

Best Practices from School to University



published by



Informatics Europe is the Grant Holder institution of COST Action CA19122 EUGAIN (European Network For Gender Balance in Informatics). With over 160 member institutions across 33 countries, Informatics Europe connects over 15,000 researchers, promotes concerted positions and acts on shared priorities in the areas of education, research, knowledge transfer and social impact of informatics. The predecessor of EUGAIN was a series of activities coordinated by the Women in Informatics Research and Education (WIRE) Working Group, supported by Informatics Europe. More information: www.informatics-europe.org

This publication is based upon work from COST Action EUGAIN CA19122 (European Network For Gender Balance in Informatics), supported by COST (European Cooperation in Science and Technology).

COST (European Cooperation in Science and Technology) is a funding agency for research and innovation networks. Our Actions help connect research initiatives across Europe and enable scientists to grow their ideas by sharing them with their peers. This boosts their research, career and innovation.

www.cost.eu



Funded by
the European Union

- **Angela Nebot**
Universitat Politècnica de Catalunya, Spain
- **Anna Szlavi**
Norwegian University of Science and Technology, Norway
- **Chris Staff**
Institute of Technology, Carlow, Ireland
- **Eliot Bytyci**
University of Prishtina, Kosovo
- **Kai Marquardt**
Karlsruhe Institute of Technology, Germany
- **Keara Barret**
Institute of Technology, Carlow, Ireland
- **Lucia Happe**
Karlsruhe Institute of Technology, Germany
- **Monica Landoni**
Università della Svizzera italiana, Switzerland
- **Nora Pireci Sejdiu**
St. Kliment Ohridski University, North Macedonia
- **Özge Mısırlı**
Eskişehir Osmangazi University, Türkiye
- **Rukiye Altın**
Christian-Albrecht University of Kiel, Germany
- **Zeynep Şahin Timar**
Karadeniz Technical University, Türkiye

Introduction	1
How can we attract more girls to informatics: problems and strategies	3
Best practices in primary school curriculum to encourage female students: after-school, summer camps, competitions	8
Recruiting female students	13
Retaining first-year bachelor female students	16
Conclusion	20

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 ongoing under-representation of women in Informatics is unsatisfactory, particularly in ensuring the realisation of gendered innovations that address the needs of all citizens. The low percentage of female employees working in the technical departments of the largest technology companies, for example e-Bay, Twitter, Google can be one of the indicators of how they are represented in the field. For example, according to the Statista report, 74% of the employees in the technology department of e-Bay are male (Pasquali 2022; Dixon 2022; Bianchi 2022). Similar numbers for Twitter and Google are 67.1% and 75%, respectively. These gender ratios show that, despite the availability of tools and technology that families provide for their kids and/or the equal possibilities provided to pupils in schools, this scenario has not been mirrored in women's jobs.

Families' behaviors, attitudes, and perspectives on gender stereotypes are crucial indicators of their children's participation in any activity (Simpkins, Davis-Kean, and J. Eccles 2005; Vekiri and Chnoraki 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 (J. S. Eccles 2015) states that parents spend more time with their sons than with their daughters engaging 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 are less experienced than their male counterparts, therefore they disregard informatics as not being appealing 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 and secondary school) 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.

References

- Bianchi, T. (2022). *Distribution of Google employees worldwide in 2021, by gender and department*. research report. Statista. URL: <https://www.statista.com/statistics/311805/google-employee-gender-department-global/>.
- Dixon, S. (2022). *Distribution of Twitter employees worldwide in 2021, by gender and department*. research report. Statista. URL: <https://www.statista.com/statistics/313567/twitter-employee-gender-department-global/>.
- Eccles, J. S. (2015). “Gendered socialization of STEM interests in the family”. In: *International Journal of Gender, Science and Technology* 7.2, pp. 116–132. URL: <https://genderandset.open.ac.uk/index.php/genderandset/article/view/419>.
- Pasquali, M. (2022). *Distribution of eBay employees worldwide as of December 2021, by gender and department*. research report. Statista. URL: <https://www.statista.com/statistics/315060/ebay-employee-gender-department-global/>.
- Simpkins, S.D., P.E. Davis-Kean, and J.S. Eccles (2005). “Parents’ Socializing Behavior and Children’s Participation in Math, Science, and Computer Out-of-School Activities”. In: *Applied Developmental Science* 9.1, pp. 14–30. DOI: [10.1207/s1532480xads0901_3](https://doi.org/10.1207/s1532480xads0901_3).
- Vekiri, I. and A. Chnoraki (2008). “Gender issues in technology use: Perceived social support, computer self-efficacy and value beliefs, and computer use beyond school”. In: *Computers & Education* 51.3, pp. 1392–1404. DOI: [10.1016/j.compedu.2008.01.003](https://doi.org/10.1016/j.compedu.2008.01.003).

