

A Greed(y) Training Strategy to Attract High School Girls to Undertake Studies in ICT

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Abstract. It has been observed in many studies that female students in general are unwilling to undertake a course of study in ICT [1]. Recent literature has also pointed out that undermining the prejudices of girls with respect to these disciplines is very difficult in adolescence, suggesting that, to be effective, awareness programs on computer disciplines should be offered in pre-school or lower school age [2]. On the other hand, even assuming that large-scale computer literacy programs can be immediately activated in lower schools and kindergartens, we can't wait for >15-20 years before we can appreciate the effectiveness of these programs. The scarcity of women in ICT has a tangible negative impact on countries' technological innovation, which requires immediate action.

In this paper, we describe a strategy, and the details of a number of programs coordinated by the Engineering and Computer Science Departments at Sapienza University, to make high school girl students aware of the importance of new technologies and ICT. We call our proposed training strategy "greed(y)", because it has been conceived as a *grid* of vertical (hard) and horizontal (soft) skills, intertwining topics to which girls are traditionally sensitive, such as environmental sustainability, health, etc., with digital skills and soft skills that the public education system more rarely considers - such as team-working, public speaking, social networking, and competition - with visible consequences more for girls than for boys [3]. In fact, outside school life, boys can acquire a greater aptitude for teamwork, competition, and leadership, by practicing more markedly masculine sports, and they also have a better chance of approaching information technology, through video games.

Greedy is also a term used in Computer Science to denote sub-optimal strategies, as in our case, since we acknowledge that, in order to achieve a higher impact, similar programs should be proposed much earlier in a student's career.

In addition to describing the theoretical approach, the paper offers some project examples.

1 Introduction

In recent years, many studies pointed out the presence of a significant and long-lasting gender gap in the field of Computer Science [1]. The gender gap exists at all levels: university students, researchers, professors, public administration, and industry. Among STEM disciplines, Computer Science is the one with the highest gender unbalance, with

the percentage of women enrolled in ICT graduate programs usually ranging between 10 and 20 percent depending on the country.

The shortage of female ICT professionals also affects the job market and the sustainable development of our society. Digital transformation is currently predominantly guided by men, and this does not guarantee the diversity of positions and ways of thinking that would be indispensable in such an important field. The lack of women also contributes to the severe shortage of skilled digital workers that is retarding many countries' development.

Next Generation EU (also known as the Recovery Fund) includes digitization, innovation, competitiveness, culture, green revolution, and ecological transformation among the most funded objectives of national plans. However, the risk is that those benefiting from the funds made available by the European Community are mainly male-dominated sectors (such as indeed digital, construction, agriculture, and transport), although the pandemic has had devastating effects on female employment in particular. Therefore, the need for actions to reduce the gender gap in these areas is extremely urgent.

In order to face this problem, since 2014 the European Commission has been monitoring the digital progress in the Member States by means of the Digital Economy and Society Index (DESI³), which analyzes four key areas: Human capital, Connectivity, Integration of digital technology, and Digital public services. The European Commission also launched the Digital Skills and Jobs Platform. The lack of digital skills affects companies and public administrations at different levels: there are no experts who can develop cutting-edge technology and there are not enough employees which are able to use existing technology to improve efficiency. The DESI also focus attention on the gender gap, considered one of the causes of the lack of digital workers: from the 2022 DESI Report [14] emerges that only 19 percent of ICT specialists are female.

Despite the fact that Computer Science is the area where there are the most job offerings and the highest salaries, girls still do not enroll in ICT degree programs and do not pursue careers in Computer Science. To understand the reasons why girls are not enrolling in ICT degree programs, we do not have to focus on the job market. In fact, the factor that drives girls away from Computer Science disciplines is the persistence of gender stereotypes and biases, which lead people to consider computer science-related jobs inappropriate for women. Unlike other types of prejudices, the one relating to women's limited aptitude for information technology appears rooted and more difficult to weaken, because it tends to condition girls' interests and inclinations from an early age, leading to a rejection of information technology disciplines which is very difficult to break down in adolescence or adulthood.

