HER TECH – Her Tech, Her Terms. Engagement as the key

D3.1 Comprehensive literature review report

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D3.1 Comprehensive literature review report

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Executive summary

This report presents the results of **the Literature Review**, which aims to (i) identify effective engagement strategies and pedagogical techniques in ICT/Computer Science education, (ii) compare engagement between girls and boys, (iii) identify barriers to girls' participation and ways to address them, and (iv) highlight evidence-based approaches for inclusive and equitable teaching practices. The review is organised by **school-group clusters**: **Primary school**, **Secondary school**, and **VET & Higher Education**.

Methodology (how the evidence was collected and synthesised)

Partners conducted a structured search using agreed keywords and search strings (e.g., girls AND computer science education; gender differences AND ICT engagement; informatics teaching strategies; active learning AND computer science). Selection criteria prioritised sources relevant to partner countries (Belgium, Croatia, Finland, Germany, Ireland, Italy, Sweden) and written in English or local languages (English preferred). Each partner identified 3 or more documents; key data were extracted into a shared Literature review database (teaching strategy/intervention, engagement and learning outcomes, gender differences, and how differences were addressed). The analysis in this deliverable is therefore a cross-country synthesis of the database entries, grouping findings by school level to support transferability to the next WP3 activities and the draft engagement framework.

Key findings by cluster

Primary school

Evidence from primary-level studies and interventions suggests that **early engagement benefits from hands-on, inquiry-driven and interdisciplinary learning**, where teachers act as facilitators and students work collaboratively on meaningful problems. A recurring pattern is that **motivation and self-concept form early** and can predict later aspirations: where children experience competence and intrinsic value, interest and future STEM/ICT orientations tend to be stronger. At this stage, differences between girls and boys are often **domain- and task-specific** rather than absolute (e.g., girls may excel in communicative/collaborative ICT tasks while boys may score higher in technical subdomains), suggesting that inclusive design should provide **multiple entry points and varied task types** rather than assuming a single "best" approach.

Secondary school

Across secondary-level sources, the most consistent barriers to girls' participation are **stereotypes, lower confidence, limited exposure to technical tasks, and discouraging peer/teacher dynamics**, which shape subject choices and willingness to participate. Strategies associated with stronger engagement commonly combine:

- **Relevance and social meaning** (linking ICT to themes such as environment/health and real-world impact);

- **Supportive communities and role models** (mentoring, visible women in ICT/STEM);
- **Structured skill-building** including soft skills (teamwork, communication, public speaking) alongside technical work.

An example highlighted in the database shows that when ICT activities are connected to topics girls often report as meaningful, participants can revise perceptions of computer science, increase confidence, and engage more willingly in technical challenges. At the same time, the review also captures cautionary evidence: even female-focused creative or arts-integrated coding initiatives can struggle with **retention** if the learning design is too fast-paced, objectives are unclear, or cognitive load is too high.

Vocational Education and Training, and Higher Education

At post-secondary level, the literature emphasises that engagement is strongly shaped by **learning culture and participation structures** – for example, unstructured group work and male-dominated peer dynamics can reduce women's willingness to speak up, ask questions, and take intellectual risks, even when interest and capability are high. Recommended responses focus less on "adding activities" and more on **changing everyday teaching and organisational practices**, such as structured participation techniques, staff development to mitigate bias, and increasing the visibility and legitimacy of women's competence in technical fields. In parallel, institutional approaches (e.g., inclusive Gender Equality Plans, communities of practice, and cross-sector hubs) are reported as promising for building sustained engagement through co-creation, better data practices, and stronger networks – especially when intersectionality and context are considered.

Transferable patterns

Across all three clusters, the evidence points to a small set of transferable enabling factors:

1. **Recognition and legitimacy of girls' competence** matters: engagement improves when girls' technical contributions are explicitly valued and not sidelined into peripheral roles.

2. **Belonging and safety in participation** are critical: mentoring, supportive peer communities, and structured collaboration can counteract stereotype pressure and participation gaps.

