

# Best Practices from School to University



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Deliverable 4 From School to University “A short, compact/pocket size publication including best practices and suggestions for recruiting and retaining female students (directed to university departments).”

## **INTRODUCTION**

Data on gender distribution in education, employment and career shows that Informatics is a male dominated sector. Although technology is similarly available to adults and children of all genders, women remain underrepresented in both academia and industry careers related to Informatics. The different roles that families and societies impose on individuals based on gender may be considered as the primary reason for the under-representation of women in the field of informatics. The low percentage of female employees working in the technical departments of the largest technology companies, for example e-Bay, Twitter, Google (Statista Research Department, 2022a, b, c) can be one of the indicators that females have not undertaken Informatics degrees historically and so that the problem that existed in the past. The ongoing under-representation of women in Informatics is unsatisfactory, particularly in ensuring the realisation of gendered innovations that address the needs of all citizens. For example, according to the Statista report, 74% of the employees in the technology department of E-Bay are male. This situation is similarly stated as 67.1% for Twitter and 75% for Google. These gender ratios demonstrate that despite access to equipment and technology that families offer to their children and/or the equal opportunities offered to students in schools, this situation has not been reflected in women's careers.

Considering the behaviour of families, their attitudes and their view about gender stereotypes are important predictors of their children's participation in any activity (Simpkins, Davis-Kean & Eccles, 2005; Vekiri & Chronaki, 2008). It is possible to say that the different support or attitudes of families between genders will have an effective impact in their children's education and even their careers. Even though the financial opportunities offered to children of different genders are the same, and technology is similarly available to adults and children of all genders, still Eccles states (2015) that parents spend more time with their sons in technology-related situations.

The first barrier encountered by girls on their way to entering the world of Informatics is at school level. According to literature, female students frequently assume they are not good enough and have less experience than their male counterparts, therefore they disregard informatics as not

being interesting to them. This negative attitude is a consequence of entrenched gender stereotyping in society and family where Informatics is considered a male discipline.

We believe that starting to work on girls' attitude toward technology and triggering their curiosity and passion for Informatics from early education is a way to foster changes leading to a better gender balance in Informatics. The number of women in the informatics field will increase naturally if the female students in the first stage of formal education (primary school / K-12 level) are better supported and actively encouraged to consider Informatics as a rewarding and satisfactory future career. In this booklet, we have highlighted issues, obstacles, best practices for attracting more girls to informatics, and recommendations for enlisting and keeping female students in order to assist university departments in their efforts to implement initiatives to attract more girls to informatics.

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## **HOW CAN WE ATTRACT MORE GIRLS TO INFORMATICS: PROBLEMS AND STRATEGIES**

The underrepresentation of women in Informatics higher education and, consequently, in the ICT industry, is largely tied to practices in primary school education. It has been reported that gender stereotypes and social expectations strongly discourage girls to consider and pursue informatics (Szlávi & Bernát, 2021, Happe & Buhnova, 2022).

Young women's barriers to engagement in Informatics education and careers, however, are also linked to the classroom (Happe et al., 2021, Szlávi, 2021). The attitude of teachers and classmates, the curriculum and learning environment, insufficient knowledge regarding the myriad of jobs available within the IT job market and what competences such jobs require lead to the critically low number of girls choosing Informatics courses at university.

In this section, we introduce the significant reasons behind the under-representation of women in education and careers in Informatics, and the strategies and suggestions to remedy this social, technical, and economic problem.

### **Major Reasons Behind the Problems**

Recent studies and interviews conducted by EUGAIN's working group 1 during meet-ups with initiatives helping girls with coding, show that the major reasons can be categorised under the headings of stereotypes, access, confidence, sense of belonging and isolation topics (Happe and Buhnova, 2021).

#### **1. Access**

The first hole in the leaky pipeline on girls' pathway towards careers in Informatics is linked to the missing access to encouragement and support, together with the access

to suitable education that should build on the many different interests of girls that often span across multiple disciplines.