While boys, when choosing a course of study, are particularly attracted by the possibilities of career and economic progression, for girls social and innovation impact are a very relevant factor [13]. Studies conducted at UCLA show that for boys the main attractor in choosing to study Computer Science is a passion for videogames, while girls like computer games less [18], [4] [5]. Furthermore, recent studies demonstrate how a strong deterrent for girls is the stereotype of "nerd", as an antisocial individual with poor communication skills, thus antithetical to their aspirations [6]. Many researchers have also suggested that the media is largely responsible for this kind of stereotyping [7]. It

³ <https://digital-strategy.ec.europa.eu/en/policies/desi>

is no coincidence that Artificial Intelligence, whose fascinating applications have been widely covered by the media in more recent times, attracts girls instead [17]. In corroboration, the bachelor's degree program in Applied Computer Science and Artificial Intelligence started in 2020/2021 by the Department of Computer Science at Sapienza University of Rome has already reached 35 percent of girls' enrollment.

We may conclude that the gender gap in ICT is not the consequence of difficulty for women in accessing job positions (although some obstacles remain to reach the top positions), but rather a cultural resistance of the girls themselves when choosing their course of study. Compared to other fields, where women face objective difficulties in advancing their careers, in the case of Computer Science it is the discipline itself that does not attract school-age girls, as a consequence of deeply rooted stereotypes at the societal level.

To mitigate this problem and redirect girls into the Computer Science field, many initiatives have been launched at the European and national levels. For example, in Italy a portal to collect and connect the numerous national initiatives has been recently created ⁴, while at European level is to mention the EUGAIN Project ⁵. Most initiatives have been aimed at female high school students. Some of these projects achieved some results on a small scale but failed to reverse the general trend. Recent studies have pointed out that undermining the prejudices of girls with respect to Computer Science is very difficult in adolescence, suggesting that, to be effective, awareness programs on computer disciplines should be offered in pre-school or lower school age, that is the moment when gender biases take root in girls' mind [2]. Even if these studies show that the most effective way to proceed is to intervene at a younger age, the ongoing digital transformation and the absence of workers with adequate skills in Computer Science requires fast action. There is a need to keep acting on the high school age range, even if the bias is already deep-rooted in girls, by looking for effective compensatory measures to show girls the potential of the Computer Science field. The "greedy" strategy proposed in this paper is built on this extremely urgent problem.

2 Methodology

The term greedy refers to two aspects of the methods shaped in this paper:

1. A sub-optimal strategy, since we acknowledge that, in order to achieve a higher impact, similar programs should be proposed much earlier in a student's career. It refers to an approach to solving a problem by selecting the best option currently available, similar to greedy algorithms.
2. A strategy conceived as a *grid* of vertical (hard) and horizontal (soft) skills, intertwining topics to which girls are traditionally sensitive - such as environmental sustainability, health, and creativity - with digital skills and soft skills that the public education system more rarely considers - such as team-working, public speaking, social networking, and competition - with visible consequences more for girls than for boys [3].

⁴ <https://www.gict.it/>

⁵ <https://eugain.eu/>

As we discussed in Section 1, misconceptions concerning ICT-related professions, such as the "nerd" stereotype and the belief that ICT consists only in programming or fixing computers, affect more females than males [16]. ICT curricula in schools are, depending on the country, absent, deficient, or late, in the sense that they are introduced when these prejudices are well-established.

Likewise, education systems often lack programs aimed at cultivating horizontal or "soft" skills, which are known to be very important in career development [20]. The progress of women in any career is hampered not only by a male-dominated organization of society but also by the fact that girls' education in families and schools does not favor the learning of essential soft skills, such as the ability to compete, public speaking, teamwork, and networking. Outside of school life, boys have the opportunity to acquire some of these skills by practicing more masculine sports, which could justify the results of a recent study in which a substantial gap was observed between the performance of men and women in teamwork and team competition [19].

In conclusion, girls have fewer opportunities to develop both soft and hard skills. To mitigate these deficiencies, our method is based on two principles:

1. To attract girls' interest in ICTs at a later stage of education, it is necessary to make them understand that Computer Science has significantly contributed to the advancement of other disciplines or subjects in which women traditionally show great passion and aptitude, such as medicine [8], environment and sustainability [9], art, and social sciences.
2. Furthermore, it is necessary to integrate technical skills with horizontal skills, essential for progressing in the professional career, especially in male-dominated sectors such as ICT.

