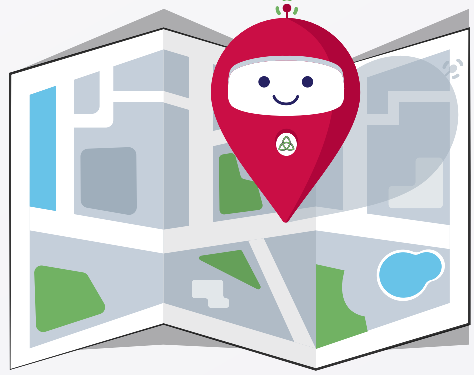
SFI Discover

Weave Project



Developing culturally responsive computational thinking skills through inquiry-based projects

Handbook for Primary Teachers

About the SFI Discover Weave Project

The SFI Discover Weave Project is a two year national project that aims to empower teachers to use computational thinking and coding within their classes to support the teaching of the Irish Primary School curriculum.

Over the two years, a total of nine schools, twenty eight teachers and over six hundred and fifty students took part in the SFI Discover Weave Project. Their input was crucial in co-developing a culturally responsive computational thinking framework. This framework will aid other schools in designing localised learning experiences to develop computational thinking skills and spark interest in the STEM (science, technology, engineering, maths) subjects, irrespective of students' backgrounds or genders.

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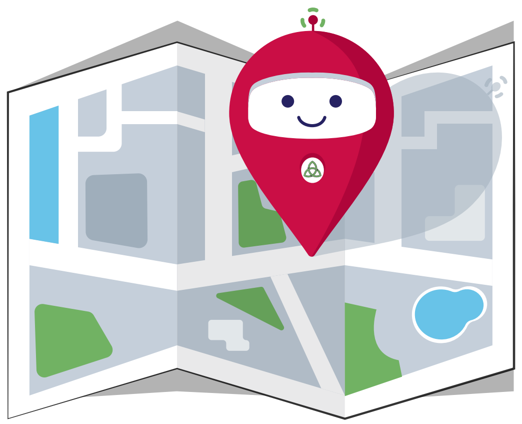
Scoil Mhuire gan Smál GNS, Green Lane

Dublin

Mary, Help of Christians GNS, Navan Rd
Our Lady of Victories BNS, Ballygall
St. Catherine's Senior GN, Cabra
St. Finbarr's BNS, Cabra
St. John of Bosco's BNS, Navan Rd

The Handbook

This handbook is intended to support primary school teachers in developing a practical understanding of culturally responsive computational thinking that is underpinned by a constructionist pedagogy.



In order to develop understanding of some of the key topics and to link them to the Irish Primary Curriculum, an overview of the five themes (Computational Thinking | Cultural Responsiveness | Co-creation | Cross-curricular Approach | Community of Practice) is first provided.

This is followed by some advice on getting started and planning your computational thinking journey using the Digital Learning Framework and school support through Oide.

As the LEGO SPIKE Essentials robotic kits are used throughout the project, a compilation of resources and tips for setting yourself up for success is then outlined.

Finally, some other resources are provided as suggestions for developing culturally responsive computational thinking skills within your school or classroom.

The Website

On our website, you'll find links to a PDF of this handbook, plus links to PDFs of all the resources. You'll also find some videos and other useful suggestions to help you along the way!

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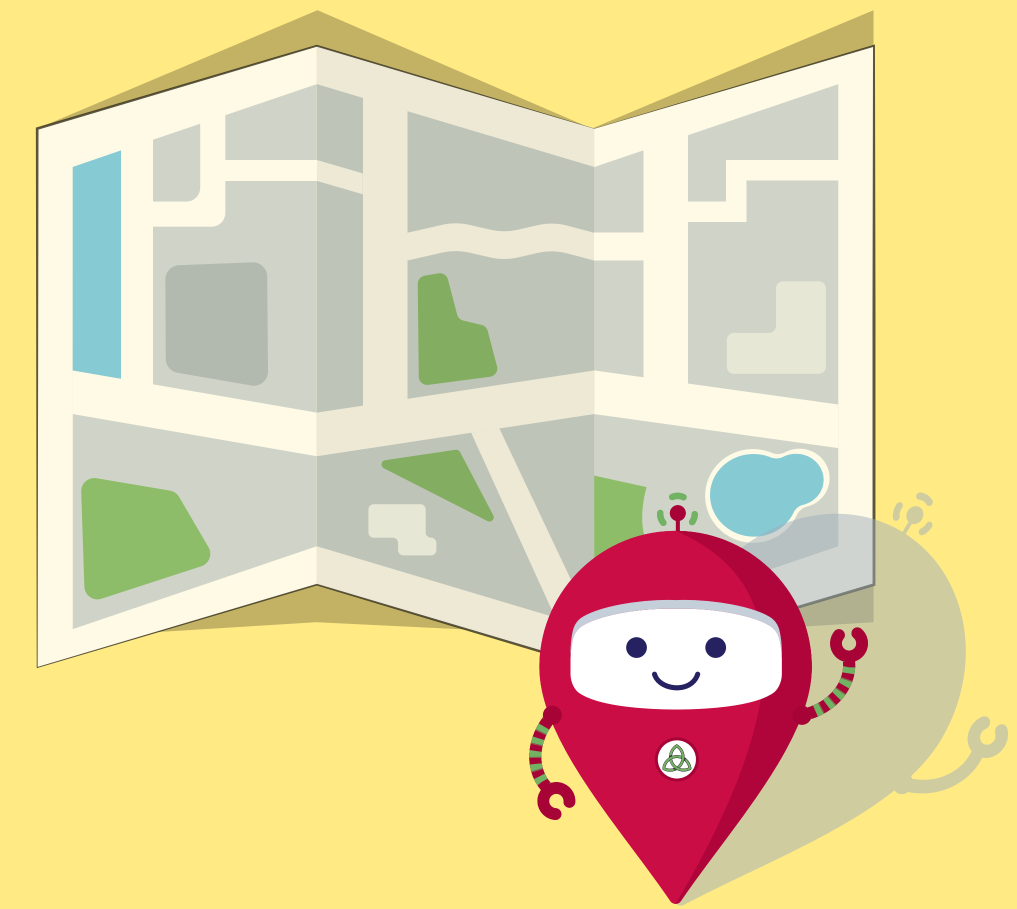
Introduction



Why a Constructionist Approach to Culturally Responsive Computational Thinking?

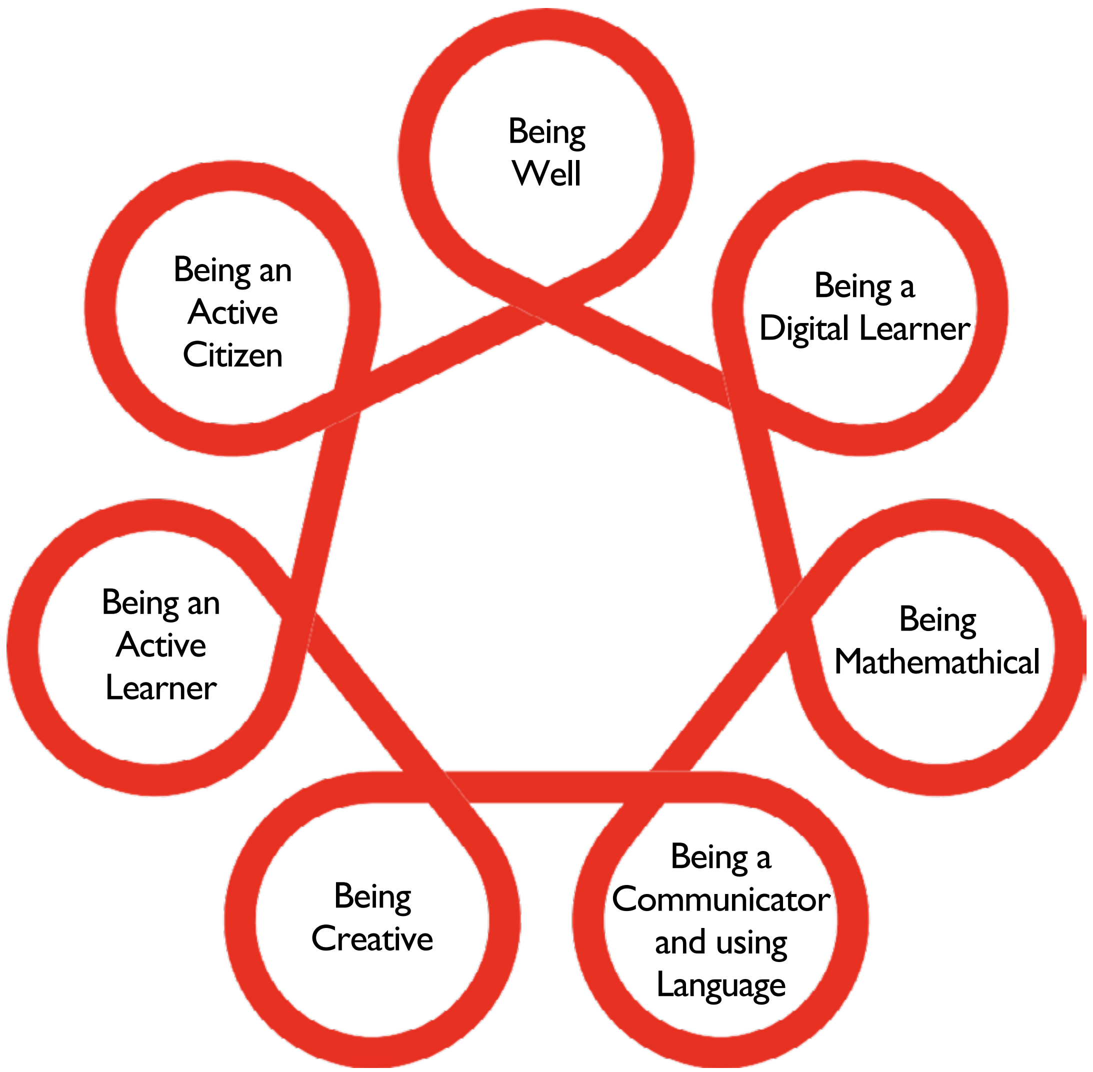
The SFI Discover WEAVE Project is underpinned by constructionism, a theory of learning where active engagement in creating tangible objects aids effective learning (Butler, 2004). These tangible objects, referred to as “objects to think with” (Papert, 1980, p.12), are key to the learning process. This approach also sees learning as a social process involving the whole person, where dialogue, meaningful collaboration and the learner’s prior knowledge form important components.

The term computational thinking originated within constructionism where the “making and understanding of computational objects” (Papert, 2006, p. 8) is a key tenet. Computers are seen as unique tools for learning, for constructing “objects to think with” and providing access to information, projects, and new ideas. A constructionist approach inherently values learners’ cultural and community connections as learning resources, providing a cultural tool for students to learn through their own frames of reference. Fostering interest, autonomy, and engagement is crucial to equip students for a changing world. Furthermore, ensuring that young, female, and minority students engage with STEM (science, technology, engineering, maths) is essential due to underrepresentation. Many factors contribute to this, such as bias, discrimination, social norms and so on. Girls, in particular, tend to lose interest in the STEM subjects with age so it is vital that these subjects are presented in such a way at primary level that sparks curiosity and raises interest.

Throughout the SFI Discover Weave Project, teachers and students engaged in inquiry based projects that aimed to raise interest and awareness in computational thinking and programming. Five themes supported this work which lead to the development of a Culturally Responsive Computational Thinking framework for Irish primary schools. This framework supports the Irish Primary School Curriculum and leverages the design thinking methodology. These, along with the five themes (Computational Thinking, Cultural Responsiveness, Cross-curricular, Co-creation, Community of Practice) will be outlined next.

The Primary School Curriculum

In March 2023, the Minister for Education Norma Foley launched the new Primary Curriculum Framework for all primary and special schools. The new Framework sets out the vision and principles for a redeveloped, modern curriculum. This includes the introduction of seven key competencies, shown below, to support students with developing skills to thrive and succeed today, and into the future. The new curriculum also includes the introduction and expansion of aspects of learning to include STEM (Science, Technology, Engineering and Maths) Education, a broader approach to Arts education and a flexi-time option amongst other revised elements. For further details on the new Primary Framework see: https://www.gov.ie/en/press-release/9f981-minister-foley-launches-new-primary-curriculum-framework/



Seven Key Competencies:
This figure was created by the NCCA (2020) and illustrates the interlinked nature of learning and of the construction of knowledge.

Exploring the Seven Key Competencies

These seven competencies are interconnected, aligning with the vision of the new primary curricular framework. This framework aims to empower each child to flourish and realise their potential, while viewing students as unique individuals and teachers as skilled, agentic professionals.

The curriculum promotes inclusive, evidence-based teaching, supporting progress in all areas of learning. Each competency is dynamic and interrelated, fostering an integrated approach to education.

Although the work done on the SFI Discover WEAVE Project touches off all competencies, the competency that will is the main focus is that of "Being a Digital Learner".

