



THE GiST

Girls in STEM Toolkit

**Classroom strategies
for inclusive
STEM learning
environments**

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Acknowledgement

This document is based on *The GiST's Seven principles for a gender-inclusive learning environment*, written by Melanie Isaacs.

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Education Services Australia wishes to acknowledge the Kulin Nation, Traditional Custodians of the land on which our offices are located, and pay our respects to Elders past, present and emerging. We also acknowledge the Traditional Owners of the lands across Australia, their Elders, Ancestors, cultures and heritage.





Minister's Foreword

Encouraging girls and women to embrace science, technology, engineering and mathematics (STEM) subjects and careers is a personal passion, and something I'm pleased to see all levels of governments actively support. Collectively, we recognise that the study of STEM subjects and the pursuit of STEM careers are essential for Australian industry and national prosperity. Denying girls and women equal opportunities in these areas is not only unfair to them, it reduces the pool of skilled workers needed for the task ahead.

The Australian Government is committed to removing barriers that stand in the way of girls and women studying these subjects and excelling in the careers that follow.

We have produced a range of initiatives, including the *Advancing Women in STEM* strategy, which outlines the Australian Government's strong leadership role and support in three key areas: enabling STEM potential through education; supporting women in STEM careers; and making women in STEM visible. We also appointed a Women in STEM Ambassador, Professor Lisa Harvey-Smith, who continues to do great work both as an advocate and role model.

This resource from Education Services Australia (ESA) complements and builds on initiatives taken by governments and institutions across the country. *Classroom strategies for inclusive STEM learning environments* goes to the heart of one of the problems we have faced, creating encouraging and supportive learning environments in which girls and young women can feel comfortable in embracing STEM subjects.

This document will be an invaluable resource for teachers and follows another excellent resource developed by ESA, the Girls in STEM Toolkit.

The most important thing is that we are all on the same page, and all working towards the same goal.

I am confident that with continuing efforts in education, such as this valuable guide for teachers, we can dramatically increase the number of girls and young women studying and embracing STEM.

The Honourable Karen Andrews MP

Minister for Industry, Science and Technology

Summary

Building a diverse science, technology, engineering and mathematics (STEM) workforce is critical for economic growth and prosperity, with STEM-skilled jobs growing 1.5 times faster than any other job sector (Australian Academy of Science, 2019). However, globally, only 35% of students enrolled in STEM are women (UNESCO, 2017) and only 16% of women make up the STEM-skilled workforce in Australia (Australian Academy of Science, 2019).

The problem starts in secondary school, with only 32% of females choosing at least one STEM elective subject, compared to 70% of males (Department of Industry, 2020). Confidence is relatively low among Australians, with 67% reporting that they felt confident in science, technology and mathematics and only 38% in engineering. Even when performing at the same level or above as boys, girls are still less likely to choose subjects such as mathematics. For example, they report having lower levels of confidence, and seeing less intrinsic value, in mathematics (Cole, Jane, Suggett, & Wardlaw, 2016).

Stereotypes, biases, a lack of role models, a limited understanding of STEM careers, disengagement from STEM education, and family influences are known barriers facing girls and young women in schools. Girls and boys can develop stereotyped perceptions of STEM careers and professionals from an early age (Hansen et al., 2017; Miller et al., 2018), and students can develop negative attitudes towards STEM prior to Year 10 (Ing & Nylund-Gibson, 2017), requiring early and ongoing interventions and strategies across primary and secondary years.

Gender disparities in STEM have been attributed to controllable factors (Wang et al., 2015), such as *growth mindsets* that can influence motivation in task mastery, perceived success in further study and self-efficacy (Schleicher, 2019). Girls place more emphasis on aligning careers with *personal interests, skills and abilities and social impact* (Department of Industry, 2020).

Schools and classrooms play a pivotal role in engaging and influencing students in STEM learning.

Teachers and peers play an important role in STEM engagement, encouragement and as role models, with 30% of friends and 24% of teachers being cited by youth as the most influential people for STEM subject selection (Department of Industry, 2020). Additionally, classroom culture and pedagogy have been found to influence STEM learning and interest, with recommendations to build students' views of intrinsic and extrinsic value (Cole et al., 2016).

Seven principles for inclusive STEM education

1. **Create a gender-neutral learning environment.**
2. **Ensure everyone gets hands-on.**
3. **Design learning experiences to embrace context and problem-solving.**
4. **Connect learning to careers and role models.**
5. **Engineer collaborative learning.**
6. **Provide choice and creative opportunities to demonstrate learning.**
7. **Encourage a growth mindset.**

Findings from research have identified seven principles as being key to inclusive STEM education. Gender-inclusive teaching and learning environments can inspire all students, not only girls and young women, to engage more deeply with STEM and to see themselves as successful STEM learners and potential leaders.