For these reasons, we have conceived a grid-shaped approach in which Computer Science is one of the vertical (hard) skills that are taught and intersected with other vertical and horizontal (soft) skills, such as those previously listed. We believe that empowering women is a complex process that requires not only upgrading their skills in strategic and traditionally male-dominated sectors, such as ICT, but also acquiring soft skills that provide them with the right tools to progress in their careers. This can help girls understand that computational skills nowadays are very important in different careers, and are becoming an increasingly required competence to access all levels and fields of the job market. It is also important to make girls understand that ICT disciplines open up many professions that are not limited to being programmers but can offer a very strong bond with society, culture, economy, and business.

3 Examples

The context in which the 'Greedy' strategy proved to be most effective in raising awareness of equal opportunities concerned two academic projects:

1. The first one, WomENCourage 2019 [10], brought together women in the computing profession and related technical fields to exchange knowledge and experience, and to provide special support for young women who were pursuing their academic

degrees or starting their careers in computing. Through a program packed with insightful interdisciplinary topics and engaging educational and networking activities, WomENCourage provided a unique experience of the collective energy, leadership, and excellence that professional women must share to support each other;

2. The other program is G4GRETA (Girls for Green Technology Applications)[11], which involves third and fourth-year students from high schools in and around Rome. This two-year project - which started in 2022 and is still ongoing - combines the development of hard and soft Computer Science skills with the theme of Environmental Sustainability. The participants learn to design apps with an eco-sustainable theme, with the help of tutors and university lecturers. G4Greta proposes lessons, exercises, and training courses that foster the self-determination of young female students in technical-scientific career paths with a holistic approach, interconnected to environmental sustainability, encouraging female students to develop digital applications and solutions that embrace innovation.

In what follows we provide additional details on these projects.

3.1 The Womencourage 2019 Conference

The ACM Celebration of Women in Computing (WomENCourage) is an annual conference whose aim is to bring together women in the computing profession and related technical fields to exchange knowledge and experience and provide special support for women who are pursuing their academic degrees and starting their careers in computing. This conference has reached in 2023 its tenth edition and has a well-assessed program including a hackathon, a career fair, workshops, and keynotes. The 2019 edition [10], although starting from this initial program, has been enriched with activities and events according to the grid scheme previously described.

Description As regards the objective of strengthening vertical (hard) skills, we have combined workshops on traditional IT topics such as gaming, cybersecurity, data science, and more, with several events concerning interdisciplinary topics that notoriously attract women, such as artificial intelligence and health, smart cities, sustainability, architecture and technology for a conscious city, art and digital. Interdisciplinary topics were given higher visibility, organizing them in the main Auditorium, in the form of Mini-conferences, keynotes, and Panels, with a focus on the scientific quality of all the invited speakers, who were selected to inspire the young attendees.

The major innovation was in the number and quality of activities aimed at strengthening vertical (soft) skills, among which the hackathon, the poster presentations, and the poster karaoke. The latter was a rather challenging activity in which girls were asked to present each other's poster, assigned by drawing among the 10 best posters selected at the end of the standard poster sessions. This activity aimed at fostering mutual listening, the ability to improvise, and to face challenges even when one feels unprepared.

Results The sixth edition of ACM Celebration of Women in Computing took place in Rome, at Museum MAXXI, from September 16th to 19th, 2019. More than 350 participants took part in the event, 55% of whom were young: 62% of them graduates, and

38% still university students. WomENCourage also showed a good presence of male participants, who represented 15% of all participants (although they were all involved in the organization of some events as speakers, company representatives during the career fair, etc.). The participants came from 32 countries and covered 4 different continents (Europe, Asia, Africa, and America). The rich program included the hackathon, the career fair, one laboratory, 9 workshops, 2 mini-conferences, 2 panels, 3 poster sessions, the poster karaoke, two scientific and four technical keynotes, and a number of recreational events. A designer created and projected the infographics of all the main events in real-time, as shown for example in Figure 1.

To date, Womencourage 2019 remains the conference edition with the largest number of participants, and the largest number of sponsoring and/or supporting partners⁶ (both national and international) to demonstrate the great interest not only of the girls involved but also of companies, public bodies, and non-profit organizations.

