudinal studies it is not possible to draw firm conclusions about whether mentees actually stay in computing in the long run, research has shown that a sense of belonging is one of the key factors for success.

Keywords: mentoring, gender diversity, computing education, retention, intervention

1. Introduction

In recent decades, computing has been characterized by a strong male majority, both in education and in the workforce [1, 2]. According to Eurostat, women make up only 32% of students in STEM majors and only 19% of the computing labor market [3]. The homogeneity of tech workers poses a serious threat and leads not only to exacerbated social inequalities but also to technological flaws. For instance, it has been shown about Artificial Intelligence that a gender-diverse team is indispensable to avoid technological imperfections in, for example, face recognition or machine translation [4]. In software development, it is also essential to strive for diversity in the composition of development teams, as people use software in different ways and, therefore, have different needs [5, 6]. Gender balance in computing education is beneficial for all genders, as research done by Lagesen et al. has shown that the dropout rate decreased not only for women but also for men when gender balance was increased [7].

However, there are many factors that hinder the recruitment and retention of women in computing education. One of the main challenges is the social stereotype that computer scientists are "nerds", i.e., pasty young men with glasses who are always sitting in front of a computer [8-10]. This kind of social portrayal – narrow and not very attractive – makes it difficult for people who significantly differ from the stereotype to consider taking such a study path. It is challenging for women, who are marginalized in the field, to feel like they "belong" in this world, which leads to lower self-efficacy and lower retention.

Research shows that mentoring – especially intersectional mentoring – can counteract this barrier, because they serve as examples of people who are not only similar to the mentee in some aspects but are also successful in the field of their choice [11, 12]. A mentoring experience, therefore, can help marginalized women in computing by challenging stereotypes, increasing their sense of belonging to a group, and strengthening their self-efficacy [10].

Consequently, setting up mentoring programs to support marginalized groups such as women in computing education could lead to better retention and a more diverse workforce. It is, however, time-consuming and challenging to lay the foundations of such an intervention, among others for lack of internal funds. While external funds, such as a couple-of-year-long EU projects, can give a push, it is vital to make such interventions sustainable by sharing the know-how, thus counterbalancing its limited time scope. In this article, we aim to present the creation and evaluation of a mentoring program targeting female students in STEM, particularly computing programs, funded by the 3-year-long Erasmus+ project called Women STEM Up.[1]

2. Background

2.1. Gender Diversity in Tech

Extensive research has consistently shown that gender diversity within teams, organizations, and education leads to positive effects. These studies highlighted several outcomes, such as more effective, coordinated, and better performing teams in workplaces, along with reduced turnover and team conflict. Moreover, gender diverse teams have been shown to have better creativity, have better innovation, and develop more user-friendly software than non-gender diverse teams [13, 14]. Research also indicates that workplace diversity can yield financial benefits for organizations, with a study by Campbell and Mínguez-Vera [15] claiming a significant positive relation between increased gender diversity on boards and firm value. Promoting gender diversity and actively including women in areas where they are underrepresented is, therefore, not only ethically responsible, but also linked with financial, performance, and innovation benefits.

2.2. Gender Diversity in Computing Education

While numerous studies have tried to explore what hinders women in choosing computing majors [16, 17], substantial research has been conducted also to understand why women choose to leave the computing field. As a starting point, the computing field as a whole suffers from high attrition rates across the world, where some universities report upwards of a 65% dropout rate [10, 11, 18]. The challenging nature and perceived difficulty of the field has been, therefore, named as one of the core reasons why students decide to leave computing [12, 19]. However, women in particular have been shown to face more discrimination, feel more isolated, feel less like they belong in computing, and are more affected by internal challenges than men in computing [20-22], which are all factors that influence women's decision to leave computing. Research shows that addressing these internal challenges are pivotal in students' academic and career trajectory [17-20], as, especially, self-efficacy and impostor syndrome are strongly correlated with persistence and success in STEM [21, 26, 27, 28].

