14 Inclusive Technologies education

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Abstract

Inclusive education aims to ensure that all students, regardless of their learning needs, culture, location, gender, and backgrounds have the right to engage in meaningful learning experiences that allow them to achieve to their full potential. In the context of technology education, this means providing every student with the opportunity to become a creator using technologies, while also leveraging technology to support their individual learning needs. This chapter explores how assistive technologies can be used to support students with cognitive, physical, language, speech, auditory, and visual challenges. Ways to promote cultural and gender inclusion are also unpacked. The digital divide is considered, including how students in remote locations and from lower socio-economic backgrounds can be disproportionally disadvantaged. The Universal Design for Learning framework is examined as a way to promote more inclusive digital design education through multiple means of engagement, representation, and expression. Examples involving culturally responsive technologies projects, 'unplugged' activities, and digital storytelling are showcased, to spark inclusive and creative Technologies education practices by teachers.

14.1 Inclusivity in Technologies education

Given the diverse nature of students in schools, there is a critical need for teachers to establish learning environments that are responsive to student needs (Mukherjee et al., 2024; Nykvist et al., 2021). Internationally, there is a focus on building a workforce that is familiar with and confident in using technologies while also being more inclusive and diverse in terms of cultural and linguistic backgrounds, sexual orientation, neurodiversity, gender, age, and geographic location of employees (Deloitte Access Economics, 2023). This is in response to the historical context where systemic biases and discriminatory practices have hindered equitable representation, particularly among women and individuals from marginalised racial backgrounds (National Academies of Sciences, 2021), as well as youth and migrants (International Labour Organization, 2020).

According to the United Nations Convention on the Rights of Persons with Disabilities (United Nations, 2006) inclusive education is recognised internationally as a human right and that all "parties shall ensure an inclusive education system at all levels" (para. 1). However,

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the notion of inclusive education is quite complex with multiple definitions existing within current literature (Hornby, 2015; Mavropoulou et al., 2021). Salend (2011) contends that the characteristic of inclusion involves valuing *all* learners in mainstream classrooms and celebrating the diversity and values of all students. Similarly, the European Commission (2017) through its endorsement of the European Pillar of Social Rights declares that "everyone has the right to quality and inclusive education, training and life-long learning in order to maintain and acquire skills that enable them to participate fully in society and manage successfully transitions in the labour market" (Chapter 1, Para. 1).

It is within this context that this chapter explores the broader nature of inclusive education, and, in particular, how students design with technology within an inclusive classroom. In an era where there is a push for digital transformation in schools, this chapter recognises that teachers can use innovative pedagogical approaches supported by technologies to ensure that the learning experiences in their classrooms are inclusive. This would ensure that all students, regardless of their backgrounds or abilities, are provided with the opportunity to engage in meaningful learning experiences aligned to the curriculum. Inclusive Technologies education recognises that catering to issues such as individual learning needs, cultural background, gender and access to technology helps to ensure that all students can achieve their full potential. The Universal Design for Learning (UDL) framework (CAST, 2024) is also explored within a technologies context as a means of ensuring "design for learning and equity" (Kelly & Zakrajsek, 2021, p. 10).

14.2 Learners with diverse learning needs and Technologies education

Learners with diverse learning needs encompass a diverse group of individuals who require additional support to thrive in educational settings due to various physical, cognitive, emotional, or developmental conditions (Oredein & Obadimeji, 2022). For example, learners with diverse learning needs include those with learning disabilities such as dyslexia, dyscalculia, and those diagnosed with Autism and Down syndrome. Physical disabilities can include conditions like cerebral palsy, and spina bifida and students with sensory impairments such as vision and hearing loss. Emotional and behavioural disorders include Attention Deficit Hyperactivity Disorder(ADHD), Oppositional Defiant Disorder(ODD), as well as generalised anxiety disorder and social anxiety disorder. Speech and language disorders include issues such as speech apraxia, stuttering, and language processing disorders.