3. **Relevance and choice** strengthen motivation: offering varied, personally meaningful ways into programming and informatics (rather than narrow introductions) supports more sustained engagement.

Contextual factors frequently interact with gender: several sources underline that school conditions, socio-economic background, and institutional structures can be as influential as gender alone and should be addressed alongside gender-sensitive strategies.

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1. Introduction

This literature review supports WP3 by consolidating evidence on barriers, enabling conditions, and effective educational approaches that influence girls' engagement, participation, and persistence in ICT/computing-related learning across key educational stages. Research consistently shows that gendered participation patterns are not well explained by "interest" alone; rather, participation develops through context, recognition, access to opportunities, classroom culture, and expectations.

The review is based on partner contributions and includes at least three relevant documents per partner country (Belgium, Croatia, Finland, Germany, Ireland, Italy and Sweden), covering both peer-reviewed research and selected grey literature. The findings are organised by age/school groups to reflect when barriers and enablers emerge and what kinds of interventions are developmentally and institutionally feasible.

1.1. Methodology

Project partners used a structured review approach to identify relevant research and policy literature addressing girls' participation in computing/ICT, with a focus on factors at **individual, pedagogical, institutional, and socio-cultural levels**.

The review addressed the following research questions:

- What are the most effective engagement strategies identified in the literature for increasing the participation and interest of girls in ICT education?
- How do engagement strategies in ICT education differ in their effectiveness between boys and girls, and what underlying factors contribute to these differences?
- What evidence-based teaching methodologies have been shown to effectively address the gender gap in engagement within ICT and computer science classrooms?
- How can curriculum design and content relevance be optimised to increase engagement among girls in ICT education?

Search and collection were conducted using online research and retrieval tools (academic search platforms and web-based repositories), complemented by partner inputs to capture national and contextual publications aligned with the project scope.

The search strategy combined gender- and participation-related terms with ICT/CS education and pedagogy concepts. Core keyword combinations included "girls" and "computer science education", "gender differences" and "ICT engagement", "informatics teaching strategies", "STEM education" and "girls participation", "active learning" and "computer science", as well as "evidence-based pedagogy" and "ICT". These strings were used to retrieve both academic and practice-oriented sources relevant to the project scope.

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Eligibility and selection were guided by geographic, language, and topical criteria. Sources were prioritised when they referred to partner countries (Belgium, Croatia, Finland, Germany, Ireland, Italy and Sweden) and were available in English or local languages, with English preferred. Included items needed to address girls' engagement and participation in ICT/CS education by describing teaching strategies, pedagogical approaches, or the barriers and enabling conditions shaping engagement, with attention to gender-differentiated outcomes where available.

Following screening for relevance to the research questions, the synthesis was conducted by extracting from each source the educational context and learner group, the described engagement strategy or pedagogical intervention, reported effects on engagement and/or learning, any reported differences between girls and boys, and measures proposed or implemented to address these differences. The extracted evidence was then consolidated to identify recurring strategies, contextual enablers, and barriers across educational stages, supporting the deliverable requirement to provide a comprehensive overview of effective approaches and gender-related differences in engagement in ICT/CS education.

The literature base covers multiple countries and education systems; transferability requires caution, especially where curriculum structures, teacher education routes, and subject status differ. Quantitative evidence can also mask how participation is shaped by classroom interactions and recognition dynamics.

2. Cluster 1 – Primary school

Research on primary school shows that engagement and learning in early STEM and informatics are mainly driven by students' intrinsic motivation (they enjoy the activity and want to learn), teaching methods that give students some choice and responsibility, and early exposure to technical ideas in a simple and positive way. At this age, studies usually do not look at subject choices yet. Instead, they describe engagement through students' interest and enjoyment, their confidence ("I can do this"), and early signs of aspiration and participation in classroom activities.

2.1. Psychological and motivational outcomes

Several studies show that what happens in the first school years is important for later motivation. In Grades 1–2, students who feel confident in science in Grade 1 often feel that science is less tiring or stressful in Grade 2. In the same period, students who see science as interesting and valuable are more likely to develop future aspirations related to STEM. This suggests that building positive motivation early can support longer-term engagement.