[1] https://women-stem-up.eu/

2.3. Mentoring Interventions

Mentoring has been found to be a key success factor for marginalized groups within STEM. Specifically for women, it has been shown to function as a facilitator for entering and staying in such fields [29]. To increase gender balance in the field, it has been shown crucial to dedicate efforts to recruit more women and retain those already in STEM, and specifically computing, education or careers. Mentoring can be used to achieve these goals through the entire educational and career pathway [13].

Mentorship programs, in particular, have shown to positively impact the students' persistence and academic outcomes [30]. For instance, a study exploring the effect of a peer-mentorship program revealed that the students who participated in the program had significantly higher average grades, retention rates, and attendance levels than those who did not [31]. Additionally, research has found mentoring to positively influence students' self-efficacy [32, 33] and the importance of specifically mentoring women in STEM has been underlined by the American Association of University Women [34].

Impostor syndrome has been named a key reason for women leaving their job in the computing field [35] and mentoring has been recommended to be incorporated in learning and career development activities to combat this phenomenon [36].

2.4. The Women STEM Up Project

Ever since the UN defined "gender equality" as one of its sustainable development goals, numerous intervention projects have aimed to tackle different forms of gender inequality in society, education, science, and technology [37]. The EU-funded Erasmus+ project "Women STEM UP" (2022-2025) is one such effort, specifically aimed at reducing the gender gap in STEM education. The project, composed of five so-called "work packages", focused primarily on supporting female students in science, mainly computing, university programs. Like all Erasmus+ projects, Women STEM Up was a consortium connecting countries and institutions, namely Linköping University in Sweden, the Norwegian University of Science and Technology in Norway, the University of Thessaly in Greece, the Digital Leadership Institute in Belgium, and Stimmuli for Social Change in Greece. The project's third work package (i.e. "WP3"), running from February 1, 2024 to April 30, 2025, aimed to make computing education, and thus the computing career itself, more inclusive and attractive to female students, by developing a mentorship program.

While the main deliverable of WP3 of the project was launching a mentorship program for women students in STEM, to support and lay the foundations for this, the project work also involved creating mentoring resources, available for use by project partners and by anyone that aims to support women students in their STEM studies. These resources included a directory of mentoring programs offered for women in the field, with the goal to bring together such efforts, as well as videos and training books about setting up a mentoring program. The project provides seven learning videos dedicated to different aspects of mentoring, which were added both to the project website and to YouTube to ensure a wide reach (see Figure 1).