This guide outlines practical classroom strategies informed by recent research. While general recommendations are presented, interests among children and young people do not fall into neat categories based on groups, such as gender and ethnicity, and the focus should be primarily on the individual (Cole et al., 2016; Holbert, 2016). These recommendations provide a starting point for teachers to consider and interpret within the context of their classroom and diverse student needs.



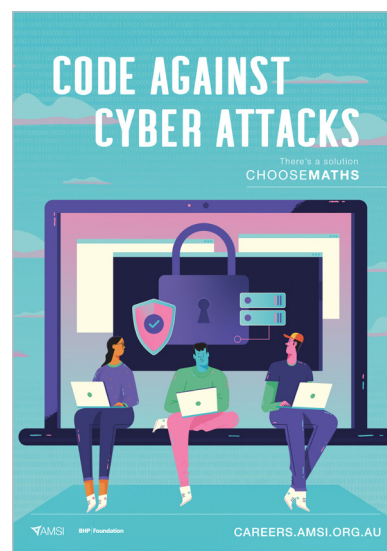
1. Create a gender-neutral learning environment

A gender-neutral learning environment is one in which teachers and learners avoid gender-stereotyping STEM, to ensure that all learners are included, appreciated, respected and treated equally. Cultural stereotypes formed by children can shape the development of their self-representations.

Look around your room and at your STEM materials and activities. What message does it send about who belongs in STEM and what activities people involved in STEM do?

Research has found the following:

- Students in their first year of school have already developed gendered perceptions of STEM and STEM roles (Bond, 2016; Coyle & Liben, 2020; Mulvey, Miller, & Rizzardi, 2017).
- Young girls who viewed stereotyped cartoons were significantly less likely to draw female scientists than girls who saw female characters doing STEM (Bond, 2016).
- Girls showed a preference toward 'feminine' construction toys over the 'masculine' (Coyle & Liben, 2020) and pastel colours over primary colours (Mulvey et al., 2017) but also enjoyed using both types. Younger boys using pastel toys demonstrated lower engineering aptitude than those using primary coloured toys, suggesting they may have less flexibility in the materials they use (Mulvey et al., 2017).
- Middle-school girls and boys have gendered stereotyped perceptions of spatial abilities, but these perceptions are stronger for boys than girls (Heyden, van Atteveldt, Huizinga, & Jolles, 2016).
- Secondary school girls in a computer science environment free from stereotypes had higher interest in computer science, with girls in stereotyped rooms reporting a lower sense of belonging (Master, Cheryan, & Meltzoff, 2016). However, some girls were attracted to a stereotyped classroom based on their personal interests.



AMSI Career Posters

Classroom strategies for a gender-neutral learning environment



Create a gender-neutral setting.	<ul style="list-style-type: none">● Inspire girls to engage more deeply in STEM and create an inspiring STEM environment.● Decorate the room with neutral objects (e.g. plants, lights, general or STEM-diverse) rather than stereotyped objects (e.g. gaming magazines).● Use gender-balanced posters, such as AMSI career posters and GiST poster series.
Select gender-neutral STEM products, or a variety of options.	<ul style="list-style-type: none">● Select gender-neutral coloured construction toys and materials, such as those in primary colours (e.g. red, blue, yellow), rather than 'masculine' and 'feminine' colours, to appeal to all learners.● Monitor how students are engaging with STEM products and invite them to share their perceptions.
Select classroom media representing gender-balanced role models in STEM.	<ul style="list-style-type: none">● Select storybooks for young students that depict all genders doing STEM (e.g. ACARA's booklist, TechGirls are Superheroes and GiST books).● Actively critique media as you search for resources (e.g. ask yourself: does this website/video have equal gender representation?).● Utilise education media that showcase diverse people (gender, race, ethnicity, geographic locations) such as Careers with STEM or AMSI Choose Maths videos and career guides.
Self-assess your environment and behaviour.	<ul style="list-style-type: none">● Use the gender equity checklist to assess your environment.● Use the self-evaluation template to evaluate your classroom interactions.● Encourage girls and boys equally in STEM and use language for gender-neutral and inclusive language (e.g. replace 'guys' with 'everyone').
Address and challenge misconceptions early and throughout secondary school.	<ul style="list-style-type: none">● Invite students to share what they know about STEM roles and professions and measure change after a period of time (e.g. Draw a Scientist Test).● Discuss diverse abilities and growth in ability, and encourage a growth mindset.● Introduce students to the issue of unconscious bias in STEM.● Address specific stereotypes about who is good at certain STEM activities and using equipment from the first year of school.