- **Lack of relatable and engaging education in Informatics:** Girls have less interest in Informatics because even if computers are available they naturally start to use computers later than boys, and they use them generally for homework, socialising, research, etc. Therefore, boys already have more experience. This makes girls stay behind boys regarding computer literacy.

## 2. Stereotypes

Close family and friends often step in to direct girls away from studying Informatics to protect them from a future where they cannot imagine the girls becoming successful. This shows how important it is to help families, especially mothers, understand that software engineering can be a great career choice for their daughters.

- **Stereotypes held by themselves:** Gender roles change according to the culture. But gender roles given to women by society or cultures, like being a housewife or having fewer active roles in business life to taking better care of the house and children, affect women while choosing their careers.
- **Stereotypes held and communicated by their families:** Families have a significant role in shaping their children's careers. Because of the lack of their knowledge, sometimes families can think Informatics is a hard, or even somehow unsafe, discipline for girls to engage with. Therefore, they aren't supportive of a career in Informatics.
- **Stereotypes held and communicated by their teachers:** Teachers influence student's life. Because of their lack of confidence or knowledge, they can be unsupportive of girls in Informatics or be more supportive of male students without being aware of it.
- **Lack of alternatives to stereotypes in the form of relatable role models:** When girls can't see or reach relatable role models as teachers in Informatics, related stereotypical images and messages can reduce girls' sense of belonging.

## 3. Confidence

When girls find themselves in the classroom, often surrounded by more-experienced learners (typically boys), they feel less confident. It can be hard to fall into the category of a slow novice learner for little girls who often excel in other subjects. This leads them to leave the stage to boys at computer labs, courses, etc.

## 4. Sense of Belonging

The girls who resist the earlier three challenges and find themselves on the education pathway toward software engineering find themselves in classrooms surrounded predominantly by boys. This can make them feel they don't belong there.

Girls need to feel safe in the learning environments. If the learning environment is not female-friendly, or perceived as hostile to their way of expressing themselves and achieving understanding, they won't feel competent.

**Isolation:** Isolation is a symptom of the relatively small number of female students enrolled in Informatics degree programmes.

- This can have a significant negative impact on female students when there appear to be few role models and peers (Stevenson, 2020).
- The larger numbers of male students, and especially when the tutors and lecturers are also likely to be male, increase the likelihood that lectures and large lab and practical sessions are dominated by male students, reducing the chances of equitable participation by female students.
- This can be compounded if the student cohort is further divided into smaller groups for computer lab and practical sessions, when the already small female student population is dispersed among a number of different groups or classes.
- When students also lack self-confidence, then the chances of becoming isolated increase. Increased isolation is inversely proportional to sense of belonging, and sense of belonging is one of the most significant indicators of student progression.

### **Strategies and Suggestions:**

According to the recent studies in the literature, and the interviews we conducted during our meet-ups with initiatives helping girls about coding, we devised suggestions to address major problems by following the strategies reported in Happe and Buhnova (2021) as detailed below.

#### **1. Strategies and suggestions for access problem:**

##### **Strategies**

Digital gaming and creative arts activities designed for girls (Main and Schimpf, 2017; Milam, 2012)

Start with offline contextualised activities (Garcia-Penalvo et al., 2016; Menon et al., 2019)

Visual programming environments to teach introductory programming (Menon et al, 2019;

##### **Suggestions**

##### **Early contact with computers or computing:**

Providing early contact (starting from at least kindergarten) through visual programming environments to teach introductory programming or game-based activities helps engage girls.

Siiman et al, 2014)

Involve discussion and reflections on the activities (Garcia-Penalvo et al, 2016)

## 2. Strategies and suggestions for stereotypes problem:

### Strategies

Provide non-stereotypical role models (Boston and Cimpian, 2018)

Portray work in computing as helpful, altruistic, and community-oriented (Boston and Cimpian, 2018)

Provide opportunities to do computing activities as part of a group (Boston and Cimpian, 2018; Brotman and Moore, 2008; Nash, 2017)

Expose girls to successful and relatable female role models in computing (Boston and Cimpian, 2018; Nash, 2017)

Include physical reminders of women's success in computing (Boston and Cimpian, 2018)

Education of teachers providing them with tools and approaches to better engage girls (Brotman and Moore, 2008; Crick, 2017; Nash, 2017)

### Suggestions

**Supportive families:** Families can be informed about education in Informatics and the gender roles. Because families could act in line with the gender roles unintentionally. For making them aware, informative events can be organized. Parents can be encouraged to take their daughters to events and excursions, share with them stories and role models from the history of computing to support children in their awareness of negative gender stereotypes.