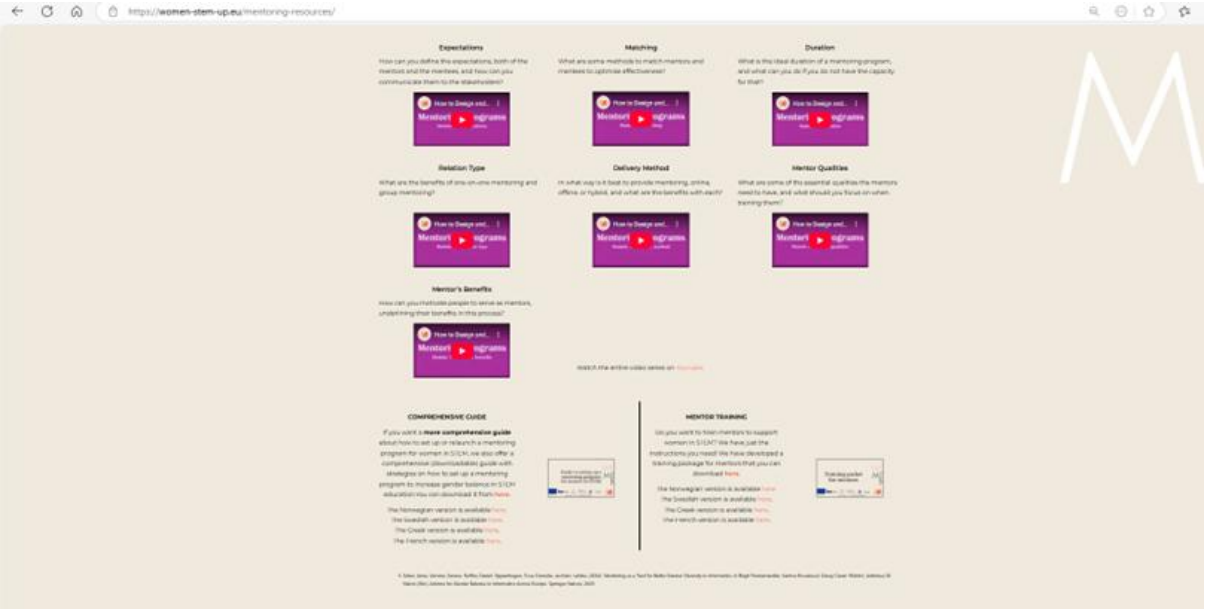

Figure 1: The resources of the mentorship program

In addition to the video series, a guidebook[2] and a mentor training packet[3] were also designed and shared on the website, in English, French, Greek, Norwegian, and Swedish. The above resources were checked and introduced to staff and faculty of the partner universities in the autumn of 2024. After the hybrid training events, the project made the resources freely available and downloadable from the website, serving not only as the foundation for the project's mentorship program for women students in STEM, but for any such initiative worldwide.

3. Methodology

The main goal of the project's WP3 was testing the concept and the resources through a pilot mentorship program for women students. In the following we will present the development and implementation of the mentorship program, and the evaluation of these efforts.

3.1. Development of the Mentorship Program

The framework and scope of the mentorship program was defined by the resources developed in the research phase of the WP [38]. As determined by the original project application, the mentorship program would involve 30 mentors worldwide and 30 mentees from the partner institutions, and it would last from November 2024 until March 2025. Both mentors and mentees are meant to be people identifying women and working or studying (respectively) in the STEM field. Considering the mentor training period in November and some weeks off due to holidays in December, it was estimated that approximately three mentoring sessions would be realized per mentee. The expectation, therefore, was that the mentor and the mentee would meet at least three times for 30-90-minute mentoring sessions.

As for the mentor recruitment, the project partners posted multiple calls for mentors on LinkedIn, as well as in each partner's own circles. The professionals, both from academia and industry, expressing interests were invited for mentor training on multiple occasions. The training sessions

[2] https://women-stem-up.eu/wp-content/uploads/2024/09/Guide-to-setting-up-a-mentoring-program.pdf

[3] https://women-stem-up.eu/wp-content/uploads/2024/09/Training-packet-for-mentors.pdf

informed them of the scope of the project, the aim of the mentorship program, the basics of mentoring, as well as offering a freely downloadable mentor training packet. In the end, 30 mentors were recruited and trained. Regarding mentees, we recruited 28 female students from STEM undergraduate, master's and doctoral programs from the three partner universities. The mentors and students were matched based on the goal and competency preferences submitted upon application.

The theme and focus of each session, and the entire mentoring, was guided by a pair-based "mentoring contract": the mentor and mentee filled out the template we sent before the first session and signed it back to us. When the mentoring ended, they re-registered with us with the mentoring contract, and only if they met the agreed conditions did they receive a certificate of mentoring.

3.2. Assessment of the Mentorship Program

The most reliable way to test the effectiveness of mentoring is through longitudinal studies, such as long-term increases in the number of female students. However, in most cases, due to time and resource constraints, such studies are not possible. Our recent systematic literature review of mentoring programs analyzed in the international literature since 2019 showed that most mentoring programs are short-term, typically a few months, and use students' self-assessments and impressions to measure the effectiveness of the mentoring program [12]. Although such a measurement has its limitations, it can show the impact of the mentoring program on the female computer science students' self-efficacy and sense of belonging, which are key success factors in staying in the field [19].