How can we attract more girls to informatics: problems and strategies

The underrepresentation of women in informatics higher education and, consequently, in the informatics 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 (Szlavi and Bernat 2021; Happe and Buhnova 2022).

Young women's barriers to engagement in Informatics education and careers, however, are also linked to the classroom (Happe, Buhnova, et al. 2021; Szlavi 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 girls don't choose informatics and the strategies and suggestions to remedy this social, technical, and economic problem.

1. 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 2022)

(a) Access

- The first hole in the leaky pipeline on girls' pathway towards 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 informatics education: Girls have less interest in informatics because they 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.

(b) Stereotypes

Close family and friends often step into direct girls away from 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 an informatics career.

- Stereotypes held and communicated by their teachers: Teachers influence student's lives. Because of their lack of confidence or knowledge, they can be un-supportive 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.

(c) **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.

(d) **Sense of Belonging**

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

Girls need to feel safe in 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 programs.

- This can have a significant negative impact on female students when there appear to be few role models and peers (Stevenson 2019).
- 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.

2. **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 2022 as detailed below.

(a) **Strategies and suggestions for access problem:**

Strategies:

- Digital gaming and creative arts activities designed for girls (Main and Schimpf, 2017; Milam, 2012 as cited in Happe and Buhnova 2022).
- Start with offline contextualised activities (Garcia-Penalvo et al., 2016; Menon et al., 2019 as cited in Happe and Buhnova 2022).
- Visual programming environments to teach introductory programming (Menon et al, 2019; Siiman et al, 2014 as cited in Happe and Buhnova 2022).
- Involve discussion and reflections on the activities (Garcia-Penalvo et al, 2016 as cited in Happe and Buhnova 2022).

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.

(b) **Strategies and suggestions for stereotypes problem:**

Strategies:

- Provide non-stereotypical role models (Boston and Cimpian, 2018 as cited in Happe and Buhnova 2022).
- Portray work in computing as helpful, altruistic, and community-oriented (Boston and Cimpian, 2018 as cited in Happe and Buhnova 2022).
- Provide opportunities to do Informatics activities as part of a group (Boston and Cimpian, 2018; Brotman and Moore, 2008; Nash, 2017 as cited in Happe and Buhnova 2022).
- Expose girls to successful and relatable female role models in Informatics (Boston and Cimpian, 2018; Nash, 2017 as cited in Happe and Buhnova 2022).
- Include physical reminders of women’s success in Informatics (Boston and Cimpian, 2018 as cited in Happe and Buhnova 2022).
- Educate teachers providing them with tools and approaches to better engage girls (Brotman and Moore, 2008; Crick, 2017; Nash, 2017 as cited in Happe and Buhnova 2022).

Suggestions:

- Supportive families: Families should be informed about education in Informatics, made aware of the opportunities it brings and reassured it is open to all genders. Due to the fact that families often unintentionally promote stereotypical views about informatics (e.g. informatics is just for boys), it is advisable to plan educational events to increase their awareness. 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.

(c) **Strategies and suggestions for access problem:**

Strategies:

- Provide low-stakes opportunities for girls to experience success (Boston and Cimpian, 2018; Nash, 2017 as cited in Happe and Buhnova 2022).
- Install as growth mind-set the belief that abilities can be improved with effort, strategies, and mentoring (Boston and Cimpian, 2018 as cited in Happe and Buhnova 2022).
- Adopt a positive, constructive attitude toward failure as a valuable learning opportunity (Boston and Cimpian, 2018 as cited in Happe and Buhnova 2022)
- Provide long-term self-directed projects (Brotman and Moore, 2008 as cited in Happe and Buhnova 2022).
- Split classes by experience.

Suggestions:

- All-girls classes or classes that are split by experience: All-girls classes or classes splitted by experience make girls feel safe, build confidence to experiment and to express their creativity.