2. Ensure everyone gets hands-on

Provide girls with multiple and sustained opportunities to get hands-on, particularly with technology. Students can develop important skills for STEM fields by undertaking spatially demanding tasks. These include manipulating objects, representing objects from different perspectives, and engaging with a game or simulation that requires spatial skills.

What opportunities do you provide to engage students in authentic hands-on STEM experiences? How are your students participating in such activities?

Research has found the following:

- Girls identified hands-on activities and experiments in science as one of the primary reasons why they enjoyed science in school (Dare & Roehrig, 2016) and culturally relevant, hands-on enrichment activities are motivating for girls from a diverse range of backgrounds (Kant, Burckhard, & Meyers, 2018).
- Girls are initially hesitant to engage verbally but do participate in hands-on science activities from the outset, yet follow boys' use of equipment (Wieselmann, Dare, Ring-Whalen, & Roehrig, 2020). Girls and boys have been found to engage differently with construction toys, with girls relying more on storybooks and instructions (Coyle & Liben, 2020).
- Sustained hands-on programming activities can increase girls' confidence in their ability to troubleshoot computers (Jenson & Droumeva, 2016), and develop interest and self-efficacy (Master, Cheryan, Moscatelli, & Meltzoff, 2017). Human-centred robotics are particularly engaging for learners (Gomoll, Hmelo-Silver, Šabanovic, & Francisco, 2016).
- Inclusion of virtual science experiences and augmented reality may increase the situational interest of both girls and boys in STEM subjects (Christophel & Schnotz, 2017).
- Girls in primary school report mathematics and spatial anxiety (Skipper & Leman, 2017) and from age ten their spatial ability starts to decrease when compared to that of boys, but girls' performance is closer to boys' when using interactive spatial tools over static activities (Jeng & Hi-Lian, 2016). Spatial awareness can be just as good among secondary school girls as boys when they are exposed to high levels of spatial thinking tasks (Moe, 2016).



Classroom strategies for hands-on learning

Encourage equal participation and sharing.

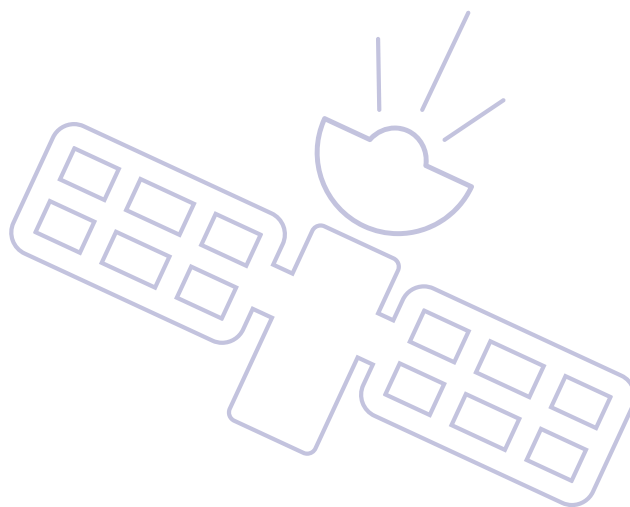
- Encourage girls to engage in collaborative hands-on use of equipment in mixed groups early on in classroom activities (e.g. rotate use of equipment and teamwork roles, allow for 'tinkering' time prior to project work, monitor groups).
- If using collaborative hands-on activities, use small groups or pair work.

Develop spatial awareness, thinking and confidence.

- Introduce direct training and development of [spatial skills and thinking](#) early in schooling and sustain it through to senior secondary school.
- Embed spatial awareness and thinking activities into a variety of STEM subjects (e.g. by considering maps, navigation, diagrams, physical activity, puzzles and spatial digital games).
- Engage girls in a variety of spatial thinking activities including interactive and static options.
- Use tangible manipulatives (e.g. blocks) and encourage use of spatial language.
- Encourage families to support girls to develop spatial awareness and thinking by [suggesting activities](#) they can do at home.

Use a range of diverse STEM equipment and technology.

- Encourage [hands-on programming and robotics](#) experiences, which can engage girls' interest in technology and build self-efficacy.
- Include [virtual science](#) and [augmented reality](#) experiences as these may increase the situational interest of both girls and boys (see the Digital Technologies Hub about [emerging technologies](#)).
- Use narratives, [storybooks](#) and explicit or modelled instruction, as these may support girls to engage in construction activities (e.g. LEGO or engineering challenges).