Accordingly, the subject of this study was to find out whether and how much the Women STEM Up mentoring program had an impact on women's persistence in computing. In order to assess the effectiveness of the mentoring program, participants were asked about their self-efficacy, sense of belonging, and attitude towards computing in a pre-mentoring survey and a post-mentoring survey. The two sets of questions were identical, and each item was phrased as a general statement rated on a 10-point Likert scale, the two endpoints being "strongly disagree" and "strongly agree". The surveys were compiled based on previous research evaluating similar mentoring programs, although some questions were slightly modified to better fit the topic of the mentoring program and the context of the questionnaire. Questions regarding self-efficacy (questions 1-6) are taken from the works of Fisk et al. [20], Cassidy and Eachus [21], and Rowbotham and Schmitz [22]. Questions regarding sense of belonging (questions 7-8) are from the works of Nolte et al. [23] and Dekhane et al. [24], while questions on internal challenges (9-10) are based on the work of [19].

We compared the results of the two sets of questions to identify shifts in student perception. Because the survey items were treated as individual Likert-type questions (ordinal data) rather than a composite scale, and given the exploratory nature of this pilot mentoring intervention, the analysis focused on descriptive reporting (frequencies and percentages) rather than paired t-tests, following common practices for presenting Likert-type survey data [39,40].

4. Results

Below, we present the results of the mentees' assessment of the mentorship program, by displaying how the mentees rated each of the statements before and after mentoring. To improve interpretability, the original 10-point scale was collapsed into three categories. This is a common practice when presenting Likert-scale results in exploratory studies where the aim is to highlight broader response patterns rather than small variations between adjacent scale points [39,40,41].

Each figure also serves as a comparison. Typically, three pairs of columns are shown on a diagram. The values before mentoring are depicted in green as the first columns of each pair, while the values after mentoring are depicted in purple as the second columns of each pair. If only one color is present, it means that no answer of the other type (no / maybe / yes) was received for that statement.

In the following, we will present the results divided into the three categories of self-efficacy, sense of belonging, and internal challenges.

4.1. Statements regarding self-efficacy

"I am confident in my computing abilities."

As Figure 2 shows, the mentees' assessments were significantly divided before mentoring: all three types of responses were given to the statement that they were confident in their computing skills. It is worth highlighting that several answered "No (I disagree)" to this question. However, in the post-mentoring questionnaire, all answers were in the "Yes (I agree)" or "Maybe" zone, meaning that the mentees' confidence had improved. Some mentees added in the free-form comments field of the questionnaire that during mentoring they had received advice from their mentor specifically on what they could do to be more confident, so it is not just an implicit improvement.

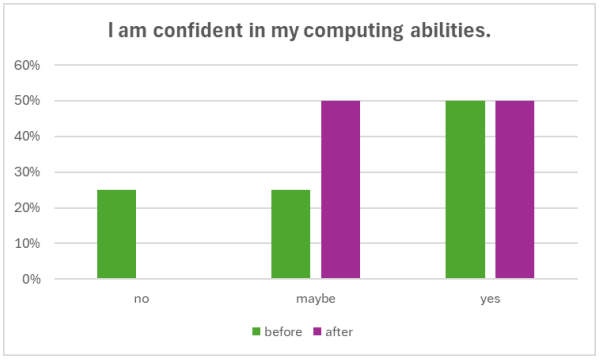

Figure 2: Results from the Pre- and Post-Mentoring Survey on Statement 1

"I am confident I can deal with any difficulties I encounter in my professional / academic life."

The next statement interpreted self-confidence and self-efficacy more broadly: here we did not only apply it specifically to computing skills, but also to difficulties arising in professional life in general. After mentoring, the number of respondents who were confident in their coping abilities increased, and the number of those who firmly stated that they were not or were not sure about it decreased.

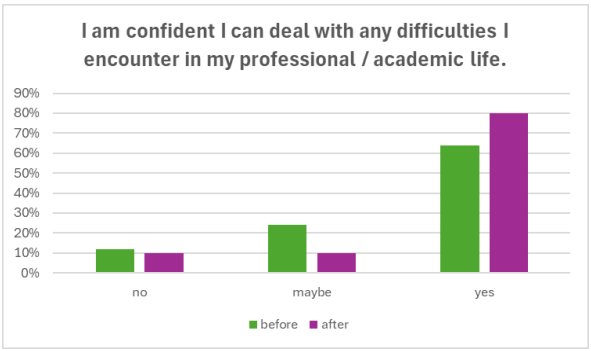

Figure 3: Results from the Pre- and Post-Mentoring Survey on Statement 2

“I often face problems when trying something new.”