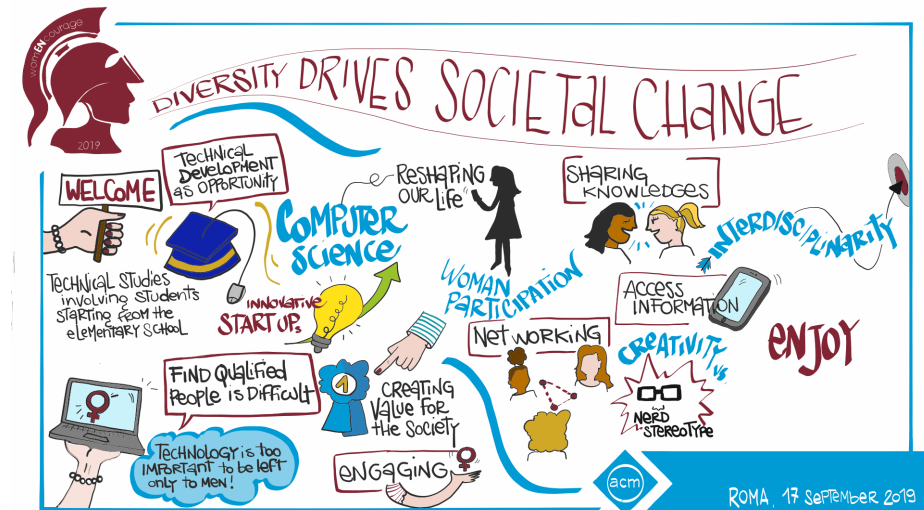


Fig. 1. One amongst the many infographics generated in real-time during the Womencourage 2019 event

3.2 The G4GRETA project

The G4GRETA project intercepts many elements of the Next generation EU [12] programme: digitization and innovation, the green revolution, and the gender gap, albeit on a small scale, such as the proposal of a pilot program on digital and environmental culture, aimed at female students of high schools in Lazio, Italy.

The objectives of this initiative were manifold. The most obvious is to encourage greater access for women to leadership roles, including technological ones, which today

⁶ <https://womencourage.acm.org/2019/supporters/>

are almost exclusively male-dominated. In turn, this could increase the push towards a green evolution of the current consumer society, in which it is usually women who demonstrate greater sensitivity towards social and environmental problems. In this regard, an article published in December 2017 by Scientific America titled “Men Resist Green Behavior as Unmanly” states the following: *“Women have long surpassed men in the arena of environmental action; Across all age groups and in all countries, women tend to lead a greener lifestyle. Compared to men, women throw less waste, recycle more and leave a smaller carbon footprint. Some researchers have suggested that personality differences, such as women’s altruism priority, may help explain this gender gap in ecological behavior.”* Whatever the explanation, it seems clear that greater involvement of women in technology choices can only advance the green economy more rapidly.

Description The project (see [11] for a detailed description of the program) is organized into 10 afternoons, 8 of which are repeated twice to be able to include a greater number of girls. The meetings are dedicated to the following activities: teambuilding, design thinking, environmental sustainability and use of technologies for sustainability, app coding (4 meetings), videomaking and social networking, pitching, final awards and party. During two months the girls independently develop their own projects (with the remote support of tutors) and submit them to a jury. In designing the coding lessons, we assumed no previous knowledge of coding, an assumption that turned out to be correct for 80% of the participants.

The G4GRETA project started in November 2022 and is currently ongoing. Overall, the project will span over a period of 7 months, followed by a period (currently scheduled for one year) during which we will follow the cohort of female students involved in the program, to evaluate its impact. For its entire duration, the project also includes a community building and management program, through social media, some of which (such as LinkedIn) aimed at putting girls in contact with professionals and role models, others (TikTok, Instagram) more suitable for networking among participants.

The proposed initiative has involved a large number of beneficiaries:

- School teachers: they will be made aware of ICT and green issues, and then independently - or with advice from the University - design similar educational projects for their students⁷;
- High school students: they will acquire technical (horizontal) skills in the field of software design and green technologies, as well as vertical skills such as:
 - team building: creating groups and learn to work collaboratively;
 - communication skills: presenting their projects effectively;
 - competition: learning to face the difficulties of competition, and accept its rules and outcomes;
 - problem solving: familiarizing themselves with the Design Thinking methodology⁸;
 - networking: actively participating in the online network created during and after the initiative has taken place.

⁷ All the teaching material is made available on the project web site.