Being a Digital Learner

This competency seeks to support students to become curious, creative, confident and critical users of digital technology and enables students to critically engage and contribute in a digitally connected and interdependent world:

> **"Being a digital learner fosters students's ability to collaborate and thrive in a world increasingly immersed in technology. Students develop their knowledge, skills, concepts, attitudes, values and dispositions through problem-solving, experimenting and creating. As students develop this competency, their confidence in using a range of digital technology to harness their imagination and expand their creative thinking and creative expression increases. Through empowering students to be active digital citizens, this competency develops their responsible, safe and ethical use of technology."**
>
> *NCCA, 2020, p. 10*

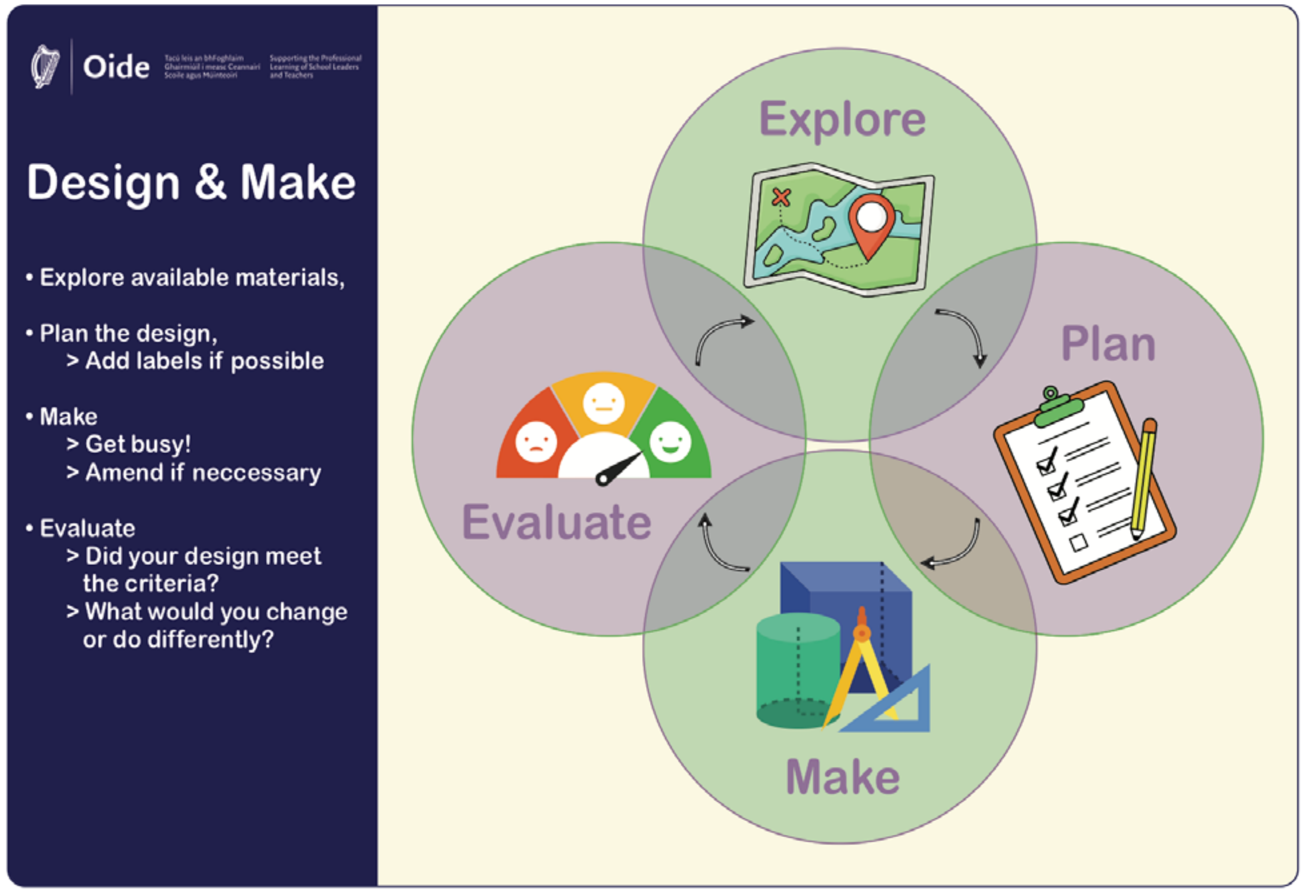
Design Thinking

Building on decades of work in relation to the use of digital technologies in primary school education, the *Draft Primary Curriculum Framework* (NCCA, 2020) and the *Primary Developments: Final Report on the Coding in Primary Schools Initiative* (NCCA, 2019) clearly highlight the importance of equipping children with the requisite skills, mindset, and knowledge tied to the competency of Being a Digital Learner.

Kenna (2021) acknowledges the challenges in crafting learning experiences for such critical and creative skills. Amid rapid technological changes, design thinking emerges as a methodology for teachers to design effective constructionist-based learning opportunities. Stepping away from traditional teaching methods, design thinking offers a flexible, step-by-step process that uses a range of methodologies, and encourages a particular mindset to address complex problems, creating new and innovative solutions that focus on the needs of the people who are most directly affected.

Oide "Design & Make"

Oide (the support service for teachers and school leaders funded by the Department of Education) puts forward the "Design & Make" framework as a simple and practical method of leveraging design thinking as a way of approaching an inquiry based project to structure cross-curricular learning experiences for the primary school classroom.



Oide "Design & Make" Approach: printable poster available on SFI Discover Weave Project website

Design Thinking and Computational Thinking

An increasing amount of research indicates that design thinking enhances and strengthens computational thinking, recommending the inclusion of art and design into the STEM curriculum, evolving it into STEAM. Both computational and design thinking possess similar characteristics as they apply a systematic and repetitive strategy to problem-solving, which is grounded in research and confirmed by data (Kenna, 2021).

The Irish Primary Science Curriculum also notes that "*The focus of a design and make curriculum can come from any response to a human need. Involvement in designing and making activities should awaken an interest in how processes are applied in everyday situations and how common tools, objects, appliances and machines work ... Designing and making is a process which draws on the whole curriculum and should be developed in association with and through visual arts, science and mathematics etc*" (Science Curriculum, 1999, p. 8).

Computational Thinking

Computational thinking can be thought of as the "making and understanding of computational objects" (Papert, 2006, p. 8). Learning through computational objects is unique in the sense that learners receive immediate feedback in some form and the computational objects can be highly personalised. Having an "object to think with" (Papert, 1980, p.12) helps to facilitate the connection between learners' existing knowledge, experiences, and interests with powerful ideas, ways of thinking and working that were not previously possible. Think of all the amazing things we use computers for in our everyday lives - technology is everywhere, in smart phones, medical devices and climate monitoring, to name but a few! When you learn about computation, it helps you to develop a basis for thinking about the world and understanding how it works (Butler, 2007).

Teaching Computational Thinking

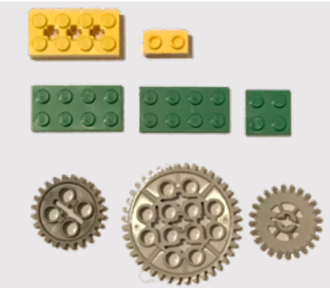
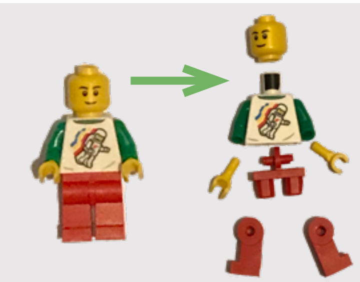
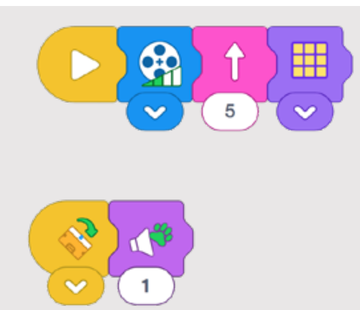
This involves helping students to see these connections in the real world, to help them to think like an artist, a scientist, a geographer and so on and to understand how to use computation to solve their problems, to create, to critique and to discover new questions that can be explored through many avenues (Hemmendinger, 2010).

Developing Computational Thinking

A knowledge of computational thinking concepts (such as abstraction, algorithmic thinking, decomposition, debugging and pattern recognition) can help learners to translate a set of steps into instructions a computer can understand.

Over time, learners can develop competence in computational thinking through building on these concepts and using strategies that help them with making and understanding computational objects.

Computational Thinking Concepts

Decomposition Managing complex tasks or situations by breaking them down into smaller, more manageable parts.		• *Encourage students to break down objects or problems into parts through a variety of tasks.* • *Support students as they engage in the process of analysis, empowering them to approach complex tasks with clarity.*
Pattern Recognition Identifying similarities and common aspects between things		• *Encourage students to identify and discuss patterns during tasks, ensuring students have the opportunity to create and explain their own patterns.*
Abstraction Reducing complexity or identifying general principles that can be applied across situations or problems.		• *Discuss with students what details are important and should be kept; what details should be omitted.* • *Can students identify a strategy to help them across multiple problems?*
Debugging Finding and fixing errors. Sometimes it is called troubleshooting.		• *Encourage students to persevere and to "debug" when something doesn't work as expected.* • *Support students with reasoning through a course of action for themselves.*
Algorithmic Thinking Helps a person figure out the exact order of steps to solve a problem and then to create clear, step-by-step instructions and rules.		• *Introduce puzzles that require students to plan multiple steps ahead, like maze games where they must find the correct path.* • *Create a dance routine by breaking down the steps, and have students follow or create their own dance algorithms.*

Cultural Responsiveness

The Irish Primary School curriculum is an intercultural curriculum and is based on the aim of an education that "respects, celebrates and recognises the normality of diversity in all areas of human life. It sensitises the learner to the idea that humans have naturally developed a range of different ways of life, customs and worldviews, and that this breadth of human life enriches all of us." (Intercultural Education in the Primary School, n.d, p.3.)

Being culturally responsive within the classroom entails designing learning experiences that are reflective of this breadth of diversity. We can leverage expressive computational materials (robotics in the case of the SFI Discover Weave Project), in an integrated manner while taking cognisance of the needs, interests and experiences of the learners within our classrooms (Butler, 2007). A primary aim of culturally responsive pedagogy is to create learning environments that allow students to use cultural elements, cultural capital, and other recognisable knowledge from their experiences to learn new content and information to enhance their schooling experience and achieve academic success (Howard, 2012). Such an approach provides a relevant and meaningful backdrop against which to develop competence in computational thinking skills.

Competence can be seen as the ability of an individual to use and combine their knowledge, skills and wider competences according to the varying requirements posed by a particular context, a situation or a problem (ENCoRE, 2005). Computational thinking develops within contexts as the ability to solve a problem for someone depends on an understanding of the context in which the problem exists (Tedre & Denning, 2019). **Knowledge of computational thinking concepts**, as outlined in the section previously, **can help with formulating ideas and solutions to contextual problems**.

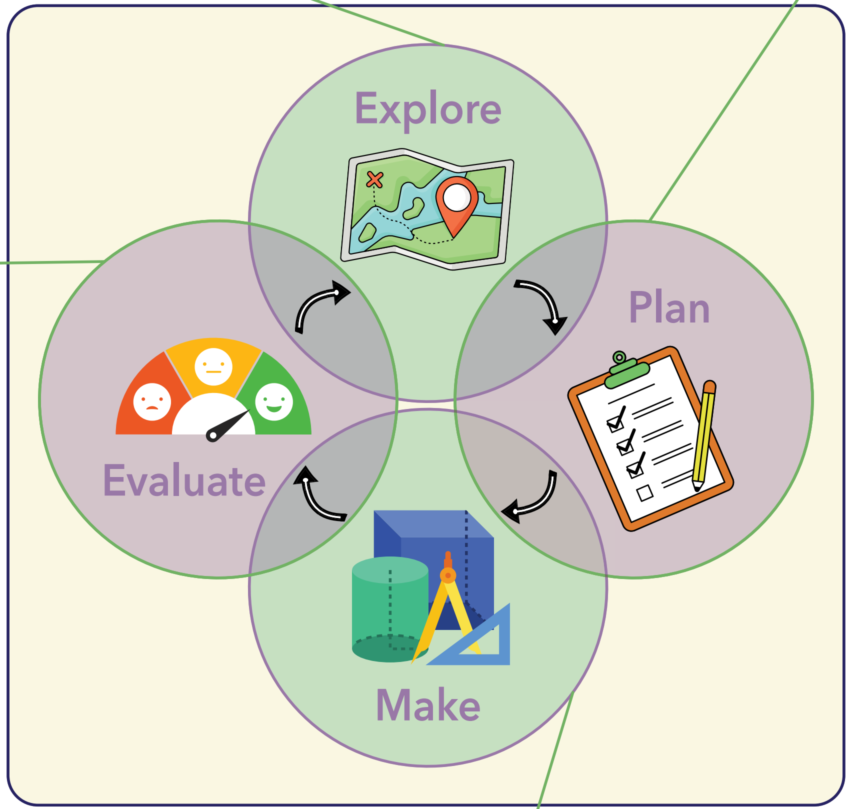
Culturally Responsive Approach

Design thinking provides a method to support Culturally Responsive Computational Thinking. It's a flexible approach for solving complex problems and creating unique solutions that are relevant to local needs. It's also a versatile way to tackle complex issues, such as becoming a digital learner. Here are some examples of connecting personal, cultural, and community aspects to the "Design & Make" framework:

Explore

During exploration, students gather knowledge and understand the problem's context.

- (Personal) Students' prior knowledge is valued.
- (Cultural) Students see their cultural understanding is important.
- (Community) What knowledge can parents, guardians, grandparents, other family or friends contribute to the research?



Plan

- *Planning involves applying practical skills to develop a design solution based on prior (and acquired) knowledge.*
- What is it we hope students will be able to do more competently as a result?
- What craft/skills are involved?

Evaluate

Evaluating - students assess the effectiveness of their design solution, consider its impact, and reflect on the process.

- Students critically reflect on their use of technology to drive social changes.
- They are also prompted to reflect on the sources of their knowledge and information.
- Classroom supports such as Buddy Maps (Bers, 2010), see page 67 for more details, can also help students learn from and connect with each other.

Make

This phase involves executing the design plan and applying craftsmanship skills to bring the concept to life.

- Through the Design & Make process, a variety of ideas and subjects are woven together in meaningful, real-world contexts.
- Students feel connected to each other and their communities.
- Students are equipped to be innovators of technology, rather than just users of it, developing a mindset that is attuned for solving complex problems which consider the end-user(s).

Cross-curricular Approach

As mentioned above, design thinking enhances and strengthens computational thinking as both apply a systematic and repetitive strategy to problem-solving (Kenna, 2021). Computational thinking always requires a context in which to develop - your ability to solve a problem for someone depends on your understanding of their context in which the problem exists in the first place!!

A Cross-Curricular Approach & Computational Thinking

Developing an understanding of context and of someone's problem requires an exploration or inquiry of some sort to be carried out. Adopting a cross-curricular, inquiry-based approach provides a way of organising the curriculum that involves exploring different subjects together around a shared theme, often through inquiry-based methods. This helps teachers to consider and establish the "how" as well as the "what" is to be learned across such projects (Bacon, 2018). History and geography great starting points! Both are "umbrella subjects" and encompass all aspects of societies; art, maths, music etc. (Rowley, 2009).

As can be seen from student work on the SFI Discover WEAVE Project, an inquiry based approach which leverages design thinking and develops computational thinking skills in a localised context results all manner of wonderful robotic-powered inventions!! Learning about computation not only supports students in developing "a basis for thinking about the world and how it works" (Butler, 2007, p.64) but it also provides a meaningful context for learners to develop their meta-cognitive skills as they "learn how to think about themselves, their learning, ideas, and experiences" (Cator et al., 2018, p. 10). This requires students to build competence in computational thinking through a range of knowledge, skills and attitudes.

Scan the QR code to listen to this student talk about her team's invention to help the President of Ireland with his daily work at Áras an Uachtaráin!

This is a great example of the competency of "Being a Digital Learner" in action!