The third question, on self-efficacy, examines initiative and risk-taking. Before mentoring, most participants were unsure about their abilities in these areas, while after mentoring, uncertainty decreased and the number of respondents who felt they would not face problems when trying new things almost doubled.

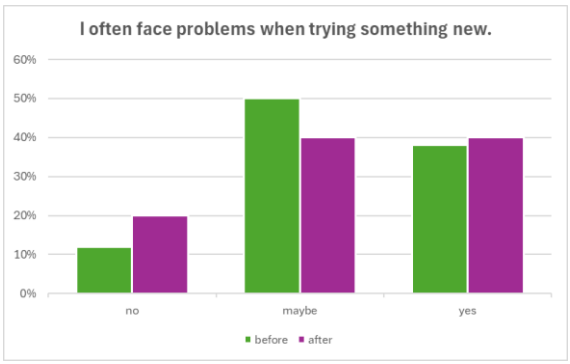

Figure 4: Results from the Pre- and Post-Mentoring Survey on Statement 3

“I am interested in computing.”

The fourth statement examined interest in informatics. Mentees rated their professional interest relatively similarly before and after mentoring, although it is a fact that the positive response was high to begin with. It should be added that there was also one negative response after mentoring. It is difficult to determine from a single question whether mentoring caused it or not, or whether it was an intentional or accidental response. The original questionnaire used the word “computing”, which is a collective term for "informatics," “computer science,” and “information technology” as potential university majors in the literature [26], but this term may not be known to laypeople. It is therefore possible that some mentees were confused by the use of the term.

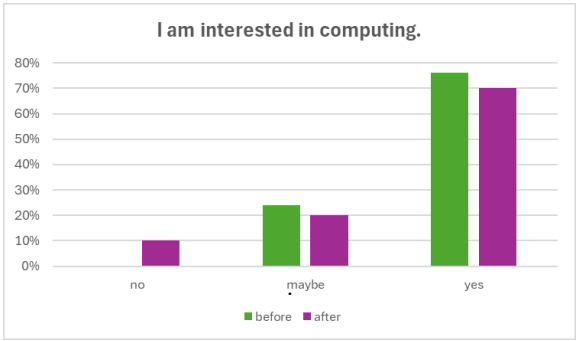

Figure 5: Results from the Pre- and Post-Mentoring Survey on Statement 4

“I am committed to my major.”

Continuing the theme of the fourth statement, the next question gave a broader framework for the subject of interest and commitment: the fifth statement mentioned “specialization”, not “computer science/informatics”. The evaluation of the mentees visibly improved after mentoring: more “yes” and “maybe” answers were given and fewer “no”. The mentees may have increased

commitment to their major after overcoming challenges or creating future goals related to their studies with their mentors. One mentee said:

> *"I got a lot more motivation to continue with my studies [after the mentorship program], because we talked about all these hypothetical situations that would happen in the future."*

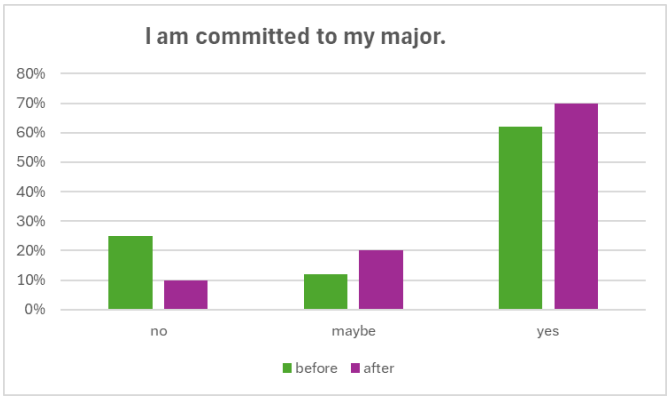

Figure 6: Results from the Pre- and Post-Mentoring Survey on Statement 5

"I am convinced I can achieve my academic goals if I try."