**Encouraging teachers:** Together with actively supporting the girls in their classes, by giving them more attention and rewarding their multidisciplinary interests, teachers could use tools which have been developed and studied to support children in their awareness of negative gender stereotypes

**Approachable and relatable role models:** Role models should be approachable and relatable by girls. They could be university students or women entrepreneurs etc.

## 3. Strategies and suggestions for confidence problem:

### Strategies

Providing low-stakes opportunities for girls to experience success (Boston and Cimpian,

### Suggestions



2018; Nash, 2017)

Install a growth mind-set the belief that abilities can be improved with effort, strategies, and mentoring (Boston and Cimpian, 2018)

Adopt a positive, constructive attitude toward failure as a valuable learning opportunity (Boston and Cimpian, 2018)

Provide long-term self-directed projects (Brotman and Moore, 2008)

Splitting classes by experience

**All-girls classes or classes that are split by**

**experience:** All-girls classes or classes spitted by experience make girls feel safe, build confidence to experiment and to express their creativity.

#### 4. Strategies and suggestions for self-belonging problem:

##### Strategies

Emphasizing the social impact and interdisciplinary nature of computing work (Brotman and Moore, 2008; Crick, 2017; Garcia-Penalvo et al, 2016; Main and Schimpf, 2017; Murphy et al., 2019; Siiman et al., 2014)

Interesting and engaging real-world inquiry-based open-ended hand-on experiences (Brotman and Moore, 2008; Main and Schimpf, 2017; Nash, 2017; Siiman et al., 2014)

Community and being part of group (Boston and Cimpian, 2018; Brotman and Moore, 2008; Nash, 2017)

Non-competitive environment (Boston and Cimpian, 2018)

Collaborative assignments (Boston and Cimpian, 2018; Brotman and Moore, 2008; Nash, 2017)

All-female education programs and classes

##### Suggestions

**Project-based and multidisciplinary activities:** More emphasis on the process of thinking, designing, and problem-solving than the actual coding (IT is a part of daily life)

**Non-stereotypical Learning Environment and Advertisement:** Do not strengthen stereotypes by the learning environment, e.g. having a lot of very technical posters in the room/posters of only men, use bright colours (not only dark/black coding colours), use people in advertisement material

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## **BEST PRACTICES IN PRIMARY SCHOOL CURRICULA TO ENCOURAGE FEMALE STUDENTS: After-School, Summer Camps, Competitions**

Recently primary schools in many countries are trying to integrate Informatics into their curriculum as more jobs require programming and algorithmic thinking skills in the future. The reasons behind why there is a need of teaching Informatics in early ages are; Informatics improves so many skills naturally such as problem solving, creative thinking and algorithmic thinking skills which prepares pupils to enter any field of study or career. Researchers suggest that all students should have the chance of meeting with Informatics because being aware of the power of Informatics becomes the centre of technology-enhanced society and the world (Wang et. al, 2016; Goode, 2008; Wang & Hejazi Moghadam, 2017; Haynes et. al. 2022). Despite the growth of teaching Informatics in primary schools and its popularity as a chosen field in academia, the number of female students is still a minority. The reasons behind why women are underrepresented in Informatics has been discussed by many scholars (Mejias et. al., 2021; Rankin et. al., 2021; Hoffman et. al., 2019; Phelps & Sant, 2021). There are great examples of women in Computer Science such as: Ada Lovelace wrote the first algorithm, Grace Hopper defined COBOL language, Jean Bartik took the role on the first computer ENIAC so without them, we wouldn't have the technology on its stand today. Women should be encouraged at the early

ages to have gender diversity in the field of Informatics. This part of the booklet will focus on the best practices in primary school to empower and encourage female students to study Informatics.