3. Design learning experiences to embrace context and problem-solving

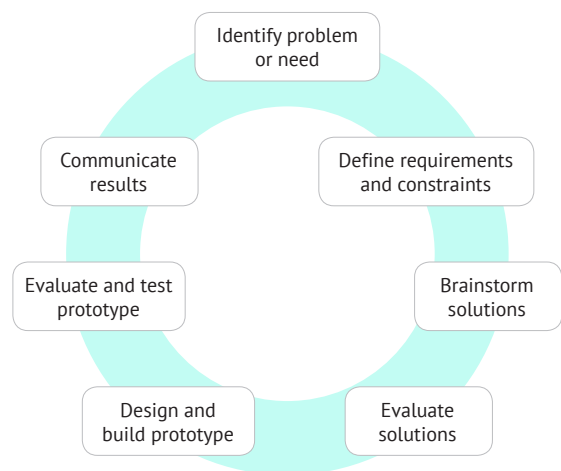


Context-based learning is critical to girls' engagement and perception of what it means to do STEM. Girls want to see the relevance of STEM subjects to their lives, and to see their social value.

To what extent do STEM learning activities embrace diverse contexts and problem-solving pedagogies?

Research has found that:

- Interdisciplinary STEM curriculum can improve learning outcomes for both girls and boys (Oldakowski & Johnson, 2018).
- Students embrace open-ended STEM projects, staying true to their lived realities and identities in the making process; however, scaffolding is needed to activate *STEM content* discussions and participation (Tan & Calabrese Barton, 2018).
- Integrating and explicitly teaching the engineering design process, within project-based pedagogy, can foster an enjoyment among girls in finding creative and better ways of doing things (Adams, Burns, & Martin-Hansen, 2018) and allow for freedom of creativity and personalisation of projects within a structure (Gomoll et al., 2016). This can motivate girls in their learning, and increase interest and persistence through construction challenges (Holbert, 2016).
- Involving students in the process of identifying the social value for their project can improve emotions and engagement (Kwah, Milne, Tsai, Goldman, & Plass, 2016).
- Model-based inquiry and virtual-based inquiry are found to be mostly more effective than traditional pedagogies in developing scientific inquiry skills, particularly for secondary school girls' learning attitudes and communication skills (Wang, Guo, & Jou, 2015). Student-centred teaching practices that use an inquiry approach focused on improving the world positively influence students' attitudes about science and STEM (Knezek & Christensen, 2020).
- Culturally responsive STEM pedagogy *is an approach to teaching that harnesses the diverse cultural characteristics, experiences and perspectives of ethnic groups* (Morrison, Rigney, Hattam, & Diplock, 2019), which can increase problem-solving and interest in study and careers, particularly for underrepresented groups (Kant et al., 2018).



Engineering design process

Classroom strategies for embracing context and problem-solving



Engage students in identifying meaningful and personal problems.

- Involve students in the process of identifying the social value for their project and how they can [make a difference with STEM](#).
- Provide students choice over the direction of their STEM projects to align STEM with their personal interests, values and cultures. CSIRO [Science Pathways](#) for Indigenous Communities has resources to support schools in delivering activities on Country in the classroom.

Adopt pedagogies that engage and support students in STEM.

- Use [student-centred teaching practices](#) that use an inquiry approach focused on [improving the world](#), as these positively influence students' attitudes about science and STEM.
- Teach students about STEM processes, such as the engineering design process, to support girls in problem-solving within problem-based projects to increase motivation, interest and persistence in construction challenges.
- Use [culturally responsive pedagogy](#) to enable girls to engage their ethnic diversity and identity in solving problems.
- Favour a [project-based curriculum](#), as model-based inquiry and virtual-based inquiry pedagogies develop scientific inquiry skills.