The sixth and final statement, which aimed to assess the students' self-efficacy, focused on goal orientation. Most mentees are confident that they can achieve their professional goals. Mentoring slightly improved the numbers: on the one hand, there were no negative answers, only uncertain ones, and on the other hand, the number of affirmative answers also increased compared to the original numbers.

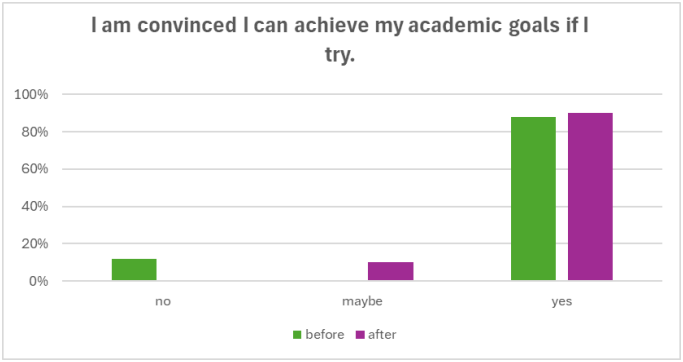

Figure 7: Results from the Pre- and Post-Mentoring Survey on Statement 6

4.2. Statements regarding sense of belonging

"I am confident I belong in computing."

In addition to examining self-efficacy, we sought to answer the question during the empirical study whether the mentoring program has an effect on female students feeling better in the IT community, that is, whether their sense of belonging to the group increases. Statements 7-8 sought to answer this. The present question focuses on the extent to which the mentees feel that they have a place in IT. Not surprisingly, many negative and skeptical responses were received before the mentoring, because there are many more men in the IT field, so women easily feel like outsiders. However, after the mentoring, the numbers improved somewhat: more positive, confident responses were received and fewer negative ones.

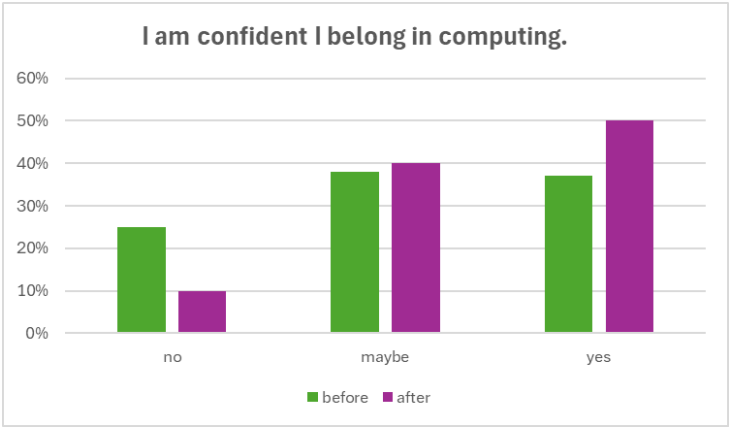

Figure 8: Results from the Pre- and Post-Mentoring Survey on Statement 7

"I feel like I fit in with the computing community."

The next statement specifically focuses on the feeling of belonging to a community. As expected, we have many negative and uncertain answers before mentoring, but after mentoring, the number of those who believe and feel that they belong has doubled. Mentoring can be very effective in developing a sense of community, especially if the mentor is a minority herself. When a mentee sees from time to time that there is someone here who has managed to succeed in the field, despite being similar to her (because, let us say, she is a woman), it gives her confidence and the feeling that this environment is not so hostile. The great value of mentoring is that it creates a direct connection between a successful woman already in the field and an aspirant who is just starting out, which creates an example and a connection to the field.