### **School Curriculum:**

The need for integrating Informatics in the primary school curriculum has been gaining significance because of the digital era. Scholars agree that the way of teaching Informatics to students in primary school is as important as its importance of being in the curriculum (Falkner & Vivian, 2015; Goode, 2008; Hubwieser et. al., 2014; Falkner et. al., 2019). It is stated that students' levels of learning, pedagogy, interdisciplinary collaboration and abstract examples from real life are the essential things to facilitate education in Informatics (Goode, 2008; Falkner et. al., 2019; Wang & Hejazi Moghadam, 2017). Carter (2006) states that lack of a well-designed curriculum is one of the reasons that makes female students opposed to Informatics. Phelps and Sant (2021) support the idea that school curriculum should be revised and redesigned by including goals to welcome all students and extracurricular activities to attract female students' attention. This section will give best practices in primary school level in four parts both in and out of class activities as; kindergarten, elementary school, secondary school, high school and after school examples.

- **Kindergarten:**

Learning a skill at a young age is crucial for many reasons. Otterborn et. al. (2020) states that teaching Informatics concepts in early ages is important because it has common skills with the computational skills concepts which are logical thinking, algorithmic thinking, decomposition, evaluating and abstracting and these are essential skills to be a person with high awareness of what's going on around the world. Clarke-Midura et. al. (2021), highlights that Informatics integration in kindergarten can be with unplugged activities which are based on card games, drawing or with professionally developed toys.

- In Class:

- Unplugged activities should be integrated into the curriculum which should make students think abstractly. Sample examples:

- Colour by numbers: Students are supposed to complete a given page by colouring the given binary numbers to see the complete picture. For instance, 10001 binary numbers will be given to students, and they'll be asked to colour only zeros to find the pattern.

- After School:



- In Class:
  - One encouraging success story of a female technology entrepreneur or inspiring female character in IT/ ITC per term is included in the school curriculum.
  - Leaflets are distributed to highlight female technology celebrities.
  - Interdisciplinary Collaborations are integrated into the curriculum.
- After School:
  - International projects that can be virtually carried out are organized and conducted.
  - FLL: FIRST LEGO League) can be held.
  - Bebras Challenges are organized.
  - After school club curriculum on coding is created to attract attention to the world of coding.
  - Summer school/camp is organized to expand the exposure of the ICT world to the young learners.

- **High School:**

Understanding the problems of why female students are under-representative in the field of Informatics, scholars mostly look for the answer at high school level. Scholars expressed the reasons why females are feeling uncomfortable with Informatics during the high school education as; limitation on access to programming experiences, male oriented curriculum with the abstract programming, lack of real-life integration, implicit and explicit stereotyping by school staffs (Fisher & Margolis, 2002; Weston et. al., 2019; Okoye et. al., 2020). The activities below are given as the best practices in the level of high school for Informatics integration in curriculum. The goal is integrating Informatics in all other subjects to show students Informatics is more than a computer or a programming language so this will change the “geek” stereotype male role model for female students.

- In Class:
  - International projects that can be virtually carried out are organized and conducted.
  - Female coders/technology related people are invited to schools to give motivational talks (positive discrimination).
  - Leaflets are distributed to highlight female technology celebrities.
  - Parents are informed and encouraged to guide their children to take part in the computing world.
  - Counseling service of the school plans and conducts informative meetings with the female students to raise their awareness about the field.
- After School:
  - FLL: FIRST Robotics Competitions can be held.
  - WRO: The World Robot Olympiad can be held.
  - Science fair per term is organized to facilitate the increased usage of the internet and technologies.

- After school club curriculum on coding is created to attract attention to the world of coding.
- Summer school/camp is organized to expand the exposure of the ICT world to the young learners.