Cross-Curricular Approach:

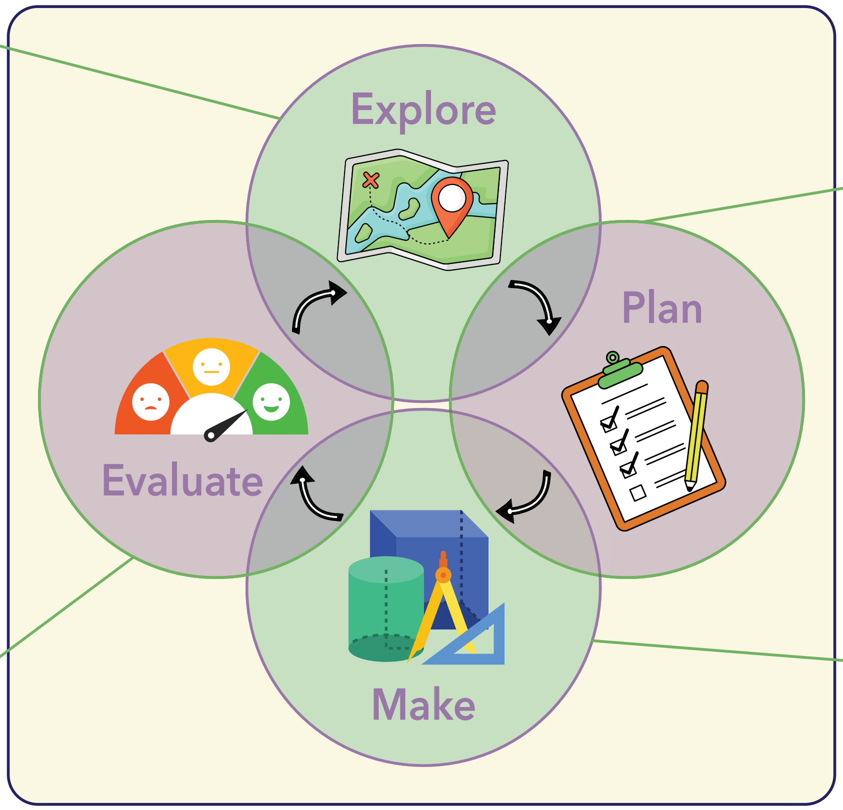
Leveraging Cultural Responsiveness & Computational Thinking

To succeed in inquiry based, cross-curricular projects that span subjects and involve students making and understanding computational objects from their own perspectives, students need to actively engage in the process. This includes steps like prototyping. This process lets students explore different ways of understanding and using computers, while also developing their computational thinking abilities.

Below, you'll find some examples of questions that fit into the "Design & Make" framework, helping you think about what students need to be successful in terms of knowledge, skills, and attitudes to be culturally responsive and develop competence in computational thinking.

Explore

- Students' build on and extend their prior knowledge;
  - → What new **knowledge** do students need for this inquiry?
  - → What are the key terms or vocabulary required?
  - → What **knowledge** about computational thinking concepts is required?



Plan & Make

- What practical **skills** will students need?
- What **character** skills will students need to be successful in this project?
- How will students realise their ideas? (for example; build a working robotic model).

Evaluate

- What outcomes are addressed in this inquiry?
- How does the inquiry align with cross-curricular objectives?
- What artefacts will be used to assess understanding, **knowledge**, **skills**, **attitudes** and thinking? For example; robotic builds, writing pieces, digital portfolios

Competence in Computational Thinking

To help with considering some answers to those questions posed above in the "Design & Make" process above, we can use the competence in computational thinking framework to think about what knowledge, skills, and attitudes might be required.

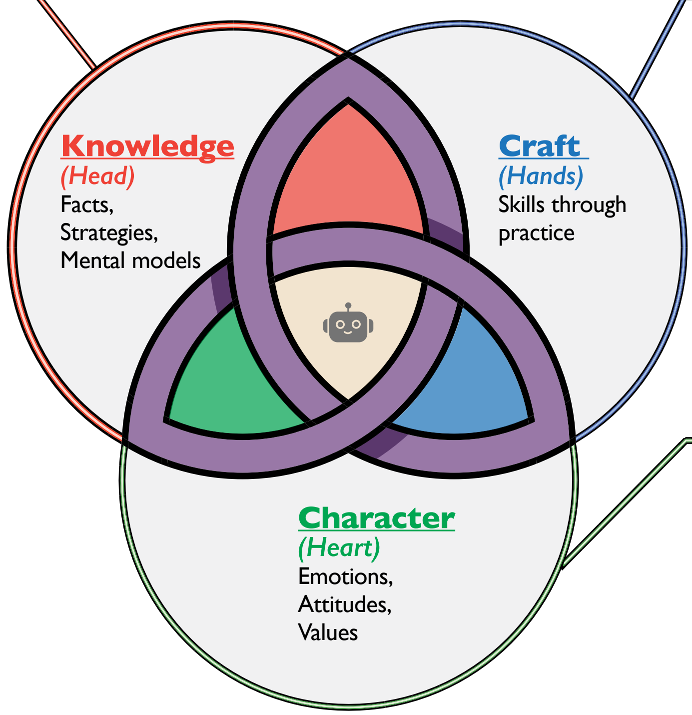
Developing competence in computational thinking doesn't happen on its own. It grows gradually, within specific situations, and can be thought of as a bridge connecting different subjects. Competency extends beyond mere knowledge and actions. It entails navigating complex situations using not just expertise and skills, but also through clear communication and personal attributes such as attitudes and behaviors.

Developing competence in computational thinking requires a mix of knowledge, craft and character. Engaging in the process of constructing and programming a computational object to think with can help with developing such skills.

Knowledge

What must I learn?
- debugging
- decomposition
- algorithmic thinking
- pattern recognition
- abstraction
- computer systems

What am I doing?
- answering
- explaining
- predicting
- analysing
- reasoning



Craft

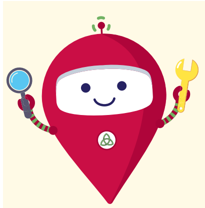
What must I learn?
- programming
- constructing

What am I doing?
- tinkering
- creating
- collaborating
- iterating

Character

What must I learn?
- expressing
- questioning
- connecting
- empathising
- evaluating

What am I doing?
- imagining
- caring
- appreciating
- persevering



competence in computational thinking
=
knowledge + craft + character

Competence in Computational Thinking diagram modified from NCCA, (2018) Review on Computational Thinking Literature

Computational Thinking in Action

As students develop computational thinking skills and the competence of "Being a Digital Learner", they must also draw from a wide variety of skills and knowledge, enhancing other competences such as "Being an Active Citizen", "Being Creative" and so on.

The table below provides some examples of what developing culturally responsive computational thinking skills could look like in action.

"Head" and "Hands"

Theoretical knowledge becomes practical through hands-on activities, like designing and programming a robot to navigate a maze.

- This involves understanding programming logic, sensors, and algorithms (head), and using this understanding to code the robot's actions (hands).
- For success, students must juggle multiple computational thinking concepts, work with various levels of abstraction, and hold different notational models.

"Hands" and "Heart"

Hands-on learning merges with empathy, social skills, and understanding consequences. For instance, students make robotic pets for emotional support.

- Students build and program the pets (hands), developing empathy for users' needs (heart).
- Meeting these needs requires understanding computer systems and programming basics, along with adapting the design to fit requirements.

"Heart" and "Head"

This area merges knowledge and empathy, highlighting the need for a blend of understanding and emotional intelligence. For example, older students could act as peer-mentors to younger students.

- Students teach robotics to peers and community (heart).
- Emotional/social aspect - attending to diverse audiences and adapting different communication modes (heart).
- Intellectual aspect could involve grasping robotic concepts to perform a particular simulation and using subject specific terms (head).
- Students enhance connection, simplifying complex ideas for others.

Central Area (Balance and Integration of All Aspects)

The overlap of circles represents a holistic learning experience, blending knowledge, practice, emotional growth and social awareness within real world contexts.

- Students create robots for real challenges: environment, community etc,
- By crafting an "object to think with" students learn about robotics, programming and engineering (head). They collaborate to build functional robots (hands) while considering societal impact (heart).

Co-creation & Community of Practice

Throughout the SFI Discover WEAVE Project, running alongside the themes of computational thinking, cultural responsiveness and a cross-curricular approach, the themes of co-creation and developing a community of practice were also explored.

Co-creation

In a constructionist learning experience, students and teachers learn collaboratively, sharing their diversity of knowledge and benefit from each other's insights. Co-creation can be described it as a joint effort that values every participant's input, highlighting the significance of diverse knowledge and viewing teaching as a means to foster transformative experiences by building on existing knowledge (UNESCO, 2021)

Robotics naturally combines constructionist and culturally responsive approaches through co-creation. Teachers select curriculum aspects explored via robotics, resulting in student-driven projects. Each robotic creation is distinct, merging prior and new knowledge from peers and teachers.

Community of Practice

One of the benefits of a culturally responsive and cross-curricular approach is the development of a community of practice. A community of practice can be defined as a "group of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (Wenger, McDermott & Snyder, 2002, p. 4). There is a synergy between the development of a community of practice, co-creation and the theory of constructionism as learners collaborate and construct knowledge together.

Getting Started:

Within my school...

Creating a **Digital Learning Team** is a great way to begin fostering a community of practice for sharing knowledge and cultivating computational thinking skills. The **Digital Learning Framework** website has resources and supports to get started. Platforms like Scoilnet can also serve as repositories to exchange ideas and build a resource library for your school's use. Additional guidance for nurturing a community of practice can be found on pages 37 of this handbook.

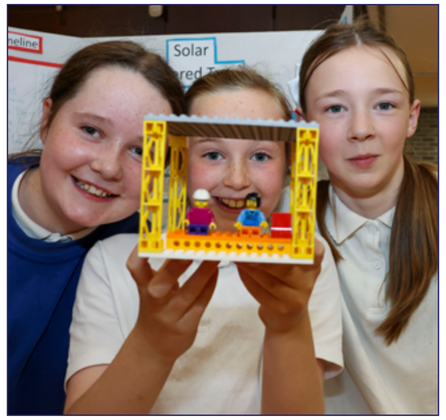
Within my classroom...

Robotics allows for students to engage in collective knowledge construction as students work together on hands-on projects to create innovative solutions and meaningful artifacts. A classroom community of practice fosters collaborative knowledge construction in various domains, often involving cross-generational input like talks from parents/guardians. This leads to shared resources and insights that benefit all members.

All Five Themes Together!

Computational Thinking | Cultural Responsiveness | Cross-curricular | Co-creation | Community of Practice

In essence, the SFI Discover WEAVE Project demonstrated that developing culturally responsive computational thinking skills; underpinned by constructionism and supported through co-creation and a community of practice, is not just an individual endeavor but a collaborative, social and iterative process. Learners construct knowledge together, leveraging their experiences, hands-on creations, and shared discussions to deepen their understanding in a supportive community setting.



Scan the above QR code to watch some of the final robotics projects from the SFI Discover Weave Project Showcase 2023 bring the five themes to life!

All Five Themes in Action!

Computational Thinking | Cultural Responsiveness | Cross-curricular | Co-creation | Community of Practice

The Empowering Minds project was a separate study led by Prof. Deirdre Butler in 1998 involving nine teachers from four Irish schools. Built on constructionism, this project also utilised expressive computational tools (LEGO Mindstorms and Logo Microworlds, which were predecessors to LEGO SPIKE robotics) and harnessed students' personal, cultural, and community connections to realise meaningful, student-led projects.

Five learning stories (Táin Bó Cuailnge, Castletown House, The Selfish Giant, Díarmaid agus Gráinne, The Local Coalmine) from this project help to further illustrate how robotics can be used to support inquiry-based, cross-curricular learning experiences that facilitate the development of computational thinking skills within localised, community settings.

!!! In the learning stories, reference is made to the LEGO RCX Brick.

RCX stands for Robotic Command eXplorers and was used in the first generation of LEGO Mindstorms.

The LEGO SPIKE hub is the modern equivalent.

LEGO SPIKE Essentials Hub

Learning Story 1: Táin Bó Cuailnge

Táin Bó Cuailnge—meaning, the Battle of the Bulls—is an epic story in Irish lore. A project around the legend was guided by Tommy Maher, a teacher in the Clontubrid National School. Clontubrid is a two-teacher public school located in the parish of Lisdowney, near the town of Kilkenny. (Because of many factors, including its rural nature and its local orientation, Ireland has a heritage and continuing support for small, one-, two-, and three-teacher primary schools, located in rural areas.). Mr. Maher's class consists of a mixed age group of sixteen children, including the third through sixth classes (children nine to twelve years old).

In the Táin Bó Cuailnge legend, Medb, an ancient queen of a western province of Ireland, needs to procure a powerful bull to equal the majesty of a bull owned by her husband Ailill. She learns of a worthy bull, the Brown Bull of Cooley, and goes to war with its owner to win it. The final part of the tale recounts the fight of the two bulls when they meet.

The Brown Bull of Cooley killed the king's White-Horned Bull, impaled his body on his horns, ran around the whole country scattering parts of the bull in different places around the country, and finally collapsed and died himself. The places where the parts of the White- Horned Bull landed gave their names to that place; e.g., the Irish name for Dublin is Baile Átha Cliath (the town at the ford of the ribs). In the hands of a teacher like Mr. Maher, students learn that myths like this one often have a basis in fact. In this case, as Mr. Maher explains:

The story seems to have some loose basis in fact and to stem from folk memories of ancient actual wars between the northern and southern parts of Ireland. As cattle were, in ancient Ireland, regarded as units of currency, units in which all debts and fines could be paid. Even a murder could be forgiven by the payment of a certain number of cattle and each class of person in society had an honour price measured in cattle.

The children chose the Battle of the Bulls as the part of the Táin Bó Cuailnge to illustrate, having examined each of the seven parts of the story. In the previous year, some of the children made PowerPoint presentations of the entire tale; in their work with the Mindstorms materials, these stories were brought to life.

The children decided to build bulls from the Mindstorms materials, and initially had both bulls trying to find each other by sensing and following light. The light source was a small high powered flashlight mounted in each of the bull's heads (see Figure 1). After a lot of time and effort spent programming and testing, however, this strategy had to be abandoned as the light source was too easily corrupted (e.g., by turning on an overhead lamp or the main classroom lighting).

Another complication was that a bull would sometimes reverse too far out of range and consequently no light source could be detected by the other bull. This problem of light sources causing difficulties was a recurrent theme which the children in all classrooms involved in the project experienced at one time or another, causing them to rethink how they were going to solve the problems they encountered.

The children went about redesigning the bulls to simulate the battle. Inspiration came from another group of children in the class who had been working on building a bug which reversed when its antennae hit an object. Using this concept they built a set of horns for each of the bulls which when struck would release a touch sensor. This would cause the bull to retreat before driving forward to attack again. When building each of the bulls, great care had to be taken to ensure that both sets of horns were at the same level to facilitate the releasing of the touch sensors.

The children also decided that the victorious bull would do a victory charge around the large map of Ireland to symbolize his trip around the country. They made a large map of Ireland with holes at the places named from the bull's body parts. These place names had covered LEGO lights behind, which were all wired back to an RCX (*the RCX is the equivalent of the LEGO SPIKE hub!*). As the bulls fought they were programmed to send occasional signals back to the RCX running the lights. When this RCX received the signal it was programmed to have the lights on the map flashing on and off.

Much of the technical challenge in this project revolved around the interaction between the two bulls and the map. The children made good use of the RCX's built-in communications capability, both in the bulls' interactions, and the subsequent map display. In essence, the children designed a system that consisted of three separate yet interdependent entities, and programmed them so that a desired pattern of interaction would occur.