(d) **Strategies and suggestions for sense of belonging problem:**

Strategies:

- Emphasize the social impact and interdisciplinary nature of working in Informatics (Brotman and Moore, 2008; Crick, 2017; Garcia-Penalvo et al, 2016; Main and Schimpf, 2017; Murphy et al., 2019; Siiman et al., 2014 as cited in Happe and Buhnova 2022).
- Utilise/create interesting and engaging real-world inquiry-based open-ended hands-on experiences (Brotman and Moore, 2008; Main and Schimpf, 2017; Nash, 2017; Siiman et al., 2014 as cited in Happe and Buhnova 2022).
- Promote community and being part of group (Boston and Cimpian, 2018; Brotman and Moore, 2008; Nash, 2017 as cited in Happe and Buhnova 2022)
- Create a non-competitive environment (Boston and Cimpian, 2018 as cited in Happe and Buhnova 2022).
- Prefer collaborative assignments (Boston and Cimpian, 2018; Brotman and Moore, 2008; Nash, 2017 as cited in Happe and Buhnova 2022).
- Offer 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: Avoid stereotypes in the learning environment by, e.g., balancing the number of technical posters in the room with non-technical posters; posters containing images of people should be gender-balanced; using bright colours (not only dark/black coding colours); using people and not just technology/equipment in advertisement material.

References

- Happe, L. and B. Buhnova (2022). “Frustrations Steering Women Away From Software Engineering”. In: *IEEE Software* 39.4, pp. 63–69. DOI: [10.1109/MS.2021.3099077](https://doi.org/10.1109/MS.2021.3099077).
- Happe, L., B. Buhnova, et al. (2021). “Effective measures to foster girls’ interest in secondary computer science education”. In: *Education and Information Technologies* 26, pp. 2811–2829. DOI: [10.1007/s10639-020-10379-x](https://doi.org/10.1007/s10639-020-10379-x).
- Stevenson, M. (2019). “The Gender Gap in STEM and Computer Science Jobs: A Study Investigating Job Abandonment Rates of Women in Computer Science”. PhD thesis. Northcentral University. URL: <https://www.proquest.com/openview/e68d62f1a30a115f6a4be0d59bf8cfcf/1?pq-origsite=gscholar&cbl=51922&diss=y>.
- Szlavi, A. (2021). “Barriers, Role Models and Diversity. Women in IT”. In: *Central European Journal of New Technologies in Research, Education and Practice* 3.3, pp. 20–27. DOI: [10.36427/CEJNTREP.3.3.2582](https://doi.org/10.36427/CEJNTREP.3.3.2582).
- Szlavi, A. and B. Bernat (2021). “Young Women’s Barriers in IT”. In: *Journal of Teaching Mathematics and Computer Science* 19.1, pp. 77–101. DOI: [10.5485/TMCS.2021.0521](https://doi.org/10.5485/TMCS.2021.0521).

Best practices in primary school curriculum to encourage female students: after-school, summer camps, competitions

Recently primary and secondary schools are trying to make an effort to integrate Informatics into their curriculum as more jobs require programming and algorithmic thinking skills in the future. The necessity to educate informatics at a young age stems from the fact that it naturally enhances numerous skills, including problem-solving, creative thinking, and algorithmic/computational thinking, preparing students for any field of study or job. Researchers believe that because informatics has the potential to become the focal point of a technologically evolved society and the world, every student should have the chance to engage with it. (Wang, Hong, et al. 2016; Goode 2008; Wang and Hejazi Moghadam 2017; Haynes et al. 2022). Despite the growth of teaching Informatics in primary and secondary 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. 2019; Rankin, Thomas, and Erete 2021; Hoffman, Morelli, and Rosato 2019; Phelps and Santo 2021). There are great examples of women in Informatics such as Ada Lovelace wrote the first algorithm, Grace Hopper defined the COBOL language; a female team made of Jean Bartik, Betty Holberton, Marlyn Wescoff, Kathleen McNulty, Ruth Teitelbaum, and Frances Spence handled the programming side of the first programmable computer ENIAC, so without them, we wouldn't have the technology we have 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 and secondary schools to empower and encourage female students to study Informatics.

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

- **Kindergarten:**

Learning a skill at a young age is crucial for many reasons. A., Schönborn, and Hulten 2020 states that teaching Informatics concepts in early ages is important because it fosters the development of computational skills such as logical thinking, algorithmic thinking, decomposition, evaluating and abstracting. All necessary abilities for developing as people and achieving a high level of global awareness. 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 color only zeros to find the pattern.

– **After School:**

- * After school club curriculum on programming is created to attract attention to the world of programming.
 - Algorithm with toys: Students can make a toy move on a map according to the given orders. For instance; move your toy two steps forward to catch a strawberry.

• **Elementary School:**

Studies show that Informatics is not only about learning fundamentals of computers and programming but it goes beyond it because of its natural link with other skills such as problem solving, algorithmic thinking, creativity and so on (Clarke-Midura et al. 2021; Phelps and Santo 2021; Goode 2008) which are the 21th century skills. Since we are living in a digital era and the new generation is called Digital Citizens, Informatics plays an important role in elementary school as well. The activities below are given as the best practices in the level of elementary school for the integration of Informatics in school curriculum.