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## RECRUITING FEMALE STUDENTS

Although boys and girls have the same skills and abilities in the use and learning of technologies, girls underestimate their competencies in this regard due to pressure and gender stereotypes, which skew their professional expectations. It is essential to get girls to have sufficient self-confidence and interest in technology from an early age, when they are still in school.

### ***Best practices and Recommended actions for Universities, Research Centers and Educational Institutions:***

- Informatics is an interdisciplinary discipline that increasingly plays a role in other fields such as humanities, medicine, social services, art, etc. This discipline includes many areas from data science to machine learning, from web development to genomics, to give just a few examples. **It is important to transmit this reality in all promotional events of computer-related degrees so that young women can see that they can contribute,**

**within this discipline, in those areas that are of interest to them and that motivate them the most.**

- There are groups of female teachers, researchers, Ph.D. students, etc. in the area of computing that do an excellent job and that they have promoted the area despite being a minority. **It is important to convey that all women in the computing field of a given institution are brought together in a way that minimizes the effect of being in a minority group.**
- In general, there is a lack of orientation of training opportunities as well as possible career paths in the field of computing. **It is important to organize information sessions throughout the year to properly orient students about all the computer-related degrees they can pursue and their career opportunities.**
- To promote female references in the technological field in schools, breaking stereotypes and making visible the technological women. **It is important to develop activities to make visible new female references in a way that is attractive and appropriate for girls.**
- Advertisement material should not build on stereotypical pictures of Informatics (such as dark colors, coding men,...), instead **use bright, friendly colors, include people and communication (Grabarczyk et al. 2022)**

*Example:*

*“Aquí STEAM-UPC” is a set of initiatives of the Universitat Politècnica de Catalunya (UPC), Spain, to bring female talent to technology and engineering studies, specifically aimed at girls between 9 and 14 years old in Catalonia. Some of the projects are: “An engineer in every school” [1], “We are Scientists” [2] and “+Girls ICT” [3].*

### ***Best practices and Recommended actions for Schools:***

- It is essential that computer science is part of the school curriculum and that teachers have the appropriate level to teach it. When the teacher does not know the subject sufficiently well, students perceive greater difficulty and lack of confidence, producing the opposite effect to the desired one, i.e. disinterest.
- The course should be designed and developed in an inclusive manner, providing examples and exercises that may be of interest to all genders. The goal is for the girls in the course to feel part of the community and have a sense of belonging.
- The most relevant aspects to consider during the development of the course in the classroom, so that female students do not feel intimidated, are the following:
  - No male-centric paraphernalia in the classroom.



- o Control those "know-it-all" students who create a toxic environment.
- o Avoid unhelpful instructors who make female students feel that computers are not for girls.
- o Help female students feel self-confident
- Learning environment should not strengthen stereotypes, e.g. very technical posters/only posters about men or "nerdy" insider jokes etc., choose of colors and light, e.g. Informatics class does not always have to take place in the basement in a dark computer lab...

### **Best practices and recommendations for Ministry of Education:**

- Computer science should be considered in a separate course as part of school curriculum and in the development of that course female computer scientists should be involved.
- The course should start from an earlier age, some countries are starting also from 1st grade, and should be motivational more than professional, presenting successful female computer scientists and their roadmap.
- Girls with self-interests should be encouraged through social media campaigns and promotional activities, jointly with local NGOs involved in supporting girls.

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- [2] “We are Scientists”: <https://www.epsem.upc.edu/ca/noticies/somos-cientificos>
- [3] “+Girls ICT”: <https://iguatlat.upc.edu/ca/projectes-clau/noiestic>

## RETAINING 1st YEAR BACHELOR FEMALE STUDENTS

Comparatively few female students compared to male enroll in first-cycle degree programs in Informatics in universities throughout the EU. Attrition rates in the first year of study are normally higher than in any other year of study (Takács *et al.*, 2022). Retention rates are strongly affected by a sense of isolation, e.g., a lack of a sense of belonging (Sax *et al.*, 2018), and low self-efficacy (Mejias *et al.*, 2019). When it comes to initiatives, parents are often the neglected group even though it is well known that they have an even earlier influence on their children (Zauchner *et al.*, 2021).