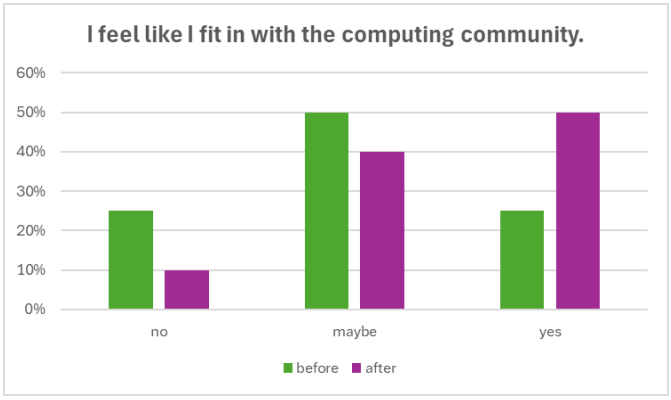

Figure 9: Results from the Pre- and Post-Mentoring Survey on Statement 8

4.3. Statements related to internal challenges women face in computing

"I got where I am today by sheer luck."

The third and final major theme of the questionnaire – in addition to self-efficacy and group feeling – was the examination of internal challenges. The first statement of the theme aims to assess to what extent the students attribute their success to their own efforts, and not to luck. Before mentoring, there were those who attributed their success solely to luck, while after mentoring, such an answer was no longer given.

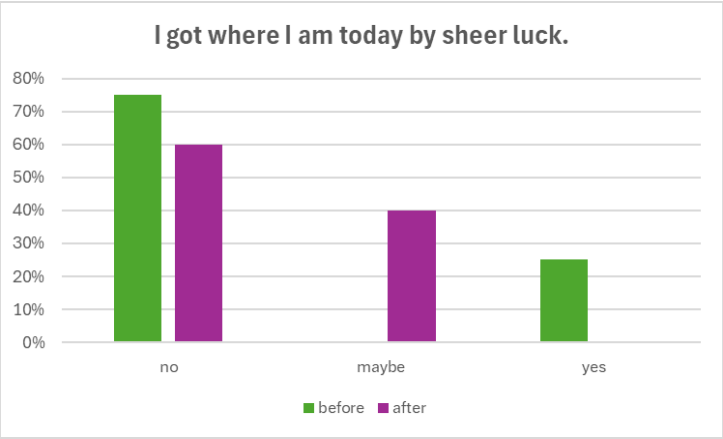

Figure 10: Results from the Pre- and Post-Mentoring Survey on Statement 9

"I am afraid of failure or showing signs of vulnerability."

Finally, the last question was about avoiding and coping with failure. It is noteworthy that many students indicated that they were afraid of failure. This was still the most popular answer after mentoring, although the number of those who felt this way decreased, indicating that the mentoring program was able to alleviate the women's internal challenges. However, it is important to note that this question itself points to the importance of paying increased attention to supporting women in the computing field. Mentoring is an effective tool for this goal, but there are other initiatives, including the use of role models [18], support communities [11], professional days [27] and inclusive education [28].

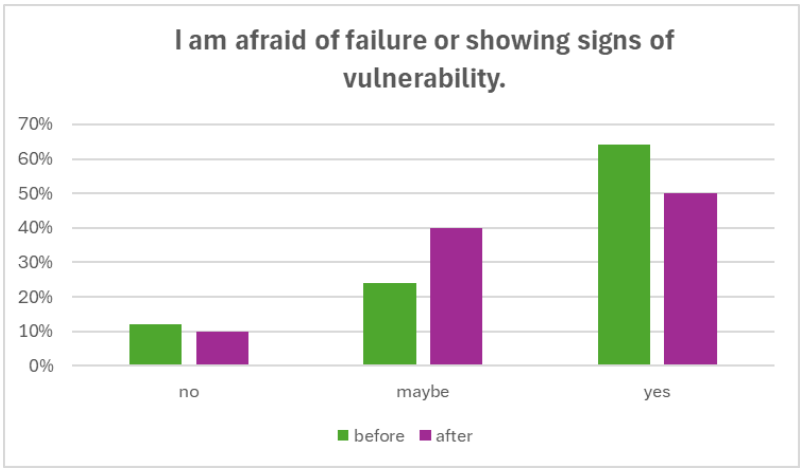

Figure 11: Results from the Pre- and Post-Mentoring Survey on Statement 10

5. Discussion

In this section, we will provide an overview table of the results, organized according to the three categories of self-efficacy, sense of belonging, and internal challenges, and divided by the averages from the pre-mentoring survey and the post-mentoring survey. The results of the questionnaires are given in Table 1, where 10 is the highest possible score. As we can see, the average results of the first two categories increased in the questionnaire after mentoring, which indicates that the mentoring program positively influenced the mentees' self-efficacy and their sense of belonging to

the group. As for the third category, internal challenges, the average decreased after mentoring; that is, thanks to mentoring, the students feel more capable of overcoming field-related obstacles.