One way that students with diverse learning needs can be supported to participate as digital designers is to provide them with access to appropriate assistive technologies, including assistive hardware, software, and online environments (Rao et al., 2021). For example, features like speech-to-text and text-to-speech software can help students with dyslexia manage reading and writing tasks more effectively (Mossige et al., 2023). Inbuilt thesaurus software can help students articulate their ideas where they have difficulty finding the right words or experience writer's block (Fine, 2015). Students with physical constraints can use voice commands to type or perform screen actions (Lister et al., 2020). Text-to-speech technologies and other accessibility features of iPads and other tablet devices such as the screen zoom feature can also be used to support students with visual impairments (Maher & Young, 2017). Text-to-speech technologies and other Augmentative and Alternative Communication (AAC) devices can also facilitate communication for people who have speech difficulties (Syriopoulou-Delli & Eleni, 2022). The use of video recordings and corresponding transcripts can help students for whom the language is not their first or fluent language, helping them to more easily interpret the meaning of content in their own time and translate content into their preferred language (Zaidi et al., 2018).

In the domain of Technologies education, robotics, and visual programming activities can be particularly suitable for some students with speech, hearing, behavioural, or cognitive needs, because of their tactile nature (Kert et al., 2022). Engaging in robot design and programming activities, students develop crucial cognitive skills, such as selective attention, processing speed, and spatial abilities, which are vital for design tasks. These activities also provide tangible, hands-on experiences that can make abstract concepts more accessible. The process of building and programming robots fosters creativity, problem-solving, and critical thinking, enabling students to actively participate in design projects. While robotics may not be suitable for all students with disabilities including physical or visual disabilities, it offers students with speech, hearing, behavioural or cognitive disabilities an opportunity to engage with the 'hands on' technology. Thus, it is imperative that students are provided with choices and alternatives in the technological tools, materials, and content with which they engage, and teachers help students to make these choices (Bakken & Obiakor, 2023).

One promising area of development is the use of Artificial Intelligence (AI) to support learners with diverse learning needs. For instance, AI assistants can be used to provide personalised cognitive support for students with neurodevelopmental disorders (Barua et al., 2022). Generative AI can also be used by students with language difficulties to support their writing and reduce anxiety by providing feedback and helping students work at their own pace (Gayed et al., 2022; Young & Maher, 2023). Recent developments have also experimented with the use of AI and neural implants to enable direct brain-computer interfaces (Neuralink, 2024). It appears likely that there will be increasing use of AI to support learners with diverse learning needs engage with digital design projects. However, for teachers to take advantage of AI and other technologies to support students with technologies projects, it is imperative that they remain abreast of how technologies can support learners with diverse learning needs and undertake appropriate professional learning (Celik, 2023).

14.3 Culturally responsive Technologies education

There is increasing importance placed on providing culturally relevant curricula in Technologies education, with educators working to create more inclusive and equitable learning environments (Gumbo, 2020, 2023; Leonard & Sentance, 2021). Traditional approaches to technology education have often overlooked the diverse backgrounds and experiences of students, which may lead to disengagement. The Wind River Elementary CS Collective exemplifies how integrating computer science with culturally relevant content, such as First Nations histories, languages, and knowledge systems, can result in heightened student engagement, greater confidence, and effective mastery of computer science concepts for First Nations students (Wilson et al., 2023).

Culturally Responsive Pedagogies (CRP) honour and embrace the diverse cultural backgrounds of students and are essential for creating inclusive learning experiences in Technologies education (Eden et al., 2024). This requires educators to incorporate diverse cultural perspectives into teaching materials and resources to make learning experiences more meaningful and relatable for students, allowing them to see themselves represented in the learning.

Closely related to CRP, Culturally Responsive Teaching(CRT) is a pedagogical approach designed to address the diverse cultural backgrounds of students, particularly in technology-supported learning environments (Chuang et al., 2020). For example, including culturally diverse examples in computing problems and encouraging discussions that allow students to draw on their own cultural experiences can make technology education more inclusive. For this, teachers need to be knowledgeable and aware of cultural diversity and to use this understanding to design relevant curricula, and engage in cross-cultural communication to create learning communities which value students' cultural identities (Chuang et al., 2020).

To support culturally responsive pedagogy and teaching, the Kapor Center (2021) published a research-driven culturally responsive-sustaining computer science education framework with two main elements. The first element is a shared definition of culturally responsive-computer science classroom pedagogy, and the second focuses on implementation (Kapor Center, 2021). The framework includes six core pillars: acknowledge racism in computer science and enact anti-racist practices; create inclusive and equitable classroom cultures; rigorous pedagogy and curriculum that are relevant and encourage sociopolitical critiques; prioritising student voice, agency, and self-determination; incorporating family and community cultural assets into computer science classrooms (Kapor Center, 2021). CRPs such as these aim to assist teachers with their curriculum development and adoption of culturally sustaining practices when teaching Technologies, so as to close equity gaps and improve outcomes for marginalised students.