### Best Practices

- Make female role models prominent, visible, and available to female students from early in the students’ first-cycle degree education.
- Encourage outreach from women working in the IT industry as role models - invite female guest speakers from industry/academia to share their honest experiences as undergraduates, and to talk about their achievements.
- Increase the visibility of female peers (i.e., other female students in the same cohort) by placing female students together in the same lab/practical group, in those cases where first-year students cannot all take the same lab/practical session together due to limited resources (e.g., there is less than a 1-to-1 ratio of enrolled students to computers in a lab).
- Provide mentoring support to female students in early stage first cycle degree programs. Female mentors are preferred, as evidence points to a greater sense of belonging when mentees can identify with their mentors.
- Encourage and support female mentors from amongst the 2nd/3rd/final year student cohort in first cycle degree programs and postgraduate programs. Evidence also shows that self-efficacy and self-confidence increase when a female student is asked to mentor another female student.
- Recognise mentorship as a valued voluntary activity on supplementary degree transcripts. This increases opportunities to recruit mentors from among the student population as they will be able to demonstrate a tangible, much sought after skill, to potential employers.

- Increase opportunities for students to demonstrate they do know the material, and they are capable and competent, through positive feedback in an environment that promotes and encourages student participation, by providing regular feedback on work/assignments during the academic term/semester.
- Parents also play an important role in encouraging their children not to give up on their studies. Faculties should organize group meetings with parents of first-year students and inform them about the deficit of female students in the field of ICT, and the importance of gender balance in ICT, also accepting suggestions from parents themselves. Parents should be made aware of the way their children may feel, the experiences their children may go through, as well as the support they should give their children to overcome these challenges.

### **Other recommendations**

- Make it easier for women to ask/answer questions in mixed-gender mixed-ability lab/class environments. This can be achieved by visiting each student in turn and soliciting questions which will not be overheard. Always point out that the questions are good, or that many people have those questions, and encourage asking questions. In a lecture room environment, consider allowing anonymous question-asking and answering through online services.
- Encourage small-group activities/extra-class (e.g., lab exercises, assignments, etc.) and support all-female groups.
- Recognise, allow for, and support, students who are also primary careers.
- Create a feedback loop, to discover the underlying reasons why a student has decided to not pursue studies in Informatics, that can help institutions make better decisions in their choice of support mechanisms.

### **Case - School of Computer Science, TU Dublin, Ireland**

Since 2012, TU Dublin have introduced several retention strategies to support their undergraduate Computer Science degree programs. The strategies include ensuring that no lab has only one female student; lab assistants solicit questions from students one-on-one; the School supported the creation of a society for female technology students; and actively involves female mentors from industry (1). The School of Computer Science has improved their overall first year student progression rate from an average of 45% per year (2004-2008) to an average of 89% (2012-2017), and the progression rate of female students is slightly higher than male students'. Coupled with an improved recruitment strategy, in 2020 TU Dublin female students made up 30% of the intake across three computing degree programs (2).

(1)McKeever, Susan, and Deirdre Lillis. 2021. "Addressing the Recruitment and Retention of Female Students in Computer Science at Third Level,". <http://arxiv.org/abs/2110.06090>.

(2) <https://irishtechnews.ie/female-intake-computer-science-degrees-tu-dublin/>.

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## CONCLUSIONS

Here, we have included representative examples of how to attract girls to Informatics and discussed strategies and suggestions. As a strategy to arouse interest in girls' early years and to spark their curiosity, we have also offered specifics of effective K12 practices. The examples offered are not exhaustive, but we hope they will serve as a starting point for readers' reflections and discussions. The last two sections of the booklet, which deal with attracting and keeping female students, may be the most directly applicable to the university departments in their recruiting efforts. However, these sections wouldn't be as effective without the early planning activities aimed at children who are still in the initial stages of their educational careers. So, in our opinion, a concerted effort including families and educators of all orders is required.

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