A key approach used in primary interventions is Self-Determination Theory (SDT). SDT explains motivation through three basic needs: autonomy (having some choice), competence (feeling capable), and relatedness (feeling connected to others). Teaching methods that support these three needs can strengthen intrinsic motivation and can be especially helpful for girls' engagement in ICT-related learning. Research also reports a clear link between motivation and learning results: students with higher motivation, especially intrinsic motivation, often perform better in Computational Thinking (CT). CT here means problem-solving skills such as breaking a problem into steps, finding patterns, and testing and improving solutions.

2.2. Learning and skill development

Inquiry-based learning is often described as a strong approach in primary school. In inquiry-based learning, students explore, experiment, and test ideas. They learn by observing, trying things out, and reflecting on what happened. This style of learning can increase curiosity, creativity, and active participation.

Studies also show that boys and girls may develop different skill strengths, even when the total ICT results are quite similar. Boys often do better in more technical tasks, such as software or hardware setup. Girls often do better in communicative and collaborative ICT tasks. This does not mean that one gender cannot do the other type of task. It suggests that teachers should make sure that all students practice both technical and collaborative tasks. Research also indicates that when students get more experience with CT, motivational differences between girls and boys may decrease.

2.3. Engagement strategies and classroom observations

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The teacher's role is important for keeping students engaged. Research suggests that engagement is stronger when the teacher acts as a facilitator, not only as a traditional instructor. This means guiding teamwork, supporting decision-making, and helping students feel safe to try, make mistakes, and learn from them.

Observations in Finland show that girls in Grades 1–2 often find science very meaningful and interesting. Their interest and confidence can stay high and stable in these early years. Some studies also note that boys' motivation may drop more easily during early science education, so teachers should also support boys' engagement. At the same time, a change can appear later. By Grade 8, boys are often reported as more motivated in programming than girls. Researchers explain this mainly through differences in experience and social messages about who programming is "for". Because of this, they recommend giving girls more support and more positive experiences with programming before they lose confidence.

To keep motivation high, researchers suggest offering different ways to learn programming and CT. Students should have several options and contexts (for example: different topics, formats, or projects), not only one single method of introduction. This helps more students find something that feels interesting and possible for them.

2.4. Addressing gender differences in primary STEM and informatics

In primary school, gender-sensitive practice is mainly about designing learning activities that give equal chances to participate and learn. SDT-based teaching supports autonomy, competence, and relatedness, which can strengthen motivation and engagement, especially for girls in ICT. Teacher facilitation is also important to avoid unfair role distribution in group work and to make sure that girls and boys both work with key technical tasks.

Research also suggests that it is better to support girls' high interest early, instead of waiting until secondary school to act. Schools can do this by giving regular exposure to CT and programming, using meaningful contexts, and creating a supportive classroom climate.

Finally, many sources stress that individual differences are often larger than gender differences. For this reason, teachers should focus on individual learning needs. At the same time, they should also check that girls get enough practice in technical tasks and that boys also develop collaborative and communicative ICT skills. More experience with CT can help reduce motivation differences over time.

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3. Cluster 2 – Secondary school

Research on secondary school shows that "engagement" in ICT/CS is usually described through students' interest, enjoyment, confidence in their own ability, classroom participation, and willingness to continue (for example, choosing optional CS subjects, joining extra activities, or staying in a programme until the end). In this cluster, engagement is also discussed as persistence over time, because several studies report that students can start with curiosity but then drop out if the experience feels too difficult, too fast, or not meaningful for them.

A key message is that motivation and confidence are strongly shaped by the learning environment. Programmes that create a supportive climate, give students clear goals, and allow time to practice and reflect are more likely to keep students engaged, especially students who begin with lower confidence in ICT/CS.