– **In Class:**

- * Motivational posters are prepared by the students with the guidance of the Art, Social sciences, English and/or native language of the students to display in the school corridors to raise awareness about women in ICT on International Women Day.
- * The ICT integrated English lessons and activities are prepared and conducted to prepare the students for real life experience.
- * Interdisciplinary projects are organized to encourage students to use digital skills while learning.
- * STEAM activities are held yearly.
 - A collaborative event can be held. Schools should ask the teachers from different departments related to the STEAM field to prepare an event together. It can be planned as a competition. Each field may choose their own challenges. Such events raise the motivations of female students.

– **After School:**

- * Jr FLL: Junior FIRST LEGO League can be held.
- * Coding clubs can be organized.
- * International projects can be organized and conducted.

- * After school club curriculum on programming is created to attract attention to the world of programming.

- **Secondary School:**

Secondary school is playing an important role to move programming type from unplugged, blocked to text based with a written algorithm. Students in secondary schools start to learn problem solving in math and science classes in a serious way unlike in primary school (Jua 2018; Simamora, Saragih, and Hasratuddin 2019). The activities below are the example of how to have a smooth shift from block coding to text based coding with the activities that take students' attention in all genders.

- **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-represented 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 highschool 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 and Margolis 2002; Weston, Dubow, and Kaminsky 2019; Okoye et al. 2020). The activities below are given as the best practices in the level of high school for the integration of Informatics in the 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 organised and conducted.
- * Female coders/technology related people are invited to schools to give motivational talks about 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. This will help female students to have support from their parents. Also, including parents in such activities will play a great role in encouraging their children to take up informatics.
- * Counseling service of the school plans and conducts informative meetings with the female students (and their parents) to raise their awareness about the field.

– **After School:**

- * FRC: 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.
- * Promote after-school activities to parents, and explain to parents why developing skills for informatics is so important to their children’s future.

References

- A., Otterborni, K.J. Schönborn, and M. Hulten (2020). “Investigating preschool educators’ implementation of computer programming in their teaching practice”. In: *Early Childhood Education Journal* 48.3, pp. 253–262. DOI: [10.1007/s10643-019-00976-y](https://doi.org/10.1007/s10643-019-00976-y).
- Carter, L. (2006). “Why students with an apparent aptitude for computer science don’t choose to major in computer science”. In: *ACM SIGCSE Bulletin* 38.1, pp. 27–31. DOI: [10.1145/1124706.1121352](https://doi.org/10.1145/1124706.1121352).
- Clarke-Midura, J. et al. (2021). “Developing a kindergarten computational thinking assessment using evidence-centered design: the case of algorithmic thinking”. In: *Computer Science Education* 31.2, pp. 117–140. DOI: [10.1080/08993408.2021.1877988](https://doi.org/10.1080/08993408.2021.1877988).
- Falkner, K., S. Sentance, et al. (2019). “An international comparison of k-12 computer science education intended and enacted curricula”. In: *In Proceedings of the 19th Koli calling international conference on computing education research*, pp. 1–10.
- Falkner, K. and R. Vivian (2015). “A review of computer science resources for learning and teaching with K-12 computing curricula: An Australian case study”. In: *Computer Science Education* 25.4, pp. 309–429. DOI: [10.1080/08993408.2016.1140410](https://doi.org/10.1080/08993408.2016.1140410).
- Fisher, A. and J. Margolis (2002). “Unlocking the clubhouse: The Carnegie Mellon experience”. In: *ACM SIGCSE Bulletin* 34.2, pp. 79–83. DOI: [10.1145/543812.543836](https://doi.org/10.1145/543812.543836).
- Goode, J. (2008). “Increasing Diversity in K-12 computer science: Strategies from the field”. In: *In Proceedings of the 39th SIGCSE technical symposium on Computer science education*, pp. 362–366.
- Haynes, M. et al. (2022). “Equity in Access to and Participation in K-12 Computer Science Education”. In: *In Proceedings of the 53rd ACM Technical Symposium on Computer Science Education V. 2*, pp. 1111–1111.
- Hoffman, B., R. Morelli, and J. Rosato (2019). “Student engagement is key to broadening participation in CS”. In: *In Proceedings of the 50th ACM Technical Symposium on Computer Science Education*, pp. 1123–1129. DOI: [10.1145/3287324.3287438](https://doi.org/10.1145/3287324.3287438).