Teacher Professional Development (PD) can also build teachers' capacity to implement culturally responsive and inclusive teaching practices. A study by Codding et al. (2020) identified that teacher PD should provide teachers with opportunities to engage in self-reflection about their biases and learn strategies to integrate CRP into lesson planning. The research concluded that PD focused on CRP can help teachers to plan lessons that are not only culturally relevant but also promote equity and inclusion across diverse student populations (Codding et al., 2020). Sustained and equity-focused PD should encourage collaboration among teachers, provide modelling of culturally responsive practices and offer contextualised support that aligns with the realities of teachers' classrooms and communities (Codding et al., 2020).

14.4 Gender and Technologies education

Despite the efforts of educators to ensure equality within the classroom, there is still a continuing gender disparity in Technologies education (Stoet & Geary, 2018; Sultan et al., 2019). While the Organisation for Economic Co-operation and Development (OECD) recognises that progress has been made in recent years, "across OECD countries, only 1% of girls report that they want to work in ICT-related occupations, compared to 8% of boys, with the gender gap in terms of interest in these occupations widening over the past few years" (OECD, 2024, p. 14). Research identifies that as children grow older, differences in interests, abilities, and career aspirations in technology tend to widen between males and females (OECD, 2019) and more needs to be done in schools to eliminate gender bias from teaching practices, address stereotypes and implement strategies to encourage gender equality (OECD, 2024).

While this section focuses on gender and Technologies education, much of the current literature focuses predominantly on the differences between boys and girls in Technologies education. There is a growing body of research that recognises a broader definition of gender and its implications for inclusivity of students who may also identify as LGBTQ in the classroom and the workplace (see Freeman, 2020; Justice & Hooker, 2019). Despite the fact that "LGBTQ people have pioneered major scientific advances" (Freeman, 2020, p. 141), they are often the most discriminated in their workplaces and tend to leave at a greater rate than other employees.

In Technologies education, it is important to ensure that all students feel safe and have a sense of belonging. This can often be achieved through small changes such as the deliberate use of inclusive language in the classroom or where blended (including online) learning spaces are accessible to students, the idea of anonymity online can allow a student to express their views more freely (Justice & Hooker, 2019). According to Sultan et al. (2019), the largest factor for girls not being involved or interested in Technologies education can be linked to culture. Sultan further posits that the easiest way to address this in the Technologies classroom is by "making sure the social context of teaching is adapted to girls" (Sultan et al., 2019, p. 20). In addressing the social context, perhaps one of the largest movements in Technologies education over the past couple of decades has been through the creation of subsets of groups that focus on 'girls' in Technologies education such as coding and STEM clubs for girls (Maltese et al., 2024; Zagami et al., 2015) or girl technology camps (Sultan et al., 2024). However, for this to be truly inclusive in Technologies education, there is a need to consider ways to ensure that these camps and events can promote inclusivity. Moving forward in this space of gender-based clubs, a truly inclusive approach would be represented by a range of gender expressions, though this is sometimes difficult to achieve in some educational settings. Sultan points to the issue that the clubs or camps can become 'girlified' which can give a false image of real-world industry and when girls sign up to these clubs or camps, they may already have an interest in technologies (Sultan et al., 2024).

Increasing participation of girls in Technologies education can be further achieved through the use of positive role models, addressing peer and parental perceptions of girls in Technologies education, future-based career positions, and through positive reinforcement that builds confidence (Hur et al., 2017; Zagami et al., 2015). A study by Sharma et al. (2021) highlighted the positive impact of girls playing computer games, which was found to increase their personal perceptions of computer science. Other studies have demonstrated the positive impact of early intervention, showing how coding can help students explore their identities and empower them by increasing their knowledge in the field (Akkuş Çakır et al., 2017).

14.5 The digital divide in Technologies education

Another issue in inclusive Technologies education is the disparity in access to technology, also commonly referred to as the *digital divide* which exists not only between different countries and regions but also within communities and among individuals worldwide (Bon et al., 2024). At least three types of digital divides exist: (1) the gap between those with access to internet and devices and those without, (2) disparities in digital skills and usage patterns, and (3) the inability to leverage digital opportunities to result in material or social benefits (Graafland, 2018). Across countries in the OECD, geographic challenges, equipment shortages in schools, and socio-economic disparities create significant digital access inequalities, both within and between countries, limiting education systems' ability to offer equitable learning opportunities (Burns & Gottschalk, 2020).