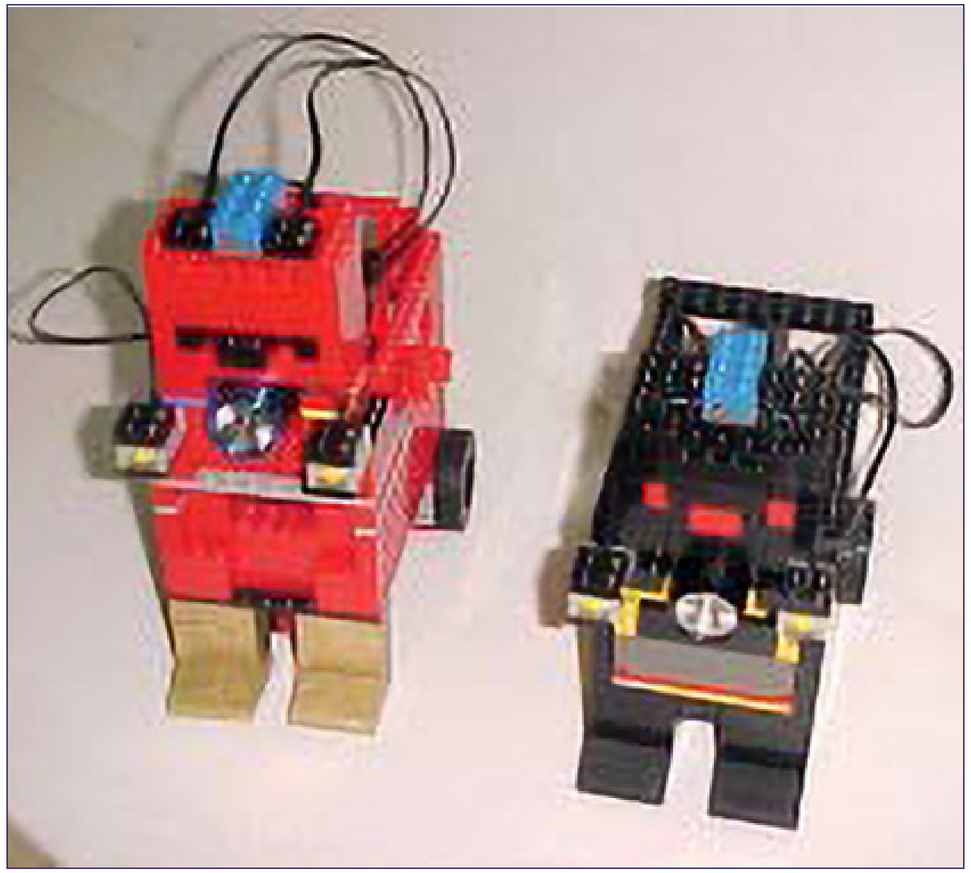


Figure 1:The Bulls of the Táin

Learning Story 2: Castletown House

The Castletown House project was led by Joan O'Rahilly, a teacher at St. Finian's National School, who had a fourth class (children aged 10 years old). St. Finian's is a medium- sized public school (approximately 220 children) located in New Castle, a suburb of Dublin. Ms. O'Rahilly's class drew inspiration from the local legend of Castletown House, a large mansion in the nearby town of Celbridge.

In the Castletown House story, hundreds of years ago the owner of the manor spent a day hunting, and while on the hunt met a handsome stranger, whom he befriended and invited back to his home. That evening, while playing cards with the stranger, the owner happened to drop a card off the table and when picking it up, noticed that his companion had cloved hooves as feet. Panic and other excitement ensued as he realized he had invited the devil into his home! A priest was sent for to exorcise the devil. The priest threw a bible, which shattered a mirror, and chased the devil into the fireplace. The devil then escaped as a puff of smoke through the chimney.

When the class decided upon the Castletown House legend as a project theme, Ms. O'Rahilly organized a series of activities to engage the imaginations of the children, and integrate this work into the life of the classroom. The class took a field trip to visit the mansion itself. While there, children took photographs of the house with the digital camera that was provided to the school as part of the project.

Back in the classroom, the children engaged in many activities to interpret the Castletown legend. They had extensive discussions, dramatic role play, storyboarding and other drawing, as well as writing up their own stories. It was the basis of classroom work for a good period of time, explored at many levels. With art materials, the children re-created features of the house, including the furnishings and portraits (Figure 2).

Figure 2:The Castletown House Model

As the central project, the class designed a miniature Castletown House of their own,which they populated with characters from the story—LEGO models controlled by the RCX bricks (*the RCX is the equivalent of the LEGO SPIKE hub!*) running programs written by the children. These actors included the lord of the manor, the devil, the priest, a maid. Figure 3 shows a child working on the devil.

The house itself also incorporated active elements, including window frames that moved up and down on their own, and flashing lights to suggest fire in the fireplace. The children conceived of a complex series of events to be enacted by the models representing the characters of the story. When they made their initial plan, they imagined each of their actors would work perfectly and predictably, but the reality was far from their ideal vision. Much of the children's learning resulted from facing the difficulties in implementing their vision.

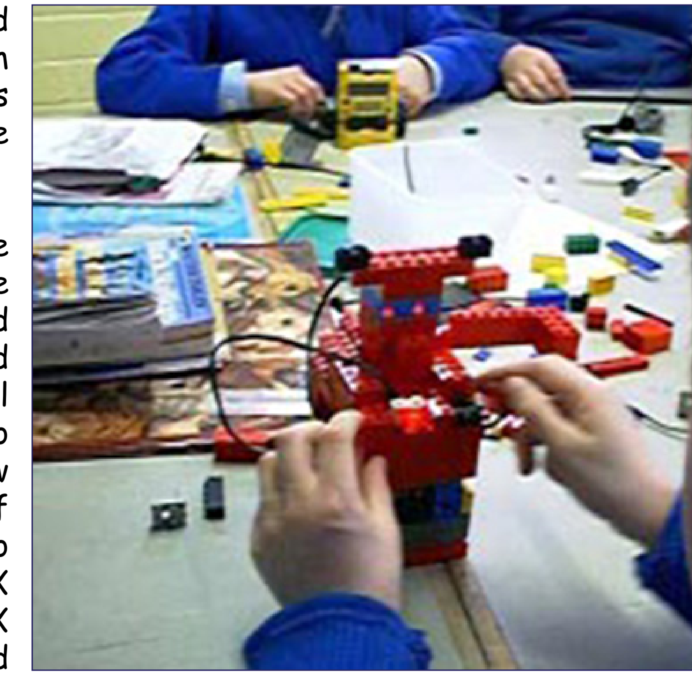


Figure 3:The Devil of Castletown House

For example, "The Maid" would start the story by moving towards the "Corpse in the Coffin." The Corpse's RCX would be waiting for a message which would signal it to rise out of the coffin and fall back down again. A pause was built into the Maid's program which would allow for this. She would then reverse as if in fright and begin a series of beeps to signal her alarm. Then, the Corpse's RCX would in turn send a signal to the RCX controlling the windows, which would cause them to begin moving rapidly up and down to add suspense and terror to the scene. However, this could not be done as the positioning of the RCX's infrared communications port did not allow it. If the Corpse's RCX port were aimed at the Maid, then it could not also communicate with the Window's RCX brick.

As an interim measure, the children incorporated a timed wait into the program for the windows. Later, they re-sorted to manually pressing the run button to control the windows, as they were not satisfied otherwise that the windows opened and shut at the appropriate time. The central character was the devil and he presented a myriad of problems for the children. They wanted him to come into the room, stop and play cards. He was then to throw off his cape revealing who he was and when the priest arrived he was to disappear up the chimney. The children wanted to program this sequence of events with a series of timed waits, moving the devil into his required locations by using a light sensor to follow a black line.

The biggest problem was getting the Devil to follow a black line. When the children solved this, and had learned how to reset the readings for different lighting conditions, they thought they had just to program the timed waits. But once the devil was programmed to respond to the line, it always did so, even when the children wanted it to move differently. The RCX Code did not provide a way to disable and re-enable its sensor-watchers.

Collectively, this project proved quite difficult to accomplish in the manner in which it was framed. Because each character in the story relied on others to work properly, children could not choose one piece of the project and just get it to work individually; all of the actors in the story were interdependent with the others.

In subsequent work, Ms. O'Rahilly plans to guide her students toward a design with less tightly coupled sub-projects, so the small teams of children working on each piece can more readily integrate their results at the end.

Learning Story 3: The Selfish Giant

The Selfish Giant project was led by Ruth Kirwan of the City Quay National School. She had a combined second and third class (children aged 8 and 9 years old). City Quay is a public school located in the city of Dublin, and serves primarily children from economically disadvantaged backgrounds.

In Ms. Kirwan's class, the children used Oscar Wilde's story "The Selfish Giant" for inspiration. In the story, a giant owns a beautiful garden that is visited by children while the giant is away from home. When he returns, the giant evicts the children and builds a wall around the garden. From then on, it is always winter in the garden and spring never comes.
One day, the giant hears a band of musicians in his garden, but it is a single bird resting in a tree and singing a song. The bird had followed a little boy who had crawled into the garden through a crack in the wall. The giant finds the boy and lifts him into the tree, which suddenly bursts into blossom. The giant then realizes it's been forever winter in his garden because of his selfishness. He then opens his garden to the neighborhood children, and the normal cycle of seasons returns. The giant has a long and happy life, but he always misses the little boy.

One winter, the giant sees a flower in bloom and wonders how this could be. He then finds the little boy, and sees that he has the wounds of crucifixion on his hands. The giant is very upset, but the boy tells the him they are wounds of love, and invites the giant to join him in his garden in paradise. Later, the children come to play, and find the giant lying in his garden, covered with blossoms. They think he is sleeping, but soon realize he has passed away.

Figure 4: City Quay School's Selfish Giant Project

The story is especially meaningful to the City Quay children because Oscar Wilde as a child lived in the same neighborhood as the children do now, and his statue resides in the Merrion Square park which could have been the garden in the story.

Ms. Kirwan used this story as the hub for a variety of activities in her classroom. The children visited Merrion Square and saw Wilde's statue. They read the story aloud in class. The children wrote poems and short stories of their own based on the tale. And the class created a community project using the LEGO Mindstorms materials around the story.

In the class project, four 4 ft. square pieces of pressboard were arranged in a square. On this tableau, the children re-created the central scene and characters from the story: a large garden walled off from the rest of the city, a tree in the garden, the giant, and the boy. Figure 4 shows the completed project.

The children also represented elements from their own lives in the diarama. Outside of the walls of the garden, they included the town dump, a highway filled with automobiles, and gray factory buildings. Little security cameras were interspersed throughout. A large sign on the walls protecting the garden read, "Trespassers will be prosecuted."

The children used the RCX brick (*the RCX is the equivalent of the LEGO SPIKE hub!*) to program patterns of movement and beep sequences into several of the cars outside the garden walls (the rest could simply be pushed along manually). The giant was the biggest single LEGO construction, and it included an RCX brick programmed to make its eyes flash and its arms rotated back and forth. The children also built swings and merry-go-rounds in the playground which were activated by an RCX.
None of the children had LEGO experience coming into the school year. These were among the youngest students involved in our project. And yet, they mastered fundamental building skills, like interlocking blocks to make a strong wall, making vehicles which could steer, and they learned basic programming and control concepts.

Most importantly, the narrative project framework gave all of the children a means for self-expression. In the final result, the children collectively built a model that not only interpreted Oscar Wilde's story but also demonstrated their own personal experiences of life.

Learning Story 4: Díarmaid agus Gráinne

This classroom example illustrates how a traditional curriculum can be approached from a 21st century perspective using expressive computational materials in an interdisciplinary way while taking cognisance of the needs, interests and experiences of the learners. In keeping with the Empowering Minds community's narrative theme, the teacher and child collaborators in this example chose to work with the "Díarmaid agus Gráinne" epic in Irish folklore. This is a wonderfully varied story of love, adventure, action, pursuit and excitement, enjoyed by male and female, young and old alike. As they created their own version of this ancient Irish epic they were engaged in a variety of learning activities ranging from exploring narrative, working with building materials and problem-solving to designing, collaborating as a team and working with sensors and programming. This classroom example demonstrates effectively that these children and their teachers were active makers of their own meanings, empowered to use and shape the world with these expressive computational materials, rather than be shaped by them.

The children and their teacher chose two scenes to construct from the story, one using LEGO Mindstorms materials with the programmable bricks and the other using clay models and the Microworlds or iMovie programming environment to create an animation. The episode I have drawn upon here is the work they engaged with using the LEGO Mindstorms materials. Conor, the teacher kept a reflective diary during the development of the project constructions. The account details the range of materials used, the types of problems that emerged, the modifications to the story resulting from negotiations with materials and Conor's appeals to the larger Empowering Minds group for help. It also demonstrates how the project facilitated the integration of many aspects of curriculum, including heritage and culture, history, science and engineering, problem solving, writing, arts and crafts, design and construction, communication and collaboration and language development.

The following is a student's description of the scene that they had selected to illustrate from the epic as presented by the teacher in his journal: *The LEGO scene we have chosen describes Díarmaid's escape from a fort he has built in the middle of a forest. He has built a stockade with seven doors in it around the fort. His enemy Fionn surrounds the stockade, so Díarmaid cannot escape. In our scene we want Díarmaid to walk around to each of the seven doors, pause at each one to find if there is a means of escape. At the seventh door he realises that Fionn is outside it with lots of soldiers. So Díarmaid decides to make his escape here. He actually pole-vaults out over the stockade using his spear, and lands well beyond the bank of soldiers surrounding the stockade. We want to get a good model of Díarmaid built to walk around to each door and stop, get each door to open, and finally at the seventh door get Díarmaid to escape over the stockade* (Conor's diary, Feb. 2003).

In order to enact this scene Díarmaid must be able to walk around the stockade and pole- vault out. The children's initial idea was to use a magnet to move him around and to build a crane to lift him, in order to give the impression that he was pole-vaulting out over the walls of the stockade (Figure 5). However, after many different design attempts, they discovered that their magnet idea would not work. The board they were using as the base was too thick, and even varying thicknesses of board did not solve the problem. The children then decided to embed a programmable brick within the Díarmaid model. This meant that the model was now autonomous and it could be programmed to move around as required. Previously, the children had built projects using light sensors and programmed them to follow a black line which determined the path of an autonomous robot. In their new plan for Díarmaid, he would follow a black line as he moved from door to door looking for a way out of the stockade (Figure 6).

However, this new design caused other problems. Díarmaid was now very heavy, and despite several different attempts at designing an appropriate crane, the children could not construct one capable of launching the new heavier Díarmaid out of the stockade. Now they had the problem of how Díarmaid could pole-vault away from his enemy Fionn and the awaiting army Unable to construct a scenario that remained true to the original storyline, the children and teacher discussed at length what to do. They decided to program Díarmaid to approach each door looking for Fionn, as outlined in the original story. Then he could send a signal to the door in order to open it and see what was behind it. If Fionn was waiting and escape was not possible he would move on and try each door in turn. This solution meant that Díarmaid needed a new program each time he moved to a new door. The original story had seven exits to the stockade. However, the brick can only store five programs at a time. After lengthy discussions and considering numerous possibilities, they decided to change the story from seven to five doors.