category	Before mentoring (average)	After mentoring (average)
self-efficacy	6.7	7.2
Sense of belonging	5.4	6.9
Internal challenges	4.4	4.2

Table 1: Averages of Q1-10 from before and after mentoring

Overall, it can be said that even a short, so-called pilot mentoring program can have a positive effect on the mentees. Of course, the results were collected from a small sample, but the purpose of this study was specifically to analyze a test mentoring program.

It was especially the mentees' sense of belonging that increased after the mentorship program, with 1.5 points. Having role models and seeing others similar to oneself in the same field has continuously been proven to positively impact one's self-efficacy and sense of belonging in a community, which is also reflected in the results.

Furthermore, the mentees were asked questions specifically about the mentorship program and their related experiences. Among other things, the mentees were tasked with rating their expectations and satisfaction on a scale from 0-10. When asked about how satisfied they were with the mentoring experience, every mentee rated their satisfaction a 7 or over. Similarly, when they were asked how much the mentoring experience met their expectations, every mentee rated their experience 7 or over, where some mentees later commented that the experience even exceeded their expectations.

Additionally, some mentees expressed a desire for more mentor sessions. The mentorship program had promised two to three sessions between the mentor and mentee. The survey revealed that everyone, except for one mentor-mentee pair, had at least three meetings, and some pairs had even planned additional sessions outside of the officially given timeframe.

To summarize, the results from the survey, the feedback regarding the number of mentor sessions that were given, in addition to the mentees' willingness to continue the program after it has ended, display the impact of the program despite its short duration.

6. Conclusion

The goal of this article was to draw attention to the importance and effectiveness of mentoring as a tool in computer science education. Women are a significant minority in both computer science education and the tech workforce, which has undesirable consequences for both software and society [4-6]. It is, therefore, vital to make the field more attractive and more inclusive. One of the most documented tools for retaining and supporting female students is mentoring [19]. This article presented a pilot mentoring program that was specifically designed to provide support to female students in STEM majors.

The framework of this pilot mentoring program was the Erasmus+ "Women STEM UP" project, whose primary scope was to tackle some of the main challenges related to the gender gap in computer science, and broadly, STEM higher education, which consequently impacts the labor market as well. Even though computing graduates are in high demand in the labor market and such jobs are highly paid, the field remains homogeneous. The first steps to making the field more diverse and more inclusive is to recruit and retain more women. Despite decades of interventions, these efforts remain challenging. Work Package 3 of this project was aimed exactly to contribute to these efforts by providing resources that can be used, on the one hand, to make STEM programs and careers more attractive for women, and on the other hand, to help keep women that have chosen STEM majors.

The backgrounds of the women serving as mentors in the mentoring program were intentionally diverse – from researchers to entrepreneurs to managers. It was important to show the diversity and opportunities of the profession, and also that – despite social stereotypes – computing is neither masculine nor monotonous, but that it very much feeds upon female creative energy. Creativity and initiative are important components of the ESTEAM[4] approach, which is increasingly gaining ground instead of the narrower interpretation of STEM. The ESTEAM approach took center stage in the next phase of the project, in Work Package 4, between March and November 2025, where female students were able to participate in thematic workshops and an international hackathon on sustainability, developing and connecting their creative skills with entrepreneurship and computing.

Furthermore, the great value of this project and specifically this WP3 was that it created resources, which were tested and approved by an international consortium, to be freely used by anyone to help increase diversity, equity, and inclusion in STEM.

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