3.1. Psychological and motivational outcomes

Several secondary-school sources stress the importance of intrinsic motivation, self-esteem, and a sense of belonging. A clear example comes from the Creative Coding workshops for girls aged 10–15 in Sweden. The programme was designed to make coding attractive through art and music, but it also faced a high dropout rate (50%). The analysis links dropout to low sustained intrinsic motivation, perceived difficulty (learning coding and music tools at the same time), a fast pace with little time for reflection, and unclear objectives. Students who stayed tended to have stronger intrinsic motivation and felt more confident in the workshop setting.

Beyond motivation, some research highlights that school culture can make girls feel that ICT is "not for them". A Finnish study describes high school as a place where many small factors (language, guidance, peer dynamics, stereotypes) can create an exclusion climate, and girls may also "self-exclude" when they do not feel they belong. A Swedish perspective also argues that the central challenge is not "creating girls' interest", but ensuring recognition, legitimacy, and belonging in technology education so that girls' existing interest can grow.

3.2. Learning and skill development

The cluster includes several approaches that combine engagement with clear learning outcomes. Game development-based learning (in lower secondary education) is described as effective for teaching core programming concepts (loops, conditionals, variables) while keeping motivation high. Students learn by creating or completing games, often linked to real-life problems, using a "low entry – high ceiling" design so beginners can start easily but still reach more complex tasks.

Hands-on robotics is also reported as motivating and meaningful. In an Italian educational robotics activity, students worked with Lego Mindstorms and a structured "Think–Make–Improve" cycle, combining guided lessons with an open-ended design project. Students reported high engagement, felt they understood basic robotics and programming, and expressed interest in doing more.

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Some sources focus on system-level skills rather than a classroom intervention. For example, ICILS data describe that many students have limited digital and information skills, and a substantial share show low performance in computational thinking tasks. This kind of evidence is important because it suggests that many secondary students need stronger basic support to engage successfully with advanced digital tasks.

3.3. Differences in girls' and boys' engagement

Across the secondary-school studies, differences are often linked to experience, confidence, and the kind of activities students find meaningful. In the game development-based learning study, boys generally had more prior experience with digital devices and games and were more likely to describe themselves as fluent programmers. Girls more often described themselves as beginners and were less motivated by programming careers; they were more motivated by doing well in class, solving real-life problems, and working together. Boys were more often motivated by competition and career ambitions.

In Belgium, an "introduction to programming" experiment (Scratch, Greenfoot, and robot programming) reports no clear systematic gender differences in motivation or competence, but it does describe different preferences in project design. Girls more often designed story-based games, while boys more often designed racing or action games.

In the Italian robotics activity, girls reported higher enjoyment and stronger teamwork experiences. Groups with mostly girls achieved the highest challenge scores, while the mixed group scored lowest, suggesting that group dynamics and collaboration patterns can influence outcomes.

In the "Coding Girls" programme in Italy (evaluated with a strong design), girls gained a lot in programming confidence and skill awareness, but this did not automatically translate into stronger intentions to choose STEM at university. Boys, on the other hand, showed stronger changes in STEM intentions and university plans. This suggests that building confidence is necessary, but it may not be enough by itself to change long-term choices if wider stereotypes, guidance, and opportunity structures stay the same.

Finally, large-scale evidence suggests that engagement differences can show up more in how students use digital tools outside class than in their tested skill levels. For example, ICILS reports a higher share of girls using digital media outside school for school tasks compared with boys, while overall competence differences are not strongly gendered.

3.4. How gender differences are addressed

A common approach in secondary school is to make ICT/CS more meaningful and socially connected, while reducing fear of failure. In game development-based learning, this is done through story, role-play, exploration, collaboration, and real-life themes such as environment and community issues, instead of focusing on competition. Another design choice is to give students "half-made" games to complete, so beginners can succeed early and build confidence. Teacher support and inclusive classroom strategies are also part of the model.

Role models and mentorship appear repeatedly. Some girl-focused programmes include contact with women in STEM careers and mentors, aiming to increase confidence and challenge stereotypes. However, the creative coding dropout analysis shows that mentorship alone is not enough if the learning pace is too fast or the goals are unclear; students also need time, structure, and learning designs that match their age and interests.