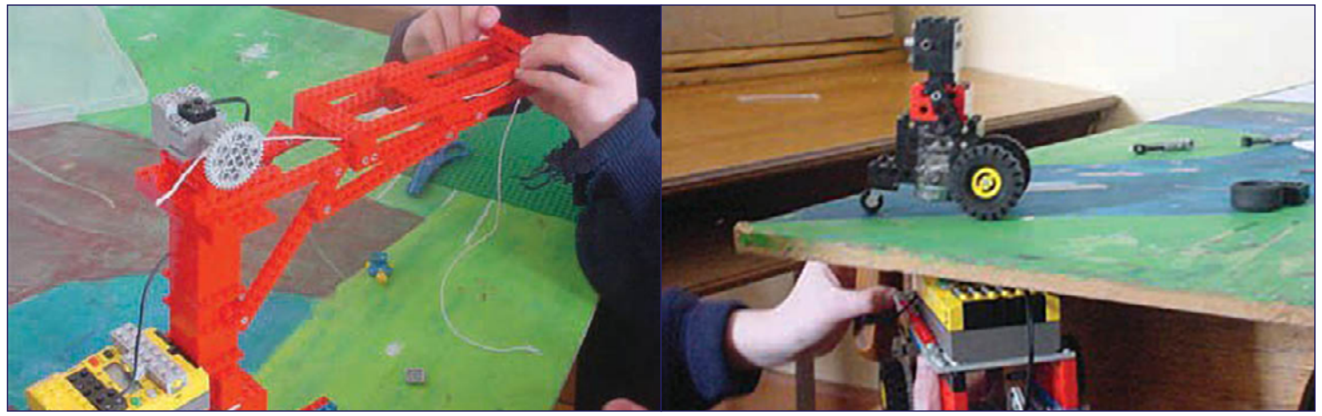


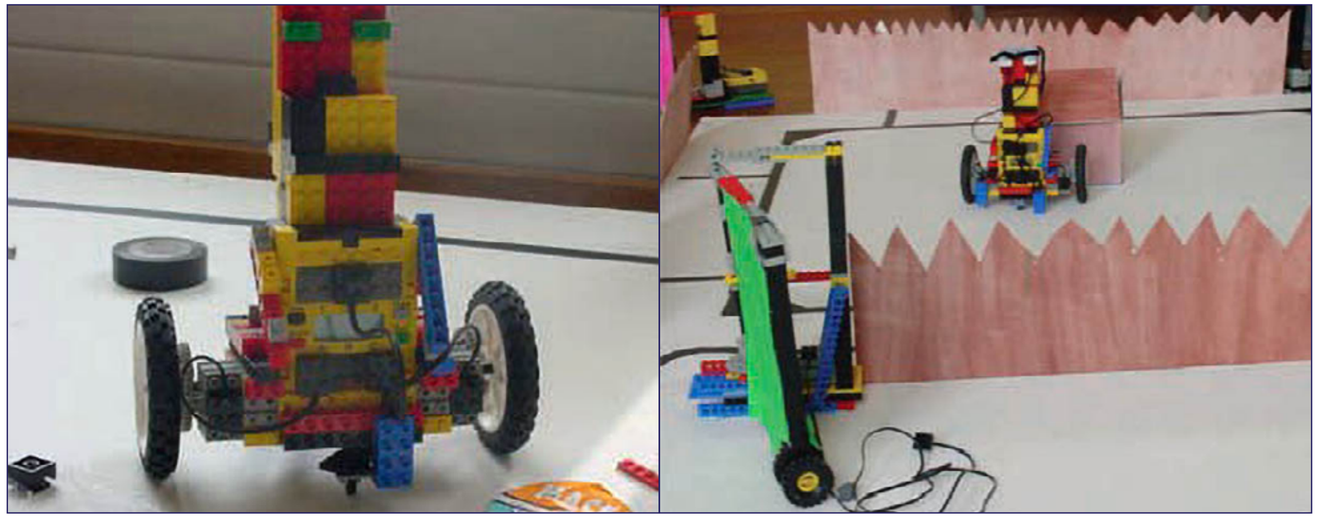
Figure 5: Building a crane to lift Diarmuid and testing the magnets to move him.

However, as Conor notes: *We still have a problem with getting the Díarmaid lifted out over the wall… so we'll have to use our imaginations to create a 'twist' in the story, to get him to escape in a different way.* (Conor's Diary, March 2003).

They decided that, because of their crane-building difficulties, they would take poetic license and change Díarmaid's escape strategy. He would no longer pole-vault, but would trick Fionn by faking an exit from door one and escaping through door five. Once they had made the story their own, they now had to programme their models to reflect the changes they had decided upon. The main programming elements involved getting Díarmaid to follow a black line, sending a message to each door's programmable brick, writing the programme for each door to open and ensuring that Fionn would move from gate five to gate one at the right time.

This learning story from the classroom demonstrates how the teacher and children have acquired a high level of digital fluency as they comfortably discuss and consider critically the trade-offs between the structure of the story and the computational materials they are using. Encouraged to explore and willing to spend time exploring, they tried out many different designs for their models using the computational materials. They were not constrained by the parameters of the story as they realised the limitations of the materials they were working with. This confidence in decision-making indicates deep understanding of the technology and the spirit of the project, as well as a strong sense of ownership and control.

Figure 6: Díarmaid with programmable brick (left); Díarmaid in the stockade



Learning Story 5: The Local Coalmine

This classroom example illustrates how children's learning can become more meaningful when it is informed by their local identity and then transformed by building cross-generational links and strong connections with their local community as a result of trying to solve an authentic problem.

The initial spark of the idea for this project was inspired as a result of an observation of the demographics of the local community. It happened during a conversation in class when one young child observed:

There seems to be lots of old ladies but very few old men in our local area.

Puzzled by this observation the teacher, Kathleen encouraged the children to enquire at home that evening if this observation was in fact true and if so what could be contributing to this. Upon investigation it emerged that a contributing factor to the shortage of «old men» was that there had been a coalmine in the area. Many of the miners acquired a condition called «miner's lung» and died. Encouraged by the children's natural curiosity to explore the connection between the existence of a coalmine in their locality over fifty years ago and the fact that many of them had no grandfathers, the teacher facilitated a large scale investigation about coalmining. The children consequently investigated how coal is formed, where coal mines are located, how coal is used today and in the past and read stories about life in the mines and so on.

Besides the project being a wonderful vehicle for developing cross-curricular linkage it also fostered strong cross-generational links between the school and the community as the children tried to construct a working model of the coalmine that had existed in their locality. The children's investigations sparked off much home discussion about the life and times of relatives who had worked underground. The children then began to use their information to write historical reports, fictional stories and poetry and to build their working model using the computational materials.

Groups of children were assigned different sections of the mine and asked to use their LEGO to build a model of a mine based on the stories and information collected from their families and their research. Adult help was enlisted to create a timber cross-section of a mine tunnel so that 'coal' could be 'mined' and brought to the surface where it could then be processed by the children's machines (Kathleen's project report).

Kathleen's enthusiasm for the project was infectious and her family too were intrigued by the children's investigations and followed the project's development with interest. The timber frame for the coalmine was actually constructed by Kathleen's retired father with input from the children about the dimensions they required. In tandem with the ongoing dialogue about the project that the children were engaged in at home the various groups of builders also had to continually collaborate with each other as the building of each section of the coalmine was interrelated. The group building the «bogies» which brought the coal to the surface had to liaise with the group that was assigned the task of getting the coal from the bogies up into the sorting «hoppers». This «conveyor belt group» also needed to liaise with the «hopper building group» about the height of the proposed «hoppers» as the amount of chain available was limited and this had a bearing on the angle of elevation on the conveyor belt itself.

Two groups of girls undertook the job of building the hoppers to sort the coal. The building of towers underneath which small trains could travel was initially difficult and as the week wore on we began to wonder if two stable structures would ever emerge. The two groups eventually agreed on a design and then the negotiations over height restrictions with the conveyor builders and the coal removal group became rather involved. These two groups now had to devise a method whereby the coal could be contained in this tower and then permitted to fall through to the waiting truck. The groups eventually adapted the vertical sliding door to create a sliding trap door in the base of each tower (Kathleen's project report).

The above extract from the teacher's project report clearly demonstrates the intricacies of the design process and how each group had to closely negotiate and collaborate in order to build a complex working model of the coalmine. Their models became their "**object to think with**" as they solved each problem as it arose. The children were motivated to continue building their models despite all their setbacks and problems as they had a personal connection with the problems they were trying to solve. Each of their models went through a series of iterative designs as they refined their ideas with feedback from the other groups. Working in this manner, students get a sense of the way in which real designers go about their work, as part of a community of designers (Resnick & Ocko, 1991).

The authenticity of the overall building process was monitored regularly by the grandfather of one of the children who had worked in the local mine during his youth (Figure 7). This ongoing cross-generational collaboration further strengthened the children's personal connections with the models they were constructing and the problems they had to solve in order to incorporate the details required to construct an authentic model of the disused local coalmine.

Mr. Kealy told the children of his experiences as an adolescent working in the mine. He used their own model to explain his working day and to further describe the machines that they had built. Their initial models were built without reference to pictures of working models so it was interesting to hear how they concurred with or deviated from actual designs. He described how in one of the mines in which he worked the men were lowered down to the workface in a cage. The air-shaft was altered the next day to show a miner being lowered with his pickaxe into the mine. He also explained how when the coal came from the mine it had to be crushed. He was carefully quizzed on what a crusher might look like and the following morning a crusher was created and placed between the tunnel entrance and the conveyor belt (Figure 8). It was felt by the children that the coal would have to be swept along to reach the conveyor belt and so a mechanical sweeper was added to push the coal from underneath the crusher. This was connected to the RCX [programmable brick] operating the hopper trapdoors as the children felt that the same programme would work (Kathleen's project report).

On one of «the grandfather's» visits when the children were demonstrating the pulley system they had designed to bring the bogies to the surface he remarked that the original mine had in fact a double rather than a single pulley system. The children immediately wanted to reconstruct their pulley system to reflect this fact. However, this desire to reproduce an authentic working model caused a major problem for the children when they tried to reproduce a double pulley system for bringing the «bogies» laden with coal to the surface. After many attempts without success; *advice was sought from family, neighbours and the wider community ….. (Kathleen's project report).*

Figure 7: Cross-generational learning

Such was their engagement with this problem that the children and teacher voluntarily worked for many hours after school and at weekends. Finally, after much input from a range of people who called to work in the school with the children:

...the pulley problem was solved. Two strings were used instead of one continuous string and a weight attached to counteract the problem of slackening thread as two different circumferences of thread simultaneously unrolled from a single axle» (Kathleen's project report).

Further refinements were made to the model of the coalmine as a result of the children's visit to a local disused mine.

Following a meeting with Mr. Seamus Walsh, an expert on the history of mining in Castle- comer the children were taken to see a local mine. They were accompanied on this trip by Mr. Kealy, Mr. Walsh and a number of parents. They were thrilled to see the bogies still standing on their tracks, miner's hats and boots, pulley wheels and gears. They were to discover that they were a great deal heavier than their own building materials. They accompanied Mr. Walsh into the mouth of the tunnel and were not impressed with the damp and the smell. They observed the piping to remove the water from the tunnels and this was added to their model as soon as we returned to school. Following their observations of the belts and crushers all the group efforts were combined to create the seamless effect of the coal arriving at the mouth of the mine to be crushed and then sorted for sale (Kathleen's project report).

This project is an example of how learners in the Empowering Minds community are actively determining their own goals rather than functioning passively in the classroom. This learning by doing is much more meaningful than rote learning or reading about something at second hand. These children were driven by their own sense of wonder, had ownership of their learning agenda and actively constructed knowledge for themselves. This pursuit of personally set learning goals suggests that when students take ownership of knowledge instead of relying solely on teachers or textbooks, they are dedicated to constructing and building knowledge rather than merely receiving and reprocessing it.

Figure 8: Crusher on the right with a conveyor belt taking the coal over to the main conveyor belt where it is being taken up to the sorting towers. The programmable bricks have been enclosed in a different coloured casing for easy identification by the different groups.

Reflecting on the Learning Stories

Computational Thinking | Cultural Responsiveness | Cross-curricular | Co-creation | Community of Practice

These Learning Stories are reflective of the themes explored in the SFI Discover WEAVE Project. Teachers and students worked alongside each other as learners and developed computational thinking skills through community based and meaningful inquiry-based projects.

Below are some examples of teachable moments for the knowledge, skills and attitudes associated with developing computational thinking skills. Can you relate these back to the stories you have read/work you have done? Can you think of any more?

	Knowledge (Head) Facts, mental models, strategies	**Craft** (Hands) Skills through practice	**Character** (Heart) Emotions, Attitudes, Values
Debugging Identifying, removing, fixing errors	**Strategies** to engage in when your code won't run as intended or when LEGO brick pieces don't fit together as expected.	**Breaking** apart your code and/or LEGO build and being able to **explain** why and what you're looking for.	**Imagining** consequences and **persevering** to explore problems when they arise.
Decomposition Breaking down information and things into parts	**Identifying** parts and relationships to break tasks down into smaller, more manageable pieces. **Thinking** through the individual steps needed to complete an action.	**Drawing** a diagram. **Building** a cardboard construction. **Coding** the development of a line-following robot into smaller tasks such as moving forward, detecting the line using sensors, adjusting motor speed for turns.	Students break down project tasks fairly and make sure everyone has a job by **agreeing** upon roles.
Algorithmic Thinking Making steps and rules	**Designing** an algorithm for a line-following robot to follow a black line on a white surface using light sensors. This involves **understanding** how to interpret sensor values and adjust motor actions accordingly.	**Coding** a working line of code	**Being curious** and **imagining** what might happen if they changed a step in the process/added something new.
Abstraction Removing unnecessary detail	**Reasoning** in regards to what details to keep or what to omit	**Drawing** a diagram	Students' meta-cognitive skills (thinking about thinking) are called upon as they **consider why** they have chosen to omit/retain certain details.
Pattern Recognition Spotting and using similarities	Ability to **recognise** attributes, similarities, differences	**Re-use** repeating patterns to form basic solutions that apply to a class of problems	**Use previous knowledge** of patterns and use this information to **imagine alternatives** and trouble-shoot to solve the problem.
Computing Systems	**Recognise** computing components.	**Constructing** a different model based on hardware limitations.	**Caring** and **persevering** as they test, evaluate and debug their robotic model to decide if it is fit for purpose. **Compare** and **discuss** different types of input and output of computing systems.

Getting Started

Planning to develop Constructionist, Culturally Responsive Computational Thinking

Now that you have an understanding of the key themes for fostering culturally responsive computational thinking skills through localised, inquiry-based projects, the following section explores the supports that ensure successful and sustainable implementation of such practices.