Students who are from poorer socio-economic backgrounds are in more remote locations, are younger, and females often have more limited access to internet and digital devices (Afzal et al., 2023). This is a concern for all countries, as they must ensure that all citizens have access to technology and possess a high level of technological competence if they are to remain globally competitive (Afzal et al., 2023). Ensuring that all students, particularly those from underrepresented and low-income backgrounds, have access to necessary technologies for their learning and digital creativity is important to make Technologies education accessible and inclusive for students (Leonard & Sentance, 2021). Thus, implementing policies which prioritise digital equity in education is important to ensure that all students, regardless of their background, have equal access to the necessary hardware, software, and internet connectivity, is an imperative of an inclusive education system (Kelly & Zakrajsek, 2021).

The digital divide goes beyond merely separating the connected from the unconnected – research also highlights differences in how students use digital tools and the quality of their digital experiences (Gottschalk & Weise, 2023). Research suggests that lack of access can in turn affect how independently and often students participate in digital activities as well as the kinds of activities they choose to engage in (Burns & Gottschalk, 2020; Mascheroni & Ólafsson, 2016). However, other research (Rienties et al., 2023) highlights that innovative pedagogical approaches can leverage technology to bridge gaps in access and opportunity, for instance, for students in rural and remote areas. For example, educators can use digital tools such as Virtual Reality (VR) to create immersive learning experiences tailored to the cultural and socio-economic contexts of their students, which can help to overcome geographic and economic barriers to learning. One project with six disadvantaged schools from diverse geographical locations around Australia, explored the enactment of the Australian Digital Technologies curriculum in disadvantaged contexts. Their research found that when students were given the chance to shape their learning experience, it created a sense of purpose and agency with the learning becoming more dynamic and relational, allowing both students and teachers to overcome limitations posed by external inequalities (O'Mara et al., 2024).

14.6 Supporting the needs of diverse students using the UDL framework

There are many frameworks that can support the needs of all students in the classroom. The framework discussed here is the UDL framework (CAST, 2024) which is also underpinned by the United Nations (2016) statement that all "parties must commit to the prompt introduction of universal design" (para 22). Despite this statement that universal design should be adopted as a framework, Graham and Tancredi (2024) claim that UDL has "not yet been widely adopted in schools and, due to its comprehensive nature, may be difficult to integrate with existing pedagogical frameworks, many of which have been widely adopted" (p. 201). However, the UDL framework is useful as it has the flexibility to include digital resources and cater for students from a diverse range of backgrounds including different social and cultural backgrounds, students with disabilities, and students across different learning levels. UDL can be used to guide students in their own design processes, whether creating projects, presentations, or any form of educational content. This content can be presented using traditional mediums such as pen and paper or via the use of digital technologies (Reale et al., 2022).

The UDL framework is set out into three learning dimensions; means of engagement, means of representation, and means of action and expression. The framework provides nine guidelines and 36 considerations as indicated in Figure 14.1.