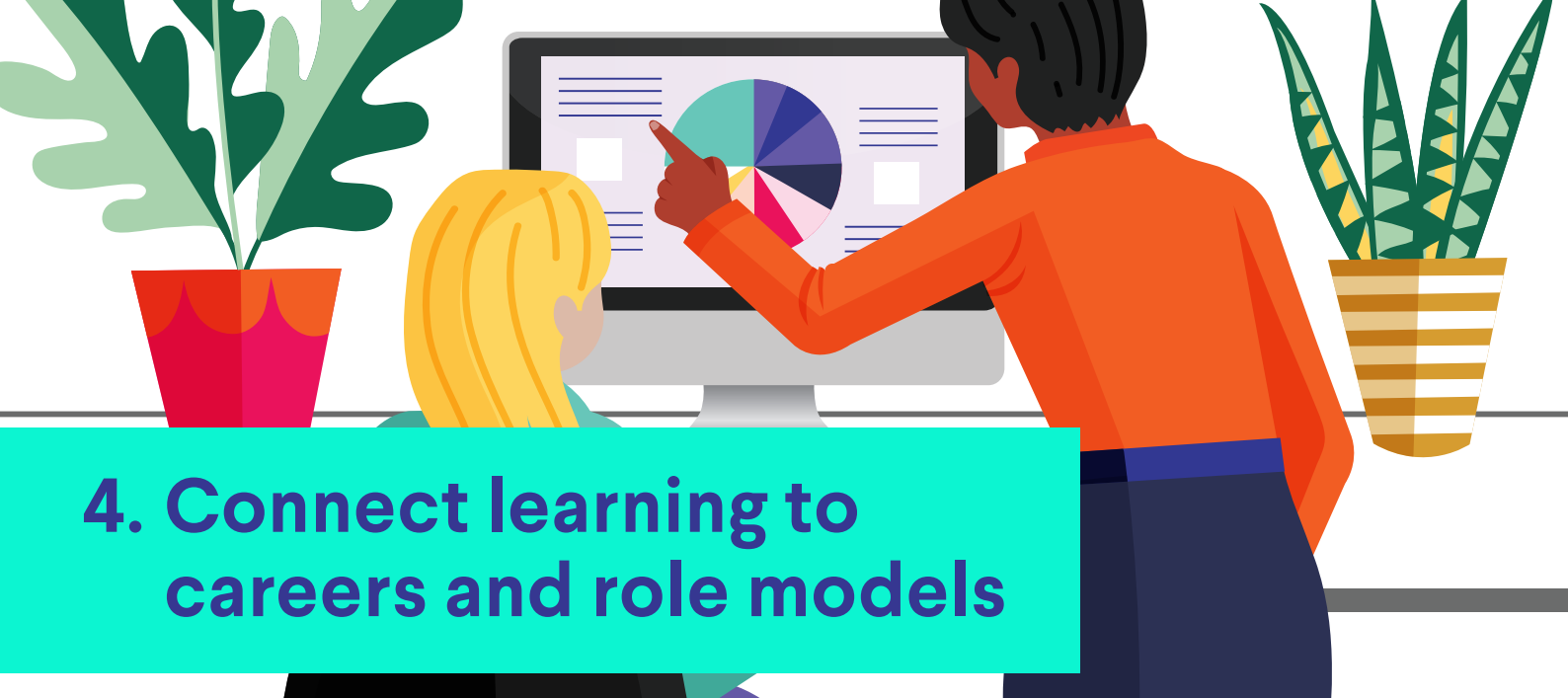
Integrate STEM authentically.

- Integrate STEM subjects with culturally relevant activities such as crafts, agriculture and local places, using culturally responsive pedagogy (e.g. [Narragunnawali](#) resources).
- Explicitly highlight where STEM subject content knowledge applies in problem-solving and project work. Prompt discussions around the application of STEM knowledge and skills.

Create and adapt lessons that are gender neutral.

- [Design and adapt lessons](#) using the [Seven principles of gender-inclusive lesson design](#) to engage not only girls, but all your students, in STEM.





4. Connect learning to careers and role models

For each topic, context or problem, explore related STEM careers and provide role models. Aim for a gender balance in both historical and contemporary figures.

In what ways can you connect STEM careers and role models to classroom learning activities and outreach?

Research has found the following:

- Explicitly showing what scientists and engineers do in learning activities can increase girls' (and boys') understanding of what they do (Adams et al., 2018). Projects that involve researching and presenting historic and contemporary women in STEM can be intrinsically motivating and informative (Rule, Blaine, Edwards, & Gordon, 2019).
- After learning about young engineer stories and stories of diverse innovators across different industries (e.g. theatre, computing, media), girls' awareness of STEM and engineering careers was found to improve, with 52% (from 25%) of girls claiming they had heard of engineers (Nation, Harlow, Arya, & Longtin, 2019).
- First Nations role models, when paired with culturally responsive pedagogy, can increase First Nations girls' motivation and interest in STEM (Kant et al., 2018).
- Group-mentoring may be more effective than one-on-one mentoring in engaging girls in STEM. Research has found that groups used 87% more STEM words than in one-on-one settings (2%), had greater networking frequency, and that girls in group mentoring had increased interest in STEM electives (Stoeger, Greindl, Kuhlmann, & Balestrini, 2017).
- School-college partnerships can encourage girls to consider STEM careers, and increase interest and confidence in STEM at school and their perceived effort to work harder in STEM subjects (Ilumoka, Milanovic, & Grant, 2017). However, they need to be sustained, as some girls, despite performing well, still lack confidence or report a lack of support once they are in STEM programs (Bystydzienski, Eisenhart, & Bruning, 2015).