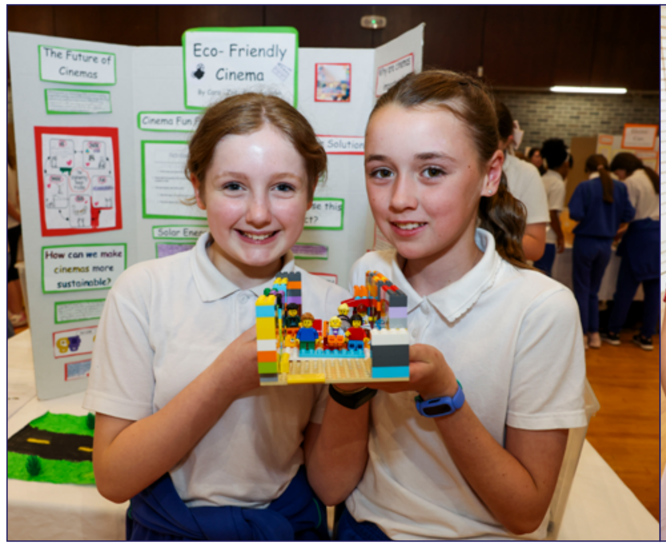
This section outlines the Digital Learning Framework, along with website links and planning resources for integrating digital technologies in your school. It also details Oide Sustained School Support and additional resources from NCCA and the SFI Discover Weave Project to enhance the development of your Digital Learning Team and community of practice for embedding culturally responsive computational thinking skills.

Digital Learning Framework & Plan

The Digital Learning Framework (DLF) supports schools in integrating digital technologies effectively into education. It guides leaders and educators in forming a collective understanding of technology's role in meeting learners' needs. Developing a Digital Learning Plan aligns with the School Self-Evaluation Six-Step Process and supports the integration of expressive computational objects into teaching. By utilising the DLF, schools reflect, evaluate, and take action to create a Digital Learning (DL) Plan outlining enhanced digital practices over a set time-frame. Schools must update this plan annually according to the Department of Education Circular (CL0077/2020). The Digital Learning Framework website functions as a tool for schools to shape their Digital Learning Plans, giving examples of effective and highly effective practice.

https://www.dlplanning.ie/

These examples of effective practice showcase many integrated uses of digital technologies along with offering guidance for establishing a Digital Learning Team in your school. The examples illustrate the wonderful examples of teaching and learning through expressive computational materials such as robotics, creative use of tablet devices, Beebots, Scratch, Digital Storytelling and many more that are ongoing in Irish classrooms!



Oide Sustained Support Model

Oide offers ongoing support through Sustained School Support, a more in-depth form of professional development. This aims to enhance internal expertise, enabling schools to independently drive change as learning communities. The assistance is provided over a span of time, following a well-structured process where schools and teachers establish shared goals. Oide Advisors help teachers and their schools to analyse, recognise strengths and gaps, before deciding on the best way forward collaboratively. Oide Sustained School Support can take many forms and is ultimately guided by what you and your school want to achieve.

To sign up for Sustained School Support, click on the link - or scan the QR code below:

https://oide.ie/

Additional Resources

The NCCA document "Review of Literature on Computational Thinking" provides some examples of examples of using computational thinking across the curriculum. Many more exist but these could act as useful discussion starters.

Table below: Examples of curricular links (taken from: NCCA, (2018) Review on Computational Thinking Literature)

CT	Competence	Precursor	Curriculum focus	Activity	Progression
Algorithmic Thinking understand the concept of sequence.	**Explaining** 'what do you see when you go on your journey home'. **Predicting** the success of a sequence of steps to go home.	Understand cause and effect between two events.	English - 11. Retelling and elaborating. Tell and retell stories and personal and procedural narratives of increasing complexity to familiar and unfamiliar audiences using appropriate sequencing, tense and oral vocabulary. TF11, C1+2.	It's your birthday, draw a map/ explain to your friend how to get from the school to your house and what steps/ stages in the journey.	Send your beebot home: Draw a map of your locality and enter the commands necessary for the beebot to navigate the map.
Decomposition identfying key elements and relationships.	**Creating** and **making** an interactive narrative.	Know the story of a past event, its context and main actions.	History - use imagination and evidence to reconstruct elements of the past.	Research a historical event and context identifying the actions in sequence and the appearance of key elements.	Develop a narrative using an interactive 3D environment to tell the story.

Further resource supports include:

NCCA An Chomhairle Náisiúnta Curaclaim agus Measúnachta National Council for Curriculum and Assessment

Community of Practice Supports for Reflecting on Learning

These materials were designed to help you and your colleagues reflect on the learning on-going in your class with the purpose of sharing practice. This can be used in relation to discussions around the use of digital technologies.

Examples from the NCCA Coding in Primary Schools Initiative

Describe the Task

What knowledge did you want your students to learn from engaging with the task?

How did you manage the task in your class?

Outline a typical interpretation of the task?

Outline an interesting interpretation of the task

How did you progress the learning?

Digital Learning Framework: Discussions

Digital learning planning often focuses on which technology to use (the What), without considering how to integrate it effectively (the How). Yet, the starting point should be why digital technology is used (the Why) and how it supports in designing learning experiences for desired outcomes. Starting with the "Why" helps schools design learning experiences tailored to learners' needs, determining the role of digital technologies if and when needed.

The DLF is designed to help schools with such considerations and provides many resources to support schools in reflecting on the ongoing learning using digital technologies and which can utilized for discussions and for facilitating practice sharing amongst teachers.

Teacher Self-Reflection on Own Practice

Supports DLF Dimension of Teaching & Learning (Prompts found on DLF website)

- Is the use of technology in your classroom always justified by an educational goal?
- Do you identify the educational goal and then consider what digital technology can be used to support this goal?
- Technology is redefining what it means to be "literate" for 21st Century students. Reading becomes "information literacy" or solving information problems using textual cues. In the subjects you teach, is technology redefining what is important for students to know and be able to do? How is this reflected in your teaching?
- What are some examples of how you have altered lesson plans to use technology in your classroom?
- Did you find ways to enhance your lessons by using technology? What kind of a challenge did this pose?
- If you were minister for a day, what policies would you put in place to better support teachers in their efforts to improve technology use in classrooms?

Key Dimensions of DLF:
Teaching and Learning
Leadership and Management
https://www.dlplanning.ie/teaching-learning/

DLF Planning Guidelines & Resources
https://www.pdsttechnologyineducation.ie/

Let's Talk Computational Thinking

Think
- Which details did you decide were unnecessary and chose to leave out?
- Were there parts of the build that you initially thought were essential but later realised were not?
- What other movements or actions would you like your robot to perform?
- How could you modify your robot to move faster/slower/more smoothly?
- What sensors could an be added to your robot to make it more aware of its surroundings?
- Do people/animals use the robot? If so, how does the robot interact with its users?

Share
- What is the main purpose of your robot?
- Can you think of another job or task your robot could do?
- What inspired the design and function of your robot?
- Can you explain your code?
- Did your code work the first time? Why/why not?
- Can you explain how you increased the speed?
- Were there elements from previous builds that you incorporated into this design?
- Did you notice any recurring problems or challenges?

Examine
- How can you make your robot look more interesting or appealing?
- What would happen if you changed the shape or size of your robot?
- Can you add any decorations/accessories to give your robot a personality?
- What components did you divide your robotic build into? Why??
- How did you identify and separate the functions of each component?
- Are there patterns or repeated elements in your design? If so, what purpose do they serve?
- Have you seen similar design patterns in other robotic builds? If so, how did those influence your design?

Reflect
- What challenges or unexpected issues arose during the build?
- How did you troubleshoot and solve those challenges?
- How could your robot be used to help people or solve a real-world problem?
- Which parts of the design did you alter based on testing?
- How did you prioritise and sequence the steps in the building process?
- What was the most/least challenging part?
- Did any of your debugging efforts lead to a complete redesign?

Extend
- How could you improve this build?
- In the real world what would make it work better?
- If you were to start over, what would you do differently?
- What skills or knowledge do you think you might need to enhance your robot further?
- Can you think of a scenario where your robot might fail or encounter difficulty? How might you overcome that?
- How might you collaborate with a classmate to combine the features of both your robots?

Revoice
- Can anyone imagine what coding blocks Joan may have used for this?
- Can anyone take Jonathan's code and add to it?
- Is there another way of solving this?
- Can you explain how Fiona made their build move?

Thanks to all participants on the SFI Discover Weave Project for their contributions to the development of this resource

STEM Learning Experiences: Observation & Reflection Checklist

This checklist is designed as a possible aid for teachers in planning, designing and reflecting on meaningful, integrated STEM learning experiences for their pupils. It is not a requirement for all STEM learning experiences to contain ALL components.

STEM Component	Prompt questions for reflection	Y/N	Notes & Observations
Authentic Problem	Does the learning experience present a real problem (an engineering challenge)?		
Pupil-centred	Will pupils relate to the problem?		
Open-ended	Does the learning experience allow pupils multiple, creative approaches and solutions?		
Cross-Curricular	Does the learning experience integrate and apply Science and Mathematics curriculum content and skills?		
Design & Make/ Engineering Design Process	Does the learning experience: • Clearly use the engineering design process as the approach to solving problems?		
	• Lead to the design and development of a model or prototype?		
Hands-on learning	Does the learning use a child-centred, hands-on teaching and learning approach?		
Technology	Is the role of technology in the lesson clear to the students?		
Teamwork	Does the learning experience successfully engage pupils in purposeful teamwork?		
Evaluation & Iteration	Does the learning experience include testing the solution, evaluating the results, and redesigning to improve the outcome?		
Communication	Does the learning experience involve pupils in communicating about their design and results?		

Adapted from Liston, M. (2018). *Designing Meaningful STEM Lessons*. & Jolly, A. (2017). *STEM by Design: Strategies and Activities for Grades 4-8.*

PDST

COMPUTATIONAL THINKING ELEMENTS

DECOMPOSITION

-> Breaking things down into smaller parts

- Can your students identify and explain the key elements/relationships?
- Do your students know the meaning of the steps that they've programmed?

DEBUGGING

-> Identifying, removing, fixing errors

- Can students employ a strategy when they become "stuck" on something?

PATTERN RECOGNITION

-> Sequence: particular order in which related things follow each other

- Challenge your students to identify the actions in sequence and the appearance of key elements (eg: when researching a historical event and context/ lifecycle of a butterfly)

ALGORITHMIC THINKING

-> Making steps and rules

- Can your students explain how the mechanism works?
- Coding a sequence
- Identifying patterns

ABSTRACTION

-> General representation of something

- Think of a storyboard in English writing exercises - unnecessary details are removed, key ideas only...
- Think of representing data in Maths...
- Sketching a science diagram with labels...

SOME APPROACHES:

tinkering | creating | debugging | persevering | collaborating

ROBOTICS CHALLENGE

CHALLENGE

What areas of interest and preferences exist that could be explored in your locality? Brainstorm below...

UH OH - PROBLEM!

What problems could be posed within this context?

POSSIBLE CURRICULUM EXTENSIONS

MATHS

-> In maths, what could "being a digital learner" look like?

- Could you draw large chalk 2D shapes in the yard? Then, since it is built already, programme the Cave Car to drive around the perimeter of the shape -> features of 2D shapes, length, time.

SCIENCE

-> In science, what could "being culturally responsive" look like?

- The little Cave Car needed a ramp to accomodate the student's friend - are ramps needed in your locality?
- Opportunity to investigate the type of wheels used, the slope of ramps, the availability of wheelchair access - what could wheelchair access be replaced with to suit your localised context?

CAN YOU THINK OF ANY OTHERS?

Roadmap for Developing Culturally Responsive Computational Thinking

This roadmap is designed to help schools with planning out their journey to develop Computational Thinking skills.

The QR codes at the bottom of the roadmap are intended to help schools and teachers to further deepen their knowledge through accessing information, materials and resources from other similar successful projects.

The roadmap is available to print from the Weave Project website:

www.weaveproject.ie

ROADMAP FOR DEVELOPING CULTURALLY RESPONSIVE COMPUTATIONAL THINKING

Whole School | Leading Teachers | In-class

Oide Sustained Support

1. Getting started (End June/Start September)

Vision
Establish a Digital Learning Team (DLT)
Review Digital Learning Framework
Create Digital Learning Plan (DLP)
DLP support focus of School Self-evaluation
Begin PDST Sustained Support Journey

Adopt a spiral approach to the development of Computational Thinking:
- What are we going to do?
  - What is our focus?
- How are we going to do it?
  - LEGO robotics, Cody Roby etc
- How can we leverage the local community & students' interests for project ideas?

Planning & Prep
Plan for teachers to have hands on time to explore the expressive computational materials; LEGO robotics, Beebots etc
- Playful approach to Computational Thinking and the materials!
- For example:
  - *Exploring LEGO Robotics "Unit Plans" in paired teacher groups*

Practicalities
Management of kit:
- *Agree plan for use in class (i.e.; spare lunchbox on teacher's table for found pieces/all bags away etc) + checklist for items,*
- *Make a plan/who has responsibility for replacing parts & doing inventory,*

Become familiar with Computational Thinking Framework
- *-> Competence = knowledge, craft & character*
- To get LEGO extension packs, register for First LEGO League "Explore" theme packs:
  - *learnit.ie*

2. Getting to know the robotics (September - December)

Vision
Establish a community of practice through sharing ideas & experiences:
- *Led by principal & DLT*
- *Sharing practice during Croke Park hours*
- *Group WhatsApp: within school*
- *Group WhatsApp: across local schools*
- *Invite parents & other schools to Showcase Day*

Planning & Prep
Regularly communicate work that is being doing in Computational Thinking within classes with staff to build community of practice and share knowledge & look to local community for project ideas
- For example:
  - *Record progress through Digital Portfolios*

Review progress through PDST Sustained Support

Practicalities
Support holistic development of Computational Thinking in all learners.
- For example:
  - *Hands-on explorations,*
  - Computational Thinking *question prompts*
  - Computational Thinking *"Lets Talk" wall posters*
  - *Cross-curricular "Design & Make" approach*
  - *PDST* Culturally Responsive Computational Thinking *Support Booklet*

3. Developing an Inquiry Based Project (January - June)

Vision
Grow community of practice through continuing to share ideas, practice & experience.

Review approach to embedding Culturally Responsive Computational Thinking in a spiral approach:
- What did we do?
- What worked well?
- How did we achieve the best outcomes for our learners?
- Review DLP for new academic year

Planning & Prep
Leverage resources (such as PDST "Design & Make" Computational Thinking STEM Challenges, First LEGO League) to engage students in a sustained challenge, aiming for deeper learning over a longer period of time;
- For example:
  - *Students complete challenges & tasks via their LEGO robotics "Explore" student notebooks*
  - *Capture and reflect on* Computational Thinking *using Digital Portfolios to develop metacognitive skills*

Review progress through PDST Sustained Support

Practicalities
Review equipment
- *Is it all in working order?*
- *Do we need to order any missing parts?*

To partake in the LEGO Robotics First LEGO League in the new academic year, expansion packs will need to be ordered in August.