- Hubwieser, P. et al. (2014). “Perspectives and visions of computer science education in primary and secondary (K-12) schools”. In: *ACM Transactions on Computing Education (TOCE)* 14.2, pp. 1–9. DOI: [10.1145/2602482](https://doi.org/10.1145/2602482).
- Jua, S.K. (2018). “The profile of students’ problem-solving skill in physics across interest program in the secondary school”. In: *Journal of Physics: Conference Series* 1022.1. DOI: [10.1088/1742-6596/1022/1/012027](https://doi.org/10.1088/1742-6596/1022/1/012027).
- Mejias, M. et al. (2019). “Underrepresented groups threats to belonging in computing”. In: *2019 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, pp. 1–4. DOI: [10.1109/RESPECT46404.2019.8985905](https://doi.org/10.1109/RESPECT46404.2019.8985905).
- Okoye, K. et al. (2020). “Impact of students evaluation of teaching: A text analysis of the teachers qualities by gender.” In: *International Journal of Educational Technology in Higher Education* 17.1, pp. 1–27. DOI: [10.1186/s41239-020-00224-z](https://doi.org/10.1186/s41239-020-00224-z).
- Phelps, D. and R. Santo (2021). “Student leadership, systems change: Opportunities and tensions for youth impact on district-wide computer science initiatives”. In: *ACM Transactions on Computing Education (TOCE)* 21.4, pp. 1–39. DOI: [10.1145/3461716](https://doi.org/10.1145/3461716).
- Rankin, Y. A., J. O. Thomas, and S. Erete (2021). “Black women speak: Examining power, privilege, and identity in CS education”. In: *ACM Transactions on Computing Education (TOCE)* 21.4, pp. 1–31. DOI: [10.1145/3451344](https://doi.org/10.1145/3451344).
- Simamora, R.E., S. Saragih, and Hasratuddin (2019). “Improving Students’ Mathematical Problem Solving Ability and Self-Efficacy through Guided Discovery Learning in Local Culture Context”. In: *International Electronic Journal of Mathematics Education* 14.1, pp. 61–72. DOI: [10.12973/iejme/3966](https://doi.org/10.12973/iejme/3966).
- Wang, J. and S. Hejazi Moghadam (2017). “Diversity barriers in K-12 computer science education: Structural and social”. In: *In Proceedings of the 2017 ACM SIGCSE technical symposium on computer science education*, pp. 615–620.
- Wang, J., H. Hong, et al. (2016). “Landscape of K-12 computer science education in the US: Perceptions, access, and barriers.” In: *In Proceedings of the 47th ACM Technical Symposium on Computing Science Education*, pp. 645–650.
- Weston, T.J., W.M. Dubow, and A. Kaminsky (2019). “Predicting women’s persistence in computer science and technology-related majors from high school to college”. In: *ACM Transactions on Computing Education (TOCE)* 20.1, pp. 1–16. DOI: [10.1145/3343195](https://doi.org/10.1145/3343195).

Although boys and girls have the same skills and abilities in the use and learning of technologies, girls underestimate their competencies (i.e., they tend to have low self-efficacy compared to boys) 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. This part of the booklet will focus on the best practices and recommended actions for different higher education institutions to recruit and encourage female students to study Informatics.

Best practices and Recommended actions for Universities, Research Centres and Educational Institutions:

- Informatics is an interdisciplinary discipline that increasingly plays a role in other fields such as humanities, medicine, social services, art, etc. It is important to transmit this reality in all promotional events of Informatics-related degrees so that young women can see that they can contribute, via computing, in those areas that are of interest to them and that motivate them the most (Stevenson; Seibel and Veilleux 2020; Vainionpää, Iivari, et al. 2020a). Consider offering two-subject degree programmes to integrate computing with an arts or non-computing subject;
- 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 (Seibel and Veilleux 2020; Vainionpää, Kinnula, et al. 2020b).
- 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 Informatics-related degrees they can pursue and their career opportunities (Stevenson; Voldase 2020; Vainionpää, Iivari, et al. 2020a). Present the career paths discussed in the literature in a way that is attractive to women as well as men.
- 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 (Voldase 2020; Tian 2020; Seibel and Veilleux 2020; Stevenson 2019).
- Advertisement material should not build on stereotypical pictures of CS (such as dark colours and coding men), instead use bright, friendly colours, include people ensuring gender-balance, and communication (Grabarczyk et al. 2022; Tian 2020). Make sure Informatics stands at Open Days as being more interesting to women
- Universities should use gender-balanced literature and also advertise that the language used is gender-neutral or balanced. Moreover, they should encourage their staff, when writing new literature, to make it attractive to females by using more gender-balanced language.
- Universities should encourage staff to make changes to the names of the courses, to make

them more interesting and accessible to women (Harvey 2012). For instance, University of California, Berkeley called an introductory programming module “The Beauty and Joy of Computing” with astonishing results - many more women took it than when it was called “Introduction to Programming”.