Several sources stress that inclusion depends on recognition and belonging in everyday classroom practice. This includes making girls' technical contributions visible, preventing them from being pushed into "creative" or "support" roles only, and structuring group work so roles rotate and all students work on core technical tasks.

At a wider level, policy and system studies from Ireland and Germany suggest that access and school structures also matter. Expanding curriculum availability, improving teacher preparation, and providing unbiased guidance are seen as important conditions for more equal participation, even if these documents do not test a specific classroom intervention.

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4. Cluster 3 – Vocational Education and Training, and Higher Education

Research in VET and higher education shows that "engagement" in ICT and computing is closely linked to participation and persistence. It is often described through students' confidence and self-efficacy, their willingness to speak and contribute in class, their experiences in group work, and their plans for future study and careers. In higher education, engagement is also connected to whether students feel they belong in a programme that is often perceived as male-dominated, and whether they see fair opportunities for learning, progression, and leadership.

A second strand of evidence looks beyond education settings and shows how engagement also matters in the workplace. For example, women and men may use digital tools equally often, but women can be less involved in choosing or shaping digital innovations at work, and they may report lower confidence in using advanced software. This suggests that engagement is not only about "using technology", but also about having influence and feeling competent in higher-level technical tasks.

4.1. Psychological and motivational outcomes

Several sources show a gap between performance and confidence. One study on computer science graduates reports that women achieve similar academic results to men, but still report lower confidence in their professional abilities and perceive fewer career opportunities unless they behave in very ambitious ways. In higher education classrooms, qualitative evidence from Ireland describes how women can feel less comfortable speaking in class, more pressure to prove themselves, and a tendency to withdraw from participation when they expect negative judgement or dismissal by male peers.

At university level, attitudes also depend on context. A large survey of university students in Belgium found no clear gender difference in study-related computer use, but women reported less positive attitudes towards computers "in general". This suggests that engagement can be strong in learning tasks while confidence or comfort with computing as a broader identity can still be weaker.

4.2. Learning and skill development

In this cluster, strong engagement is often linked to learning formats that are practical, hands-on, and connected to real systems. A Croatian study shows that using Arduino in an introductory computer science course describes project-based learning in mixed-gender teams, with learning-by-doing and peer learning. Students completed a series of projects and rotated roles (programming, documentation, assembly, presentation). The approach is reported as engaging and useful for building practical skills and understanding how hardware and software work together.

Other sources focus less on one course and more on curriculum and institutional change. A Swedish study shows that gender and technology perspectives are integrated into engineering education through teacher workshops, reflective practice, and Communities of Practice. The aim is to influence both what students learn (e.g., recognising bias in technology and design) and how they work (e.g., collaboration practices and group work structures).

4.3. Differences in women's and men's engagement

Across VET and higher education, differences are often described as differences in confidence, classroom voice, and task roles rather than differences in ability. In the Arduino project work, men reported higher engagement and self-confidence and less frustration, while women reported more technical uncertainty and lower self-assessment of their contribution, even though they showed strong focus on understanding and collaboration.

In Irish higher education, women described male peers as more confident and dominant in discussions and group work, with women's contributions sometimes undervalued. These dynamics reduced women's willingness to ask questions and take risks, even when they had strong interest and ability.

At the level of learning identity and technology culture, a Swedish study describes how gender stereotypes can shape study choices and group-work roles (for example, women doing management/documentation work while men do technical tasks), and how these patterns can continue into professional life.

Finally, labour-market oriented research points to a similar "use versus influence" pattern: women may use digital tools as often as men, but are less involved in selection or design of digital technologies and rate their advanced software skills lower.

4.4. How gender differences are addressed

A common practical answer in this cluster is to structure learning so that everyone takes part in core technical work. In practical, hands-on courses, mixed teams with at least one woman, role rotation, and support from teachers and peer mentors are used to reduce unequal task division and to help women build confidence step by step in a safe environment.