CareerswithSTEM.com.au

Classroom strategies for connecting learning to careers and role models



Build intrinsic and extrinsic value in STEM by seeing real-world applications.	<ul style="list-style-type: none">● Help students recognise that STEM subjects are worth doing and relevant to career aspirations (e.g. by incorporating into your lessons UNESCO Goals or GiST lesson plans with real-world examples).● Support a whole-school and sustained approach to STEM engagement by cross-faculty work and identifying opportunities (e.g. outreach, excursions, competitions) and supporting careers counsellors.
Select classroom media that represents diverse STEM roles and role models.	<ul style="list-style-type: none">● Find texts (e.g. storybooks, news articles, textbooks, magazines) that show a diverse range of people doing STEM. View the GiST list of books to inspire girls in STEM or the Careers with STEM e-magazine series.● Present stories of STEM people with diverse interests and backgrounds in curriculum topics (e.g. using Digital Technologies Hub careers profiles, AMSI careers and GiST poster series).
Facilitate placements or excursions to STEM locations.	<ul style="list-style-type: none">● Take students off-site to STEM learning spaces (e.g. museums and science labs) to expose them to STEM careers, role models and the kinds of activities undertaken by people in STEM. The STARportal provides ideas and the GiST has many activities and events.
Connect talented students with STEM mentors.	<ul style="list-style-type: none">● Introduce online mentoring between talented girls and STEM professionals in small groups, as it may support STEM engagement and interest in further study/careers. Ask any local tertiary institutions if they have STEM mentors or outreach programs. Search the STARportal or encourage outreach mentoring opportunities, such as via Tech Girls are Superheroes or Engineers Australia, the Curious Minds Program, and CSIRO STEM Professionals in Schools.
Embed the learning of STEM professionals and jobs into curriculum.	<ul style="list-style-type: none">● Select projects that involve researching and presenting historic and contemporary women in STEM, as these can be intrinsically motivating and informative.● Invite STEM professionals to work with you to connect classroom learning to jobs and real-world examples of STEM.● Bring STEM role models into the curriculum virtually by finding stories on podcasts, videos (on the GiST, Digital Technologies Hub, AMSI), or connect via videoconferencing or social media. Find women in STEM on the Australian Academy of Science's STEM Women or Science and Technology Australia's Superstars of STEM.● Design STEM curriculum around real-world jobs and applications.



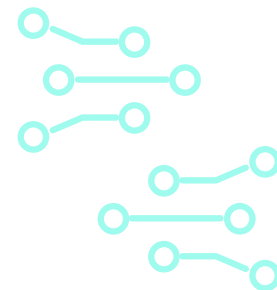
5. Engineer collaborative learning

Provide opportunities for social learning and collaboration. Girls tend to prefer social interaction and cooperative learning over competition, which can have impact on engagement with STEM subjects.

How do you design and monitor collaborative learning in the STEM classroom? What strategies do you adopt for equal and positive participation?

Research has found the following:

- Females tend to enjoy hard fun and collaborative fun, whereas males enjoy easy fun and competitive fun (Atwood-Blaine & Huffman, 2017).
- Girls prefer active and equal participation by all team members, and perceive this to be important to their learning (Dare & Roehrig, 2016).
- Boys and girls use different types of language in group work (McVee, Silvestri, Shanahan, & English, 2017). Girl-only groups use more 'team' language, such as 'we' and 'us', than boy-only groups but girls change this behaviour when in mixed groups (Schnittka & Schnittka, 2016). Mixed groups have been found to result in greater learning gains for girls than girl-only groups. However, sample sizes make it difficult to generalise.
- Males have been found to often take the lead in hands-on STEM activities, while females take a step back and watch what boys do first (Li, Huang, Jiang, & Chang, 2016).
- Girls adopt primarily a leadership role, collaborative support role, or independent role during team activities. Leadership-oriented girls can influence identity negotiation of peers and can impact on their STEM connection – whether it be positive or negative (Pattison, Gontan, Ramos-Montañez, & Moreno, 2018).
- The layout of physical spaces, such as laboratories, can influence the productivity of group work (Kwah, Milne, Tsai, Goldman, & Plass, 2016). Collaborative opportunities can be improved by providing multiple modes of engagement (McVee et al., 2017).