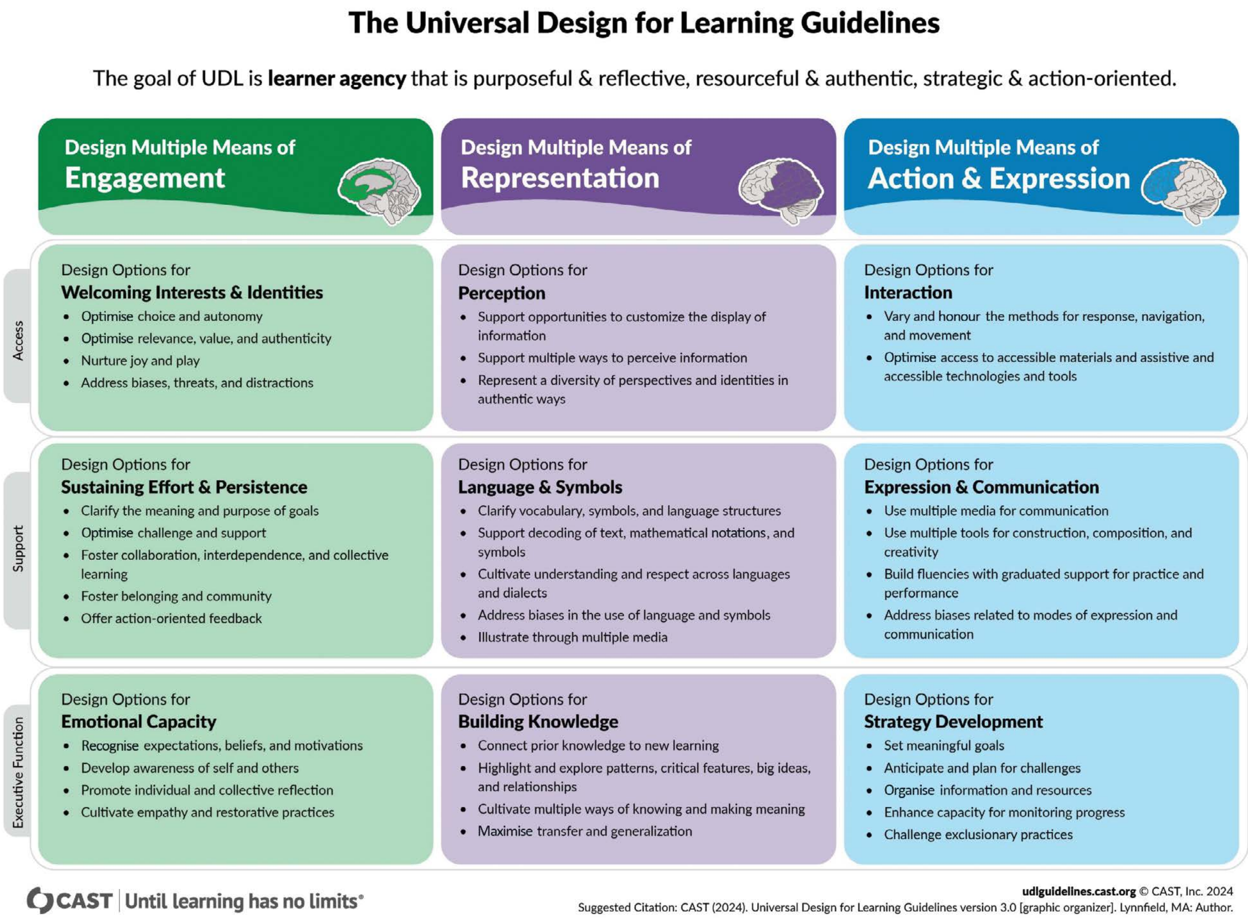

Figure 14.1 UDL framework

CAST (2024)

When planning for creative Technologies education and recognising potential barriers that may exist for learners, teachers can use the UDL Framework to identify ways to help them overcome those barriers, as illustrated in the following three brief vignettes.

14.6.1 Vignette 1 – Enhancing student engagement through culturally inclusive technology projects

One of the guidelines in the UDL is Multiple Means of Engagement which recognises that there are multiple ways of engaging students in the learning process (CAST, 2024). Student engagement is a crucial factor in the learning process, linked to motivation (Boekaerts, 2016). Student engagement occurs when students are actively involved in their learning, persist through challenges and have a desire to participate and succeed in the learning process (Saeed & Zyngier, 2012). One way to enhance student engagement and learning is by incorporating culturally inclusive technology projects. Culturally inclusive projects create opportunities for culturally diverse students to design technology solutions which revitalise their languages and culture (Rich et al., 2024) and motivation to create in ways that are more significant to their communities (López-Quiñones et al., 2023).