At programme and institutional level, several approaches have proven effective. These inclusive Gender Equality Plans in research and higher education institutions, combined with co-creation working groups, better gender-disaggregated data, Research and Innovation Hubs, and public events that highlight women role models in STEM. The actions are designed to fit local needs and include an explicit intersectional focus (for example, involving migrant girls in outreach and recognising different career paths).

One effective approach involves embedding gender awareness into engineering content, culture, and pedagogy, not by separating students, but by changing course design, collaboration norms, and teaching practices. This includes making bias in technology visible, improving group work structures, and supporting teachers through reflective communities.

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Targeted engagement designs also appear in the Italian "greedy strategy", which combines hard skills (e.g., programming, AI, software engineering) with soft skills (e.g., teamwork, leadership, public speaking) and connects computing to themes that many girls find meaningful, such as environment, health, and social impact. The reported aim is to reduce stereotypes, build confidence, and support longer-term engagement through follow-up and community support.

Finally, some initiatives focus on learning spaces and community. A Belgian example describes STEM bootcamps using digital fabrication (e.g., 3D printing, laser cutting, soldering) combined with community building and women-led role models, sometimes hosted in library-based makerspaces to reduce intimidation linked to traditional male-dominated labs.

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5. Conclusions

This literature review confirms that girls' engagement in ICT and computer science is shaped by more than individual interest. Across primary, secondary, and VET/HE contexts, engagement develops through learning experiences that build confidence, offer meaningful participation, and make girls' competence visible and valued. When learning environments provide supportive teaching practices, fair access to technical tasks, and a positive classroom climate, girls are more likely to participate actively and to persist over time.

At primary level, the literature shows that motivation and self-concept form early and can influence later aspirations. Early engagement is stronger when children experience autonomy, competence, and collaboration, and when computing-related activities are introduced through hands-on inquiry and age-appropriate tasks. Gender differences at this stage are often small overall but can appear in different task profiles, which suggests that inclusive primary design should offer varied entry points and ensure that all pupils practice both technical and collaborative activities.

In secondary school, the evidence highlights a more visible risk of disengagement, especially when stereotypes, confidence gaps, peer dynamics, and limited exposure to core technical tasks reduce girls' willingness to participate. Strategies associated with stronger engagement tend to combine relevance and real-world meaning, structured skill-building, and supportive communities (including mentoring and role models). However, the review also shows that attractive formats such as creative coding can still face retention problems if the pace is too fast, objectives are unclear, or the learning load is too high. This underlines that engagement depends not only on the topic but also on careful learning design, scaffolding, and classroom practices that support belonging and recognition.

In VET and higher education, engagement is strongly linked to persistence and to the learning culture. The literature shows that women's participation can be limited by male-dominated group dynamics, unstructured collaboration, and lower confidence even when performance is comparable. Promising responses focus on changing everyday practices: structured group work with role rotation, teaching approaches that encourage equal voice in class, and institutional actions such as gender equality planning, staff development, and networks that strengthen visibility and legitimacy of women in technical fields. Workplace-oriented evidence also suggests that equal "use" of digital tools does not automatically mean equal influence in choosing and shaping technologies, which reinforces the importance of empowerment and participation structures beyond education.

Across all clusters, several transferable enabling factors appear consistently. Engagement improves when girls' technical contributions are recognised, when classrooms provide psychological safety to try and fail, when learning connects to meaningful contexts, and when students have multiple ways to enter and progress in programming and computational thinking. The evidence also shows that gender interacts with other contextual factors (school structures, guidance, socio-economic background and institutional culture), so effective action requires both gender-sensitive teaching strategies and supportive conditions at school and system level.

Finally, the review identifies clear evidence gaps. Many sources report short-term outcomes (interest, self-confidence, immediate performance) but fewer track longer-term effects such as sustained subject choices, continued participation, or transitions into further study and work. In addition, several girl-focused initiatives report positive experiences without always providing comparative data, making it harder to isolate which design elements are most effective across contexts. These gaps point to the importance of the next WP3 activities to validate findings with educators and learners, and to document practice-based examples in case studies that connect classroom methods with school-level and institutional supports.

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