During the Weave Project, I learned...

USEFUL COMPUTATIONAL THINKING RESOURCES

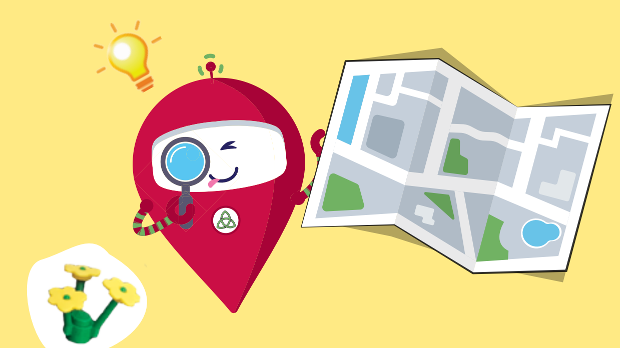
- https://www.steam-ct.org/ Computational Thinking Learning Line: Links to subject topics through practical examples (for e.g. the book "Going on a Bear Hunt")
- https://www.barefootcomputing.org/ Barefoot Computing Resources: Whole School Login Details; email: ________ password: ________
- https://pact.cs.nuim.ie/pages/resources-for-teachers.html Bebras CT Challenges: Short challenges, ideal for golden time/early finishers

COMPUTATIONAL THINKING IN THE CLASSROOM: EXAMPLES

- Constructivist Learning Environment: Prof Deirdre Butler (DCU) outlines the constructivist approach to designing learning environments using expressive computational materials.
- NCCA Coding in schools: Practical examples from Junior Infants to Sixth class of classroom activities using CT
- PDST Technology in Education: CT and Coding Hub - good practice videos and suggested resources

www.oide.ie

Working with LEGO® SPIKE™ Essentials Robotics



LEGO Robotics to develop Constructionist, Culturally Responsive Computational Thinking

This sections provides an outline of the LEGO Essentials Robotics kits and different ways of incorporating them into teaching and learning.

It begins with setup guidelines for classrooms, compiled by the teachers participating on the SFI Discover Weave Project. We then introduce the online Unit Plans, followed by STEM Challenge Cards which suggest different ways of modifying the LEGO builds made in the Unit Plans. Co-created by Weave Project teachers, these STEM Challenge Cards bridge the gap between the Unit Plans and the extended FIRST LEGO League projects. They aim to inspire extended student-led projects ranging from a day to several weeks.

Getting Set Up

LEGO robotics is an expressive computational tool which enriches classrooms with design, invention, and engineering activities. Through these robotics, students encounter big concepts in science and maths in meaningful and motivating contexts. Building models and programming with LEGO robotics fosters computational thinking and comprehension of complex systems from basic components, vital for understanding our tech-filled world and complex topics like artificial intelligence (Papert, 1984, Resnick et al., 1988).

The LEGO® SPIKE™ App guides students through lessons, providing "getting started" material, instructions, and coding experiences. These experiences evolve from visual icon block coding to word based block coding.

To get started, you need to download and install the App or use the web version.

https://SPIKE™.legoeducation.com/#/

How do I get started?

In this section, you will find some practical tips from the teachers on the SFI Discover Weave Project on how to get set up with using the LEGO robotics in your class:

Before using the kits with your class;

1. Open LEGO brick bags and put bricks in colour coded trays.
   - Label each functional part (hub/motors/sensor/matrix)/container with the same name.
   - This can be done with a class, especially the older classes.
   - If you have a younger class, enlist the help of 5th or 6th class students!
   - Store white charging cable and spare parts box separately.
2. Download the Spike (or WeDo) app to student devices.
   - If using a laptops, can be useful to have printed URL/QR code available for students to access the online version or add link to students' Google Classroom etc...
   - Keep the physical hubs and the app updated.
   - Use the white USB cable to connect the hubs to a laptop/desktop computer to update.
3. Bookmark web version on teacher desktop.
   - This can be handy for discussing code, the Unit Plans etc on the whiteboard.
4. Charge hubs before use!
   - Ordering a multi-port adapter can make it easier for charging multiple hubs.
5. Give yourself plenty of time.
   - Getting to grips with the materials will be a lot of fun but will also take some time to get used to the different components.
   - Highlight importance of looking after the pieces and allow time to tidy up.
   - Place a lunchbox on the teacher's desk and mark "spare pieces".

Using the LEGO kits with your class;

- Students work in pairs to become familiar with the motors/hubs etc - after several sessions, students can work in groups.
- Turn Bluetooth on on the tablets.
- Rename the hubs (this will need to be done when used for the first time).
- Turn the hubs off when finished with - Hold for 16 seconds until light stops flashing!
- Allow the app access to the microphone and photos on student devices.

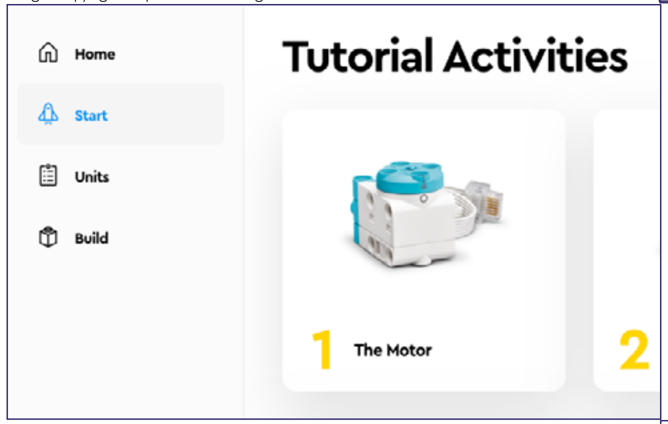
The Unit Plans

You will need the Essentials kit in the yellow box (the core kit!) to get started.

Don't forget to take out the "spare parts" box and the white charging cable to keep somewhere safe until they're needed!

Image Copyright: https://education.lego.com/en-us/

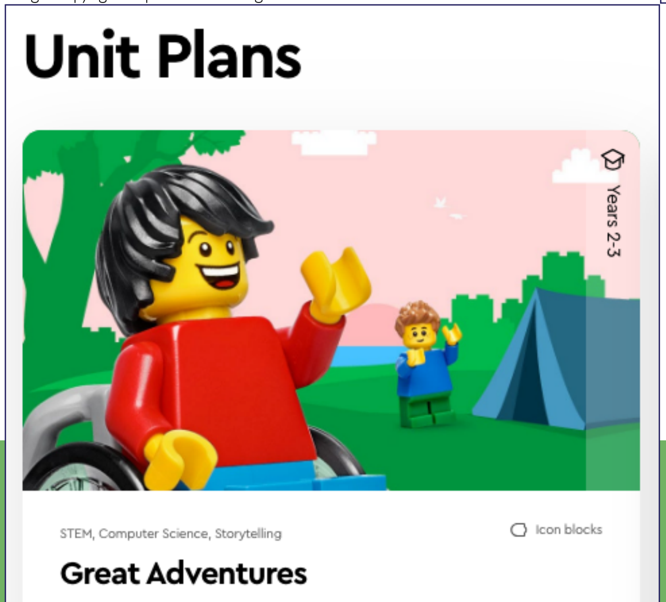
Image Copyright: https://education.lego.com/en-us/



Once you have kit and the app downloaded, or access to the web-based versions, you can follow tutorials to understand the functional pieces of your kit and begin building and coding.

The kits engage learners in playful, narrative-based learning experiences. Constructing and programming are contextualised through short stories detailing exciting challenges faced by the four mini-figures, Daniel, Maria, Sofie, Leo and their little dog, crab and frog!

Image Copyright: https://education.lego.com/en-us/



Each Unit Plan has five to eight mini-challenges, lasting about 60 minutes, using either icon or word blocks. The end of each plan features a student-directed challenge.

Icon blocks, which use images instead of text for instructions, are great for beginners and younger students as they use images instead of text to convey the instruction that the block of code will execute.

Optional Resources to support the Unit Plans

The Unit Plans can be completed solely with the core kit. The following pages are optional supports that include a mixture of resources to support the Unit Plans, should you wish to do so. The resource on page 56, which was created by Siobhán K and colleagues in Scoil Mhuire gan Smál, Carlow and shared with other schools, was found to be of great support for getting started and affording the students the opportunity to lead their own learning.

These optional resource include:

Additional Resources

Core STEM Competencies in STEM Education

Since the 1971, Irish Primary School curriculum has always placed an emphasis on the child being an active agent in their own learning and of the importance of developing higher order thinking, collaborative and problem-solving skills. The eight core STEM (science, engineering, technology, maths) competences, which include Problem-Solving, Innovation and Creativity, Communication, Critical Thinking, Meta-Cognitive Skills, Collaboration, Self-Regulation and Disciplinary Competences can help us to develop a deeper understanding of the types of competences that could be developed under such higher order thinking, collaborative and problem-solving skills.These nestle within the "**Character**" attributes neccesary to develop computational thining outlined on page 14.

Table below adapted from *Report 1 of ATS STEM Report Series: STEM Education in Schools: What Can We Learn from the Research?* (2020, McLoughlin et al).

Core STEM Competences	Specific Skills and Competences	
What must I learn?	*What am I doing?*	
Problem-Solving	• Problem-solving • Decision-making • Inquiry • Complex problem solving • Algorithmic problem solving • Non-routine problem solving • Creative problem-solving skills • Making judgements	• Research • Inference making • Hypotheses making • Seeking evidence • Dealing with information • Asking questions and gathering information to solve problems
Innovation and Creativity	• Innovation (innovative thinking) • Taking an initiative • Coming up with new ideas	• Entrepreneurship • Making an invention • Creativity
Communication	• Communication	• Presenting
Critical Thinking	• Reflective thinking skills • Critical Thinking • High order thinking skills • Logical thinking • Reasoning • Critical reasoning	• Logical reasoning • Associative thinking • Convergent thinking • Divergent thinking • Analytical thinking • Argumentation
Meta-Cognitive Skills	• Adaptability • Systems thinking • Flexibility • Cognitive & meta-cognitive skills	• Making connections with learning • experiences

Core STEM Competences	Specific Skills and Competences	
What must I learn?	*What am I doing?*	
Collaboration	• Collaborative skills • Teamwork • Interpersonal attributes • Leadership • Collaboration • Cooperative thinking • Team building • Negotiation skills • Conflict resolution • Mutual respect • Ethical awareness	• Attentiveness • Courtesy • Personal skills • Intrapersonal traits • Talking to others • Listening to others • Working with others • Social and cultural skills • Being sensitive to others' feelings
Self-Regulation	• Responsibility • Self-management • Being on time • Self-control • Self-development • Self-confidence • Self-discipline • Appropriate attitude towards • work • Dependability • Trustworthiness • Motivation	• Perseverance • Positive attitude • Autonomous learning • Working on their own • Integrity • Sustainability and Social • commitment • Career and life skills • Not giving up on a task that is too • hard to finish • Persistence • Always doing what you said you • were going to do
Disciplinary Competences	• Theoretical learning • Practical skills • Engineering skills • Engineering design skills • Mathematical (thinking) skills • Disciplinary Competences • Numeracy skills • Solving math problems • Scientific skills • Testing ideas about science • Conducting science labs/ • experiments	• Computer skills • Computing (computational) skills • Information literacy • Technology literacy • Technological skills • Digital literacy (e.g. writing code/ • analysing data) • Digital technology skills • Programming skills • Express themselves using the • technological tool

Meeting the Team

Scan QR code to read the Mini-Figure Bios

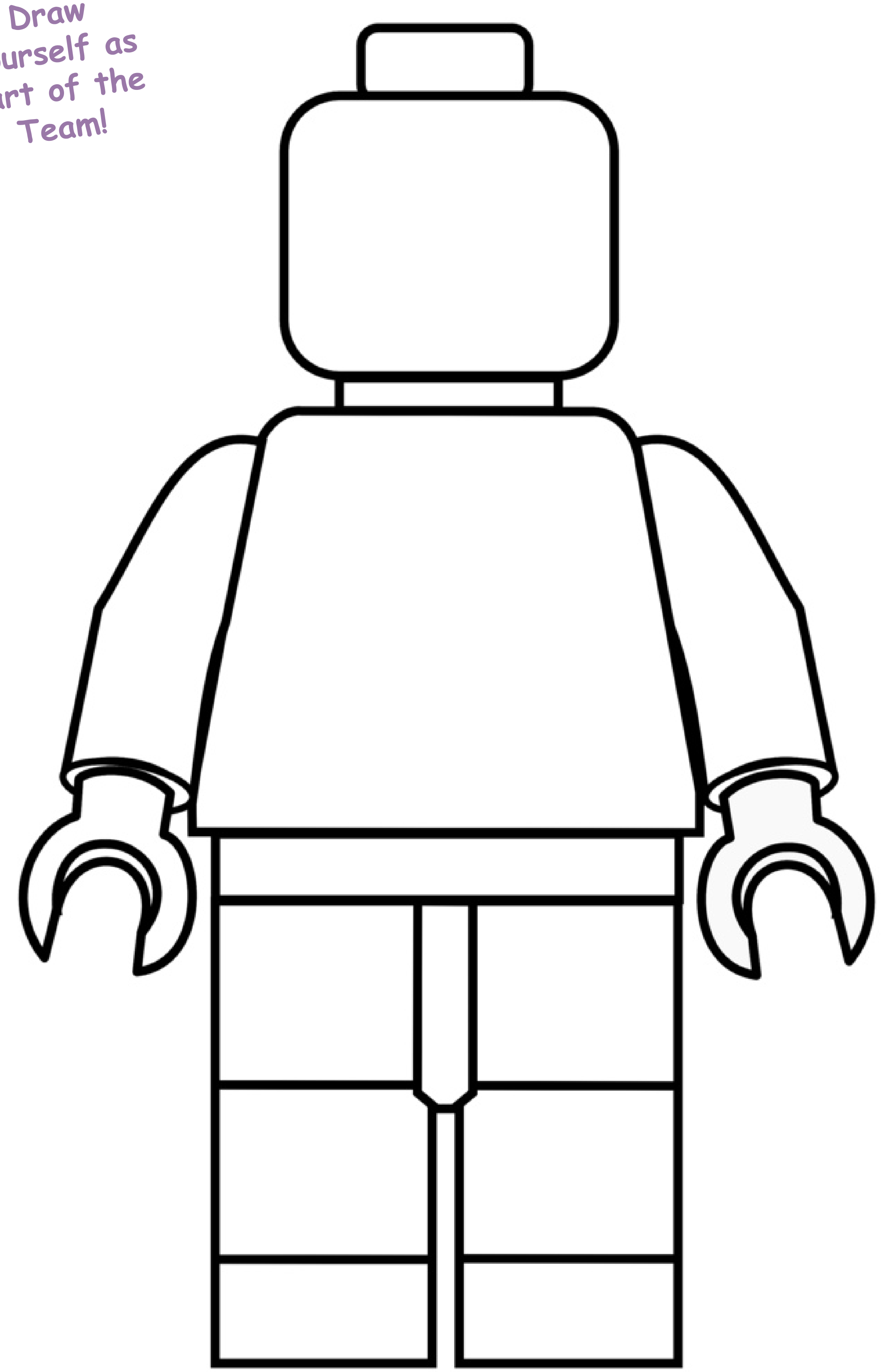
Imagine you are meeting one of the mini-figures for the first time:

- Who do you meet?
- What do you have in common with each other?
- What might you say to each other?