- Universities should encourage their female staff to have good visibility and communication with female students to see for the possibility of offering two-subject degree programmes such as education and computer science for example (Cronhjort et al. 2020).
- While women in Informatics are a minority group offering scholarships to female applicants could be considered.

Best practices and Recommended actions for Schools:

- It is essential that informatics 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 (Seibel and Veilleux 2020).
- 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 (Stevenson; Tian 2020; Vainionpää, Iivari, et al. 2020a).
 - Control those “know-it-all” students who create a toxic environment (Seibel and Veilleux 2020).
 - Avoid unhelpful instructors who make female students feel that computers are not for girls (Seibel and Veilleux 2020).
 - Help female students feel self-confident (Seibel and Veilleux 2020).

Best practices and recommendations for Ministry of Education:

- Informatics 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 (Seibel and Veilleux 2020).
- The course should start from an earlier age 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 (Grabarczyk et al. 2022; Tian 2020).

References

- Cronhjort, M. et al. (2020). “Leadership and pedagogical skills in computer science engineering by combining a degree in engineering with a degree in education”. In: *2020 IEEE Frontiers in Education Conference (FIE)*, pp. 1–9. DOI: [10.1109/FIE44824.2020.9273958](https://doi.org/10.1109/FIE44824.2020.9273958).
- Grabarczyk, P. et al. (2022). “Computing Educational Programmes with more Women are more about People less about Things”. In: *In Proceedings of the 27th ACM Conference on Innovation and Technology in Computer Science Education Vol. 1*, pp. 172–178. DOI: [10.1145/3502718.3524784](https://doi.org/10.1145/3502718.3524784).
- Harvey, B. (2012). “The beauty and joy of computing: Computer science for everyone”. In: *Proceedings of Constructionism*, pp. 33–39. URL: <https://bjc.berkeley.edu/documents/2012%20Constructionism%20-%20The%20Beauty%20and%20Joy%20of%20Computing%20-%20Computer%20Science%20for%20Everyone.pdf>.
- Seibel, S. and N. Veilleux (2020). “Factors Influencing Women Entering the Software Development Field through Coding Bootcamps vs. Computer Science Bachelor’s Degrees”. In: *Journal of Computing Sciences in Colleges* 34.6, pp. 84–96. DOI: [10.5555/3344051.3344058](https://doi.org/10.5555/3344051.3344058).
- Stevenson, M. (2019). “The Gender Gap in STEM and Computer Science Jobs: A Study Investigating Job Abandonment Rates of Women in Computer Science”. PhD thesis. Northcentral University. URL: <https://www.proquest.com/openview/e68d62f1a30a115f6a4be0d59bf8cfcf/1?pq-origsite=gscholar&cbl=51922&diss=y>.
- Tian, X. (2020). *Where Are All the Women?: Exploring the Research on the Under-Representation of Women in Computer Science*. URL: <https://scholar.uwindsor.ca/major-papers/137/>.
- Vainionpää, F., N. Iivari, et al. (2020a). “IT is not for me-Women’s Discourses on IT and IT Careers”. In: *In ECIS 2020*. URL: https://aisel.aisnet.org/ecis2020_rp/39.
- Vainionpää, F., M. Kinnula, et al. (2020b). “Career Choice and Gendered Perceptions of IT – A Nexus Analytic Inquiry”. In: *Lecture Notes in Information Systems and Organisation*, pp. 37–56. DOI: [10.1007/978-3-030-49644-9_3](https://doi.org/10.1007/978-3-030-49644-9_3).
- Voldase, T. (2020). “The Perceptions and Lived Experiences of Female Students in a Computer Science Program at a Community College Computer Science Program at a Community College”. PhD thesis. Walden University. URL: <https://scholarworks.waldenu.edu/dissertations>.

Retaining first-year bachelor female students

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 we are good at a subject we feel that we deserve to belong there. When students are unsure that they are good enough, or if they feel at fault when they do not understand, then this can act as a barrier, reducing their chances of ever ‘belonging’. When students cannot identify with their peers or their instructors, and find it hard to mix with their peers, it can increase their feelings of isolation. If they feel ‘left behind’ when they cannot grasp concepts that appear to be easily understood by others, in the absence of encouragement from peers, mentors, and instructors, it may reinforce their feelings that they are not ‘good enough’ or ‘clever enough’. In this section we make several recommendations to create opportunities to show everybody that they belong, and deserve to belong, in informatics, while providing mechanisms to support those who need encouragement. 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 and Recommendations

• Role Models

- 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 (Convertino 2020; Seibel and Veilleux 2020; Stevenson 2019).
- Increase the visibility of female peers (i.e., to 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) (Convertino 2020; Lyon and Green 2021; Seibel and Veilleux 2020; Tian 2020).