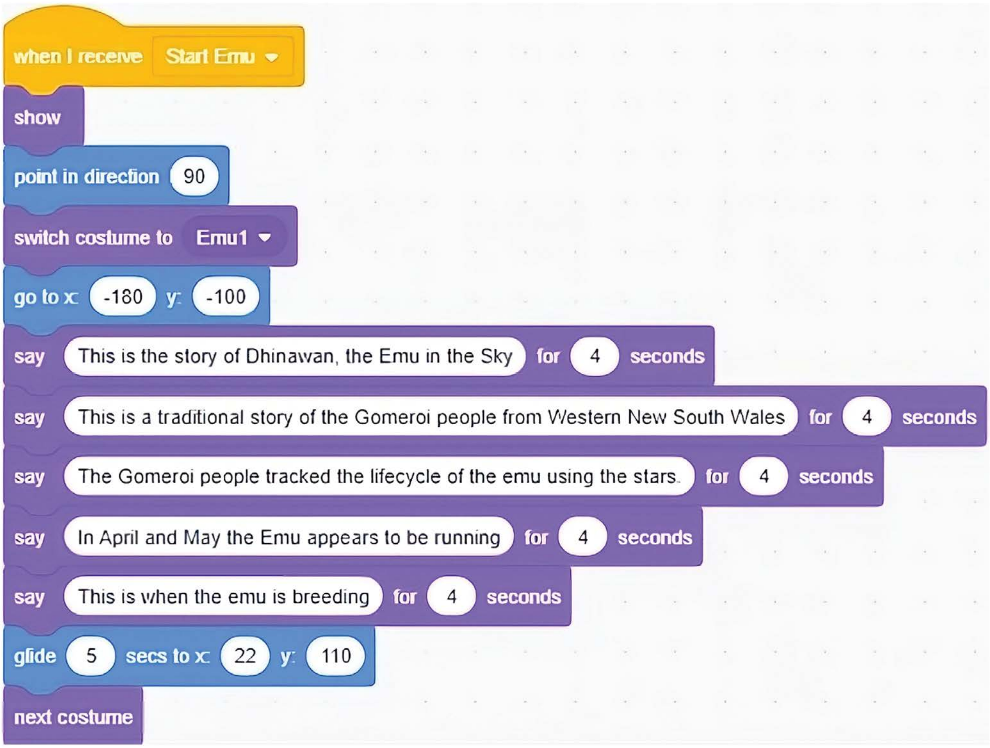

Figure 14.2 Coding example created from lesson in the Dhinawan in the Sky project (https://www.codeclubau.org/projects/dhinawan-in-the-sky/)

The First Nations Projects by Code Club Australia (CCA) are an example of culturally responsive teaching projects. These projects are designed using the First Peoples Cultural Framework drafted by CCA, which focuses on the relevant protocols and rights of First Nations communities for developing projects (Telstra, 2024). The projects developed by CCA are a partnership and aim to share culture, traditional stories, and insight into First Nations communities in Australia, thereby honouring the diversity of learners' backgrounds and experiences. There are currently four First Nations projects available for free international use on the CCA website (https://www.codeclubau.org), select 'projects' and 'topics' and then conducting a search using the search term 'First Nations'. These primary school projects using Scratch include designing a Yalanji people's game where a character collects native Lilly Pilly berries, building an animation about the Gomeroi people story of the Dark Emu (Figure 14.2) and creating an animation that tells the story of the Tagai constellation. Authentic and culturally inclusive projects like these make learning relevant and engaging for students at the same time as preparing them for a diverse and globalised world.

14.6.2 Vignette 2 – Navigating digital access with unplugged and hands-on learning strategies

Unplugged activities are another means which aligns with UDL where information and content can be represented to students in multiple ways to reduce barriers to learning (CAST, 2024). Teachers of Technologies education needs to consider whether all students in their class are able to access the learning and ensure that projects offer students multiple ways of engaging with the content. In Technologies education, the lack of access to digital tools and resources can create barriers for students, with the *digital divide* providing significant challenges (Afzal et al., 2023; Thomas et al., 2023). Some students may also learn more effectively from non-digital or alternative representations of technology concepts, such as those with a tactile learning preference or those with visual impairments. For this, there are a range of 'unplugged' activities that children can complete to help them learn computing concepts and computational thinking.

Unplugged activities are non-digital activities that help students learn technologies concepts, for instance using arrows to write an algorithm (Figure 14.3), writing pseudocode, preparing flowcharts, sketching interfaces, and acting out algorithms, which can help make abstract concepts concrete.

A systematic literature review and meta-analysis on fostering computational thinking through unplugged activities conducted by Chen et al. (2023) suggests that unplugged pedagogy can successfully cultivate computational thinking in years K-12, without the use of computers. While it may seem ironic to search online for unplugged resources to teach technologies concepts, there are many valuable tools available, such as CS Unplugged (https://www.csunplugged.org) from the University of Canterbury, New Zealand (Computer Science Education Research Group, 2024). These activities do not negate the need for students to spend time with digital technologies to develop their creative design and digital capabilities. Unplugged activities as an alternative to digital representation can help overcome the digital divide, develop key technologies concepts, and also cater to students with diverse learning needs.