⁸ <https://www.ideou.com/pages/design-thinking>

- Students, doctoral students, and young researchers of the University: they have been involved in the tutoring of school students participants, increasing their awareness of gender issues, being encouraged to network with each other and with the participating students, strengthening their sense of community, and reducing the discomfort of working in predominantly male contexts;
- University professors: they are involved in the design and implementation of the initiative, acting as lecturers, role models, and mentors, thus contributing to an important goal such as that of gender equality in ICT. They also have the opportunity to strengthen relationships with the schools, companies, and bodies participating in the initiative;
- Companies, institutions, and local bodies: the project also aimed to involve public and private institutions. We obtained the active participation of IBM Italy, the Foundation Mondo Digitale (FMD), and the Lazio Region (which co-financed the initiative). All of these organizations are already engaged on the issues of gender equality and the green transition. Participation in the G4GRETA project will therefore make it possible to develop priority issues for these organizations and consolidate relations with schools and universities.

Initial results. As we said, the project is still ongoing, although, in terms of feedback and participation, the results have been very encouraging. 24 schools have joined the project, of which 15 are in the city of Rome and 9 are in the Lazio Region. More than 600 candidates applied, but only 216 were eventually selected due to limitations of space and resources. 30 school teachers are actively following the initiative. Figure 2 shows one of the G4GRETA classrooms, during a teambuilding lesson, while Figure 3 shows a pitch during the Design Thinking meeting.

The comments - in terms of lessons learned - that we can make at this stage are purely qualitative and will need to be further explored when the follow-up program will be concluded. During the first meetings (teambuilding, design thinking, sustainability lesson and first two coding lessons) the attention of the girls has always remained high, likely as a consequence of the great effort made by the organizers to keep it high, promoting interactivity, minimizing the time dedicated to teaching lessons, and challenging them with fun but not simple tasks. We observed with surprise that, after an initial phase of stress, the girls reacted very effectively to our requests to get out of their comfort zone, answering questions in public, engaging in activities never performed before (coding, pitching), and working in a team with girls they've never met before rather than, as they would have preferred, with their schoolmates. This demonstrates, if proof were needed, that disinterest in information technology, or resistance to public exposure and competition, are certainly not female characteristics, but only a limitation of the educational system, which does not engage them sufficiently in these activities.

4 Ongoing work: designing follow-up strategies

With a view to evaluating the impact of these projects, we consider very important to design follow-up actions, in order to identify the real effect of the programs on female students when choosing to enroll in a university degree.



Fig. 2. One of the classrooms of the G4GRETA project during the team-building session (courtesy of Mindsharing.tech)

A follow-up has been planned for the G4GRETA project and it is in the process of being defined. The challenge is the lack, in the current literature, of follow-up studies that constitute examples for this type of orientation projects. Based on classroom experience, we have identified some instruments that could be useful in view of the follow-up. We plan at the end of the project to deliver a survey to understand how girls' perceptions have changed in relation to the world of Computer Science, as a result of the greedy strategy. The ultimate goal is to monitor how many girls will choose a university program in Computer Science. This is done by tracking a study cohort consisting of girls who participated in the project and comparing it with a control cohort consisting of girls with similar characteristics but who did not attend the program, in addition to designing a social engagement strategy to keep all the project participants connected and active. Since the choice of a university program is expected, in the case of the G4GRETA girls, in two years, it is necessary to maintain contact and team up with the girls until that time. This will be done by maintaining a community through social and in-person events.

The follow-up strategy will help identify best practices that need to be implemented on large scale, and similar projects to actually impact enrollment numbers in Computer Science degree programs. This leads us to a second theme of great importance, which is the necessity to identify effective strategies and, subsequently, to apply them at the national and European levels.



Fig. 3. A pitch during the Design Thinking meeting

5 Concluding remarks

The scarcity of women in ICT-related professions not only has a detrimental effect on women's career progression but also affects the lack of experts in the digital sector, with a negative impact on society. In this article, we have presented a mitigation strategy for the problem, building on the evidence offered by several studies on the motivations that determine the low interest of women in these disciplines.

We believe that it is necessary for the best practices identified in the projects described in this paper, and other similar projects undertaken worldwide, to converge to the definition of an intervention model, which, applied on a large scale, will be actually effective in reversing the negative trend of girls' enrollment percentages in Computer Science programs. We also believe it is very important to design initiatives for sharing similar experiences with other universities, public bodies, and private organizations. To encourage this exchange of experiences and best practices, we have undertaken another national networking initiative on this issue, supported by the @GICT (Atlas of Italian gender Initiatives in ICT) portal, as mentioned in Section 1.

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