• Mentoring

- Provide mentoring support to female students in early stages of first cycle degree programmes. Female mentors are preferred, as evidence points to a greater sense of belonging when mentees can identify with their mentors (Lyon and Green 2021; Pantic 2020; Stevenson 2019; Voldase 2020).
- Encourage and support female mentors from amongst the 2nd/3rd/final year student cohort in first cycle degree programmes and postgraduate programmes. Evidence also shows that self-efficacy and self-confidence increase when a female student is asked to mentor another female student (Ghio et al. 2020; Pantic 2020; Seibel and Veilleux 2020).
- 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 (Mondisa, Packard, and Montgomery 2021; Vrieler, Nylén, and Cajander 2020).

- Provide opportunities for work placement or internship during the degree programme (Lyon and Green 2021; Pantic 2020; Smith et al. 2020).

- **Feedback and Guidance**

- Make it easier for women to ask/answer questions in mixed-gender mixed-ability lab/class environments (Convertino 2020; Kreth et al. 2019; Seibel and Veilleux 2020). This can be achieved by visiting each student in turn and soliciting questions which will not be overheard. In a lecture room environment, consider allowing anonymous question-asking and answering through online services. Always point out that the questions are good, or that many people have those questions, and encourage asking questions.
- 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/year (Nguyen and Lewis 2019; Seibel and Veilleux 2020).

- **Groups, labs, and extracurricular activities**

- Create small-group activities/extra-classes (e.g., lab exercises, assignments, etc.) and support all-female groups (Nguyen and Lewis 2019). First year programming exercises and assignments should be contextualised with real world examples where possible. This will help students understand why the techniques matter (Convertino 2020).
- Actively promote inclusive extracurricular activities in safe spaces designed to encourage women to participate (Convertino 2020; Pantic 2020)

- **Additional support**

- Recognise, allow for, and support, students who are also primary carers.
- 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 Informatics, and the importance of gender balance in Informatics, 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.

- **Know the Data**

- When a student decides to not pursue studies in informatics, consider interviewing them or conducting an exit survey to discover the underlying reasons. Institutions may be able to use the data to 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 programmes. 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 (McKeever and Lillis 2021). 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 males students'. Coupled with an improved recruitment strategy, in 2020 TU Dublin female students made up 30% of the intake across three computing degree programmes (Lillis 2020).

References

- Convertino, C. (2020). "Nuancing the discourse of underrepresentation: a feminist post-structural analysis of gender inequality in computer science education in the US". In: *Taylor & Francis* 32.5, pp. 594–607. DOI: [10.1080/09540253.2019.1632417](https://doi.org/10.1080/09540253.2019.1632417).
- Ghio, C. et al. (2020). "The impacts on peer tutors of leading group supplemental instruction for first-year engineering students". In: *ASEE Annual Conference and Exposition, Conference Proceedings*. DOI: [10.18260/1-2--35336](https://doi.org/10.18260/1-2--35336).
- Kreth, Q. et al. (2019). "How prior experience and self-efficacy shape graduate student perceptions of an online learning environment in computing". In: *Computer Science Education* 29.4, pp. 357–381. DOI: [10.1080/08993408.2019.1601459](https://doi.org/10.1080/08993408.2019.1601459).
- Lillis, D. (2020). *Cracking The Silicon Ceiling – Female Intake For Computer Science Degrees*. In Tu Dublin Reaches A Record 42. URL: <https://irishtechnews.ie/female-intake-computer-science-degrees-tu-dublin/>.
- Lyon, L. A. and E. Green (2021). "Coding Boot Camps: Enabling Women to Enter Computing Professions". In: *ACM Transactions on Computing Education* 21.2. DOI: [10.1145/3440891](https://doi.org/10.1145/3440891).
- McKeever, S. and D. Lillis (2021). *Addressing the Recruitment and Retention of Female Students in Computer Science at Third Level*. URL: <http://arxiv.org/abs/2110.06090>.
- Mejias, M. et al. (2019). "Underrepresented groups threats to belonging in computing". In: *2019 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, pp. 1–4. DOI: [10.1109/RESPECT46404.2019.8985905](https://doi.org/10.1109/RESPECT46404.2019.8985905).
- Mondisa, J. L., B. W. L. Packard, and B. L. Montgomery (2021). "Understanding what STEM mentoring ecosystems need to thrive: A STEM-ME framework". In: *Mentoring and Tutoring: Partnership in Learning* 29.1, pp. 110–135. DOI: [10.1080/13611267.2021.1899588](https://doi.org/10.1080/13611267.2021.1899588).
- Nguyen, A. and C. M. Lewis (2019). "Competitive enrollment policies in computing departments negatively predict first-year students' sense of belonging, self-efficacy, and perception of department". In: *Annual Conference on Innovation and Technology in Computer Science Education, ITiCSE*, pp. 685–691. DOI: [10.1145/3328778.3366805](https://doi.org/10.1145/3328778.3366805).
- Pantic, K. (2020). "Retention of Women in Computer Science: Why Women Persist in Their Computer Science Majors". PhD thesis. Utah State University. URL: <https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=8935&context=etd>.
- Sax, L. J. et al. (2018). "Sense of Belonging in Computing: The Role of Introductory Courses for Women and Underrepresented Minority Students". In: *Social Sciences* 2018 7.8, p. 122. DOI: <https://doi.org/10.3390/SOCSCI7080122>.