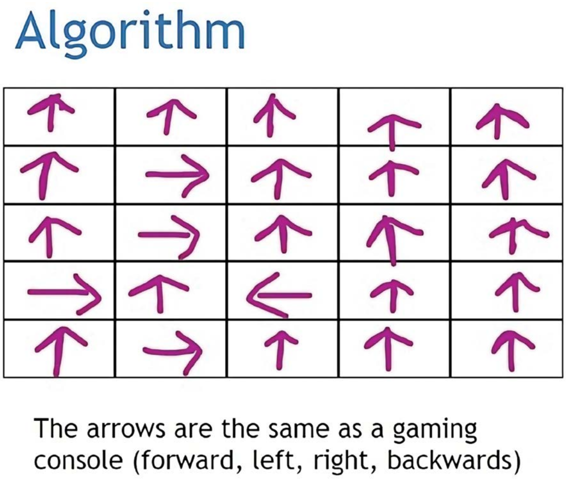

Figure 14.3 Example of an algorithm using arrows in early childhood

14.6.3 Vignette 3 – Expressing learning through digital storytelling

Digital storytelling is an inclusive strategy which enables students to demonstrate their learning and develop digital design skills (Lambert & Hessler, 2018). It aligns with the UDL framework by providing multiple means of action and expression, allowing students to demonstrate their understanding in various ways (CAST, 2024). Inclusive Technologies teachers need to draw from a broad array of strategies that can be adapted to satisfy the diverse needs of their learners and their contexts (Caena & Redecker, 2019). Digital storytelling is one such strategy that leverages digital technology, including skills in coding and programming, to create stories on specific topics from multiple viewpoints (Meadows, 2003). The process of creating digital stories can foster a deep connection with the subject matter can enhance students' sense of ownership and empowerment (Yang & Wu, 2012). It aligns with the idea of providing tasks with 'low floors' (students with varying abilities), 'high ceilings' (that extend capable students), and 'wide walls' (allowing people to express their learning in multiple ways) (Resnick & Robinson, 2017).

ScratchJr (https://scratchjr.org) is a free app that enables children as young as five to use a drag-and-drop interface to help them create digital stories (Figure 14.4). Students with low literacy levels can still use this tool to demonstrate their knowledge and skills at the same time as developing their digital design capabilities. In *ScratchJr*, audio can also be recorded and attributed to a character, providing an opportunity for all students to participate and express themselves. Additionally, students can personalise stories using the device's camera, to insert their own faces as characters or photographs of their environment as story backdrops. This level of personalisation can significantly increase student engagement, assisting students to connect more deeply with the story setting and characters. The design of *ScratchJr* allows users across ages and experience levels to engage and develop their coding skills (Blake-West & Bers, 2023). Through the creation of digital stories and animations, students also develop computational thinking and design thinking, using multimedia elements to enhance their narratives.

Figure 14.4 The *ScratchJr* interface (CC-BY M Levins)

14.7 Concluding reflections

Inclusivity in Technologies education requires a commitment from teachers to create learning environments where every student has the opportunity to succeed, regardless of their background or abilities. With rapid advancements in technology, teachers have increasing opportunities to support all learners to engage in digital design projects. Speech-to-text and text-to-speech tools, video recordings, screen zoom, and translation tools, can all be used to make learning more accessible for students with a wide range of hearing, speaking, and visual impairments. Robotics and visual programming can provide an accessible means of learning for people with language and literacy difficulties. Developments in AI mean that students with a variety of cognitive or behavioural challenges can increasingly access personalised support that is customised to the creative design task at hand. Beyond the use of specific technologies to support learners with diverse learning needs, the examples show that inclusive pedagogies involve the teacher understanding and catering to the context and attributes of learners. This includes designing tasks that celebrate diverse cultures, are mindful of gender histories and preference in Technologies education and working towards access to technologies by students regardless of their location or socio-economic background.

The application of frameworks like the UDL framework (CAST, 2024) offers a useful tool to help teachers effectively address the diverse needs of their students. The practical examples provided underscore the importance of culturally inclusive projects, using hands-on and unplugged activities, and digital storytelling to foster inclusive Technologies education. These approaches showcase how multiple means of engagement, representation, and expression can help all learners actively participate and demonstrate their abilities in Technologies education. These are just three possible ways that teachers can promote inclusion in their Technologies classrooms, and there are obviously many others. What is crucial is that in our rapidly changing technological landscape, teachers continually seek out innovative pedagogical strategies that not only use and integrate new technologies, but more importantly foster an inclusive and supportive environment where all students can learn, explore, and create.

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