Classroom strategies for engineering collaborative learning



Include collaborative STEM projects in which students work toward a shared goal.

- Set group work that involves working toward a shared goal, to give students purpose and enjoyment in their learning, e.g. using a STEM app with gamification or [robotics](#) or [collaborative projects](#) found on the Digital Technologies Hub.
- Avoid using too many STEM activities that involve competition or competitive challenges as a goal.

Create and use spaces that support effective collaboration.

- Consider the layout of your school laboratory for collaborative work, to determine if it is suitable and conducive to productive group work.
- Support students' sense of belonging in a collaborative space by ensuring it is [stereotype-free](#) (gender-neutral).
- Set up tasks so students experience, and value, [effective group work](#).

Encourage equal and active participation of all students.

- Take time to [design the group work setup](#). Encourage girls to participate as active rather than passive participants in hands-on aspects of group work.
- Provide [multiple modes of engagement](#) for all students, including [those with disability](#), to make the most of collaborative learning opportunities.
- Encourage 'productive communication' including development of teamwork language, particularly girls' skill in direct requests and boys' use of 'team' language.
- Have students [adopt teamwork roles](#), to encourage the development of teamwork skills and a fair sharing of responsibilities.

Monitor collaborative work and participation.

- Ensure all members are participating equally in group work (including hands-on and verbal engagement) by monitoring behaviour and [student discourse](#).
- Monitor group work, including how leadership-oriented girls (and boys) create or reduce opportunities and positive experiences for team mates, to facilitate positive STEM connections.
- Invite students to reflect on positive (and challenging) experiences in STEM teamwork.





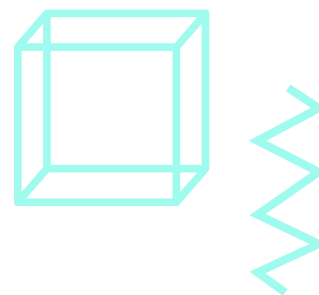
6. Provide choice and creative opportunities to demonstrate learning

Problem-solving, creativity and design have been identified as essential skills in all students' STEM development. Girls value creativity but often perceive STEM subjects and careers as lacking creativity. Creative problem-solving also encourages students to embrace failure as part of the learning process, building resilience.

When and how do students have choice and creativity over learning processes or projects? How do you scaffold learners in open-ended tasks?

Research has found the following:

- Student-centred learning and teaching combined with inquiry approaches focused on making the world a better place, with personally meaningful projects, can positively influence students' attitudes about science and STEM dispositions (Knezek & Christensen, 2020).
- Community ethnography – having students participate in and observe a community – as pedagogy has been found to ignite students to create innovative projects aligned to personal interests and values with real community relevance (Tan & Calabrese Barton, 2018).
- The open-ended nature of engineering activities and challenges has been found to lead to negotiation and participation challenges amongst boys and girls in mixed group work (Wieselmann et al., 2020).
- Students express dissatisfaction when they have no control over the purpose of their open-ended projects when they are pre-defined by the teacher. For example, students had a negative emotional climate toward designing a digital game with a specific requirement, such as a mathematics game (Kwah et al., 2016). Girls and boys, in the design of a toy for a junior class, expressed some dissatisfaction over having no control in selecting the end user of their toy (Holbert, 2016). Both studies suggest that what educators perceive to be providing choice may not align with students' experiences.



Classroom strategies for providing choice and creative opportunities

Use student-centred pedagogies.

- [Design learning experiences](#) that place students at the centre of identifying and defining the problem they want to solve, as this is motivating and builds engagement and interest in STEM.
- Use culturally relevant pedagogy that connects students with their own authentic cultures and identities, to facilitate meaningful choices and modes of creativity. Narragunnawali has culture-rich lesson plans for strengthening Aboriginal and Torres Strait Islander connections to STEM.

Have students create projects that align with their personal interests, culture and social values.

- Use community ethnography as pedagogy to ignite students to create innovative and STEM-rich projects, validated with community feedback, and to support creative problem-solving aligned with really community needs.
- Use Narragunnawali [subject guides](#) to support culturally relevant planning for reconciliation, and to include Aboriginal and Torres Strait Islander histories, cultures and contributions across the curriculum.
- Have students do [socially relevant](#) project work, to help them realise the impact of STEM, and to improve dispositions.
- Provide opportunities for students to personalise projects or objects in activities (e.g. design or dress up robots) for intrinsic motivation or through design of project direction.