- Seibel, S. and N. Veilleux (2020). “Factors Influencing Women Entering the Software Development Field through Coding Bootcamps vs. Computer Science Bachelor’s Degrees”. In: *Journal of Computing Sciences in Colleges* 34.6, pp. 84–96. DOI: [10.5555/3344051.3344058](https://doi.org/10.5555/3344051.3344058).
- Smith, S. et al. (2020). “Computing degree apprenticeships: an opportunity to address gender imbalance in the IT sector?” In: *2020 IEEE Frontiers in Education Conference (FIE)*, pp. 21–24. DOI: [10.1109/FIE44824.2020.9274144](https://doi.org/10.1109/FIE44824.2020.9274144).
- Stevenson, M. (2019). “The Gender Gap in STEM and Computer Science Jobs: A Study Investigating Job Abandonment Rates of Women in Computer Science”. PhD thesis. Northcentral University. URL: <https://www.proquest.com/openview/e68d62f1a30a115f6a4be0d59bf8cfcf/1?pq-origsite=gscholar&cbl=51922&diss=y>.
- Takács, R. et al. (2022). “Successful Steps in Higher Education to Stop Computer Science Students from Attrition”. In: *Interchange*, pp. 1–16. DOI: [10.1007/s10780-022-09476-2](https://doi.org/10.1007/s10780-022-09476-2).
- Tian, X. (2020). *Where Are All the Women?: Exploring the Research on the Under-Representation of Women in Computer Science*. URL: <https://scholar.uwindsor.ca/major-papers/137/>.
- Voldase, T. (2020). “The Perceptions and Lived Experiences of Female Students in a Computer Science Program at a Community College Computer Science Program at a Community College”. PhD thesis. Walden University. URL: <https://scholarworks.waldenu.edu/dissertations>.
- Vrieler, T., A. Nylén, and Å. Cajander (2020). “Computer science club for girls and boys—a survey study on gender differences”. In: *Computer Science Education*. DOI: [10.1080/08993408.2020.1832412](https://doi.org/10.1080/08993408.2020.1832412).
- Zauchner, S. et al. (2021). “How to engage parents in STEM”. In: *INTED2021 Proceedings*, pp. 4732–4741. DOI: [10.21125/inted.2021.0958](https://doi.org/10.21125/inted.2021.0958).

Gender-balance in informatics, in academia and in industry, cannot be achieved without increasing the numbers of women graduating in informatics from university. Likewise, gender-balance in informatics programs at university cannot be achieved without ensuring that girls in primary and secondary school have the opportunity to learn informatics. Families and educators play a significant role as enablers, and in this booklet we have brought together representative examples of how to attract girls to Informatics and keep them engaged and succeeding through to the end of the first year of a first cycle degree programme. As a strategy to arouse interest in girls' early years and to spark their curiosity, we have also offered specifics of effective primary school 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 female students to, and helping them succeed in, post-secondary education in informatics, may be the most directly applicable to the university departments in their recruiting efforts. However, these sections would not 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.

This publication is based upon work from COST Action EUGAIN CA19122 (European Network For Gender Balance in Informatics), supported by COST (European Cooperation in Science and Technology).

COST (European Cooperation in Science and Technology) is a funding agency for research and innovation networks. Our Actions help connect research initiatives across Europe and enable scientists to grow their ideas by sharing them with their peers. This boosts their research, career and innovation.

www.cost.eu



Funded by
the European Union