Draw a picture of this meeting:

What invention might you create together?

Draw yourself as part of the Team!



My Constructions

Unit Plan:		
Name of Lesson	Tick when complete	Comments
1)		
2)		
3)		
4)		
5)		
6)		

Final Task:	
Write a brief description of your starting point/problem:	
Record the step-by-step-process you used to come up with your design:	

Record your finished design

Thanks to Siobhán K and colleagues in Scoil Mhuire gan Smál GNS, Carlow for this resource

STEM Challenge Cards

After your students have engaged with the Unit Plans, they're prepared for an extra challenge! The STEM Challenge Cards are ideal for guiding an inquiry-based project spanning several weeks. These Cards suggest ways in which the Unit Plan builds could be modified and link to the primary curriculum and support the development of computational thinking skills.

These cards emphasize "problem posing" instead of "problem solving," two related yet separate concepts. The table below provides more details on this.

The "Let's Talk" Computational Thinking resource listed above (page 39) also provides support with asking probing, culturally responsive questions.

	Problem Posing	Problem Solving
Definition	• Process of formulating, presenting, or defining a problem or question, • Identifying gaps in understanding, • Spotting opportunities for improvement, • Seeing challenges that require solutions.	• Process of finding solutions to already-defined problems, • Involves understanding the problem, breaking it down, applying strategies, and arriving at a solution or conclusion.
Role in the Learning Process	• Precursor to problem solving, • Encourages learners to think critically about situations, contexts and topics, and to formulate their own questions or problems related to them.	• Builds on the problems that are posed, • Prompts learners to think critically and analytically to find answers or resolutions.
Craft and Character	• Requires creativity, curiosity, and the ability to see things from multiple perspectives. • Questions the status quo and encourages students to imagine different scenarios or challenges.	• Leans towards analytical and logical thinking, domain-specific knowledge, and the application of strategies and procedures.
In Action!	• Often used in inquiry-based learning, where students are encouraged to come up with their own questions or problems about a topic or situation, thereby deepening their engagement and understanding.	• A central aspect of many tasks! • Is applied whenever there's a clear challenge or problem that requires a solution.
Benefits	• Helps foster creativity, critical thinking, and a deeper understanding of subjects or situations. • It empowers learners to take ownership of their learning process.	• Enhances analytical skills, provides a structured way to tackle challenges, • Students have the satisfaction of resolving issues or challenges for the user(s) of their robotic builds!

10 STEM Challenge Cards

All 10 STEM Challenge cards (plus one blank card), utilise the Design Thinking methodology and can be used as a bridge from the Unit Plans to the LEGO League. STEM Challenge Cards can be downloaded from www.weaveproject.ie (scan the below QR code to access):

FIRST® LEGO® League Explore

This is a hands-on, non-competitive programme designed for primary school students ranging from 2nd class (ages 7-8) to 6th class (ages 11-12). The programme's primary objective is to inspire learners to engage in experimentation and to increase their confidence, interest, critical thinking, communication, collaboration, and design skills through immersive STEM learning activities.

Every year, the League focuses on a relevant, real-world theme. Working in teams, students utilise components from the LEGO Spike or WeDo kits, as well as from the Explore set. The Explore set is an expansion set that further extends the potential of the LEGO Spike or WeDo kits.

Essential kits

Explore Expansion sets

Students use these to explore, create, experiment, and present solutions related to the real-world theme. Through this real-world theme, students examine their localities and develop computational thinking skills through meaningful problem posing and problem solving.

To support teachers in guiding their students on their exciting FIRST LEGO League journey, each Explore set comes with a class set of student notebooks, a teacher guide and a team meeting guide. Every session encourages learners to work collaboratively; to communicate effectively; to construct; to programme; and to learn together, all the while enjoying an engaging and fun experience.

To view an example of the Teacher's Guide from a previous FIRST LEGO League Explore theme called CARGO CONNECT℠, scan the purple code below or click on the purple link. To find out more about this year's new theme and to sign up for the FIRST LEGO League Explore, scan the green code below or click on the green link.

https://fll.learnit.ie/pages/explore-registration

https://www.dcu.ie/sites/default/files/staff/2022-04/Teacher_Guide_First_Lego_League_Explore_Cargo_Connect_v15.pdf

Additional Resources

To further help you and you students with developing culturally responsive computational thinking skills, the following pages consist of a range of activities and games that you can integrate into learning experiences, ouse as stanalone activities. There are also some links to useful videos and "good practice" examples.

You can scan the codes or click on the headings to access the URL links.

Additional Resources include:

Classroom Resources

Barefoot Computing
An initiative aimed at promoting computational thinking & computer science education in primary schools.

Computer Science Unplugged
Aims to teach fundamental computer science concepts without the use of computers.

CT - STEAM
Recognises the importance of computational thinking as a cross-disciplinary skill and provides a range of supportive plans/resources.

Bebras Challenges Handbook PDF
Printable computational thinking workbook for primary school students (3rd-6th class).

Bebras Challenges Online Quizzes
Computational Quizzes for 3rd-6th class pupils

21CLD Learning Activity Rubrics
Set of rubrics to guide educators in designing & evaluating constructivist learning activities.

Creative Quick-Build Cards
These challenges can support hands-on & cross-curricular learning opportunities. A quick Google search will reveal plenty of cards!

Blockly
A series of educational games that teach programming

Scratch
Block-based programming language & website

In-Practice Examples

Constructivist Learning Environment
Prof. Deirdre Butler (DCU) outlines a constructivist approach to using expressive computational materials.

NCCA Coding in Schools
Computational thinking examples from Junior Infants to Sixth Class

Oide Technology in Education
Support for integrating technology in teaching and learning.

Primary Language Curriculum Webinars
Highlights role of digital technologies in playful learning experiences.

SFI Discover

Weave Project

Challenge 1

Visit 2 or 3 projects.
Learn about their work.

Your Team Name:

Team Name's Visited:

Use these questions to help you ask questions and learn about other teams' models:

Can you describe your team model please?

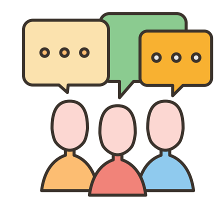
____

____

Explain the problems your model solves in your community.

____

____



How did your team decide on what to build as the team model?

____

How did your model change from the first build until now?

____

What type of sensors and motors did you use? ______________________

Can you explain your code please? ______________________________

What problems did you encounter with your code/model? How did you overcome them?

____

____

2 stars and a wish:

____

____

____

____

Challenge 1 continued...

What idea could you take away from the projects you've seen to improve or change your team's model, code or poster?

Draw a picture of this improvement. Don't forget to add labels!

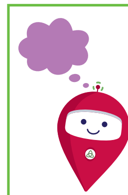
SFI Discover
Weave Project

Challenge 2

Visit 2 or 3 projects. Compare the way different motors and sensors are used

Your Team Name:

Team Name's Visited:



Think: Find a model that uses 2 motors?
- What do think the motors do? Chat to the team - what do the motors do?
- Draw a picture that shows the motors.

Look for a model with 4 wheels.
- Why does it use 4 wheels?
- Could you redesign it to use 2 wheels?

SFI Discover
Weave Project

Challenge 2 continued...

Find a light matrix. Draw a picture of it.

- Why does it light up?

Examine: Search for a model that uses the colour sensor in a way that you had not thought of. Draw a picture to illustrate.

Student Role Cards

These are examples of roles that each student in a group could take on.

Many other roles are also possible: photographer, programmer, script writer etc. and will present themselves as you work with the materials.

ENGINEER

HOLDS THE INSTRUCTIONS. DOES NOT TOUCH THE BRICKS, BUT DESCRIBES THE PARTS NEEDED TO THE SUPPLIER

ENGINEER

HOLDS THE INSTRUCTIONS. DOES NOT TOUCH THE BRICKS, BUT DESCRIBES THE PARTS NEEDED TO THE SUPPLIER

BUILDER

ASSEMBLES THE MODEL FROM THE BRICKS GIVEN BY THE SUPPLIER AND FROM THE INSTRUCTIONS OF THE ENGINEER

BUILDER

ASSEMBLES THE MODEL FROM THE BRICKS GIVEN BY THE SUPPLIER AND FROM THE INSTRUCTIONS OF THE ENGINEER

SUPPLIER

FINDS THE BRICKS DESCRIBED BY THE ENGINEER AND GIVES THEM TO THE BUILDER

SUPPLIER

FINDS THE BRICKS DESCRIBED BY THE ENGINEER AND GIVES THEM TO THE BUILDER

Cody Roby Game

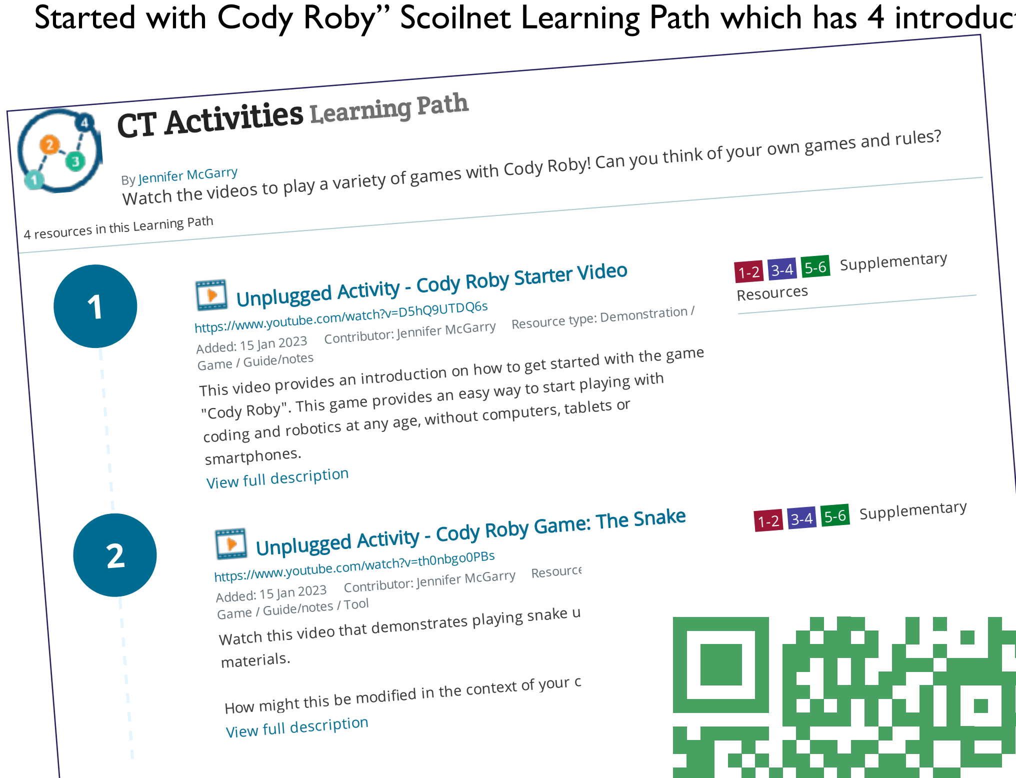
Cody & Roby is the name of a series of DIY games that provide an easy way to start playing with coding and robotics without computers, tablets or smartphones.

Roby is a robot who executes instructions. Cody is a coder who provides instructions.

At the beginning there are only three instructions: move forward, turn left, and turn right. Each instruction is represented by an arrow drawn on a card. During a game Cody selects a card and passes it to Roby, who moves on a chessboard accordingly (print out & laminate chessboard and cards on follwoing pages).

Click here to access the Cody Roby printable kit, or scan the purple QR code.

Then, print and hang the green QR code in your classroom for easy access to the "Getting Started with Cody Roby" Scoilnet Learning Path which has 4 introductory videos.

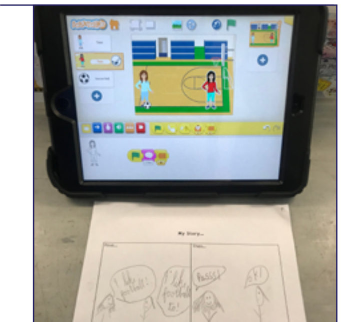


Buddy Maps, Journals and more!

There's so many ways to integrate robotics as expressive computational materials to support the teaching and learning going on in your classroom and to support your students with "Being a Digital Learner" . Here are some other suggestions that extend on the resources throughout this handbook:

Storytelling and Narratives

As described on pages 18, stories, myths, and legends offer a natural way to foster culturally responsive computational thinking. These narratives contain sequenced events that can be retold creatively through robotics. Furthermore, by reimagining endings or predicting next chapters, students can engage with the concepts on a deeper level and bring them to life through robotics!



Time for Tech Talk

Creating opportunities for student discussions about their creations is vital for developing oral language skills. Through incorporating time to discuss what they have created and coded with their digital technologies, students can reflect and share their technical expertise and subject knowledge alongside aspects of their identity.

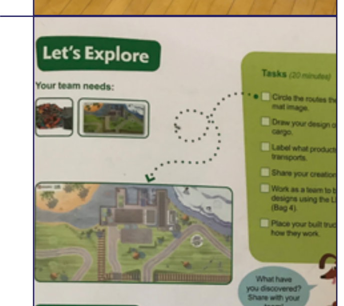
Guiding questions could include:

- How did you feel while working on this?
- What did you learn about yourself as a learner?
- How did this experience help you to get to know yourself and others better?

The "Lets Talk Computational Thinking" resource on page 39 helps students to reflect on their work and that of others.

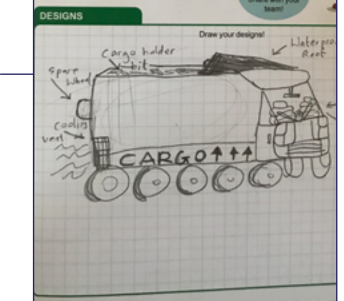
Buddy Maps

Buddy Maps encourage teamwork among students. Each robotics session starts with personalised handout for students, featuring their individual photos at the core, encircled by their peers' photos. Guided by the instructor, they draw lines from their picture to those they've collaborated with during the session. Collaboration entails various activities such as providing or receiving assistance, coding together, sharing resources, or collectively working on a shared project (Bers, 2010).



Design Journals

Design journals can complements students' digital portfolios, their robotics builds and other constructions they may have made. Keeping design journals makes their thinking process visible to others and they can see for themselves how their ideas have evolved.



Thank You!

A huge thank you to all participating schools, the academic team, the Oide Technology-in-Education Advisors and all others involved who contributed towards the success of the SFI Discover Weave Project over the last two years.

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