Provide authentic choice for students in themed projects.

- Allow students to negotiate 'choice' in projects – whether that is related to who they are designing projects for or the problem they would like to solve within the constraints of the project (e.g. a game or a website). For example, the [Tech Girls Movement Competition](#) demonstrates the diversity of app solutions when choice is provided.

Harness STEM problem-solving processes to scaffold open tasks.

- Explicitly teach methods that will reinforce student understanding of STEM problem-solving processes (e.g. the [engineering design process](#) or [computational thinking](#)). These processes can provide structure for students undertaking open-ended and creative tasks, help them understand what STEM professionals do, and to see themselves as related to STEM professionals.
- Use research processes such as community ethnography or [design thinking](#). These may provide structure within which students define problems and develop creative solutions.





7. Encourage a growth mindset

Believing that success is due to fixed reasons such as natural ability is described as having a 'fixed mindset', whereas believing that success is due to malleable reasons such as effort and persistence is a 'growth mindset' (Dweck, 2006).

How do your students see themselves as STEM learners? How do you cultivate a growth mindset in the STEM classroom?

Research has found the following:

- Perceived stereotypes about who is good at or has greater ability in STEM subjects and jobs can impact on students' sense of belonging and how they view themselves in STEM (Master & Meltzoff, 2020). Students as young as six hold stereotypes that boys are better than girls, for example in robotics and programming (Master et al., 2017) and spatial thinking (Heyden et al., 2016).
- Girls demonstrate different mindsets around their expectations and perceived success, which can affect persistence in STEM (Koch, Lundh, & Harris, 2019). Teacher feedback and encouragement positively focusing on personal ability in engineering may encourage uptake for both boys and girls (Skipper & Leman, 2017).
- Free-journaling following a STEM activity can promote STEM knowledge, reflection and identity-formation (Lewis Ellison, Robinson, & Qiu, 2020).
- Engaging girls in hands-on, problem-based, collaborative engineering challenges may support them in recognising that females can be engineers (Ergün & Külekci, 2019).
- Being referred to as 'researchers' and hearing stories about role-model innovators of a similar age helped girls see themselves as scientists when they also led their own designs and projects (Nation et al., 2019). Allowing students to practise 'being a scientist' helped to build their self-concept (Dare & Roehrig, 2016).
- It is valuable to provide regular opportunities to give and seek feedback from peers and teachers as motivators in STEM learning (Gomoll et al., 2016). Supporting students to receive feedback is important in this process as, when reviewing feedback from industry professionals, students displayed a low emotional climate in the classroom (Kwah et al., 2016).
- Explicitly allowing time in the curriculum for discussions about dealing with failure and setbacks was important for girls (Nation et al., 2019). Holding conversations about career and study aspirations helped girls to see a future that is successful (Cole et al., 2016).



Classroom strategies for encouraging a growth mindset

Help students see themselves as 'STEM people'.

- Use language that encourages girls to see themselves as STEM people – 'engineers', 'scientists', or 'researchers'.
- Allow students to practise 'being a scientist' and [doing hands-on science](#) to build self-concept.
- Help girls see their future success by talking about [career and study aspirations](#).
- Monitor the emotional climate in the classroom toward STEM, such as self-efficacy and dispositions.
- [Support families](#) to encourage and engage in STEM activities and conversations at home, particularly around careers.

Present girls with relatable STEM role models.

- Present stories of female STEM innovators who are close to the age of your students (e.g. [Tech Girls Movement](#) or [STEM professionals](#)), as these can be powerful in helping girls and young women see themselves and females as STEM people.

Provide opportunities for self-reflection in STEM learning.

- Encourage free-journaling following STEM activities, to promote STEM knowledge, reflection and identity-formation.
- Have students document their STEM work and progress (e.g. through a [digital portfolio](#)) and at the end reflect on their own personal STEM development and growth.
- Ask students to [reflect on STEM activities](#) (e.g. perceptions, questions, interests).

Support students in receiving and using feedback as learning opportunities.

- Provide students with regular opportunities to [provide and seek feedback](#) from peers and teachers as motivators via [formative and summative assessments](#), including positive feedback focused on growth in STEM ability.
- Teach [strategies for receiving and giving feedback](#) to improve STEM projects.
- Hold discussions around [productive failure](#), including role-model examples of how to overcome or use failure with controllable methods such as problem-solving. In the early years, this could include reading picture books related to failure and mistakes.
- Involve students in the design of feedback mechanisms (e.g. a survey) so they have ownership.



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