IFIP Task Force

'Sustaining relevant digital inclusive education for young people (5-18 years of age)'

Final Report

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1. Purpose of the IFIP Task Force

The International Federation for Information Processing (IFIP) was founded in 1960 under the auspices of UNESCO, as a federation for societies working in information processing. IFIP's aim is two-fold: to support information processing in the countries of its members; and to encourage technology transfer to developing nations. As its mission statement states: IFIP is the global non-profit federation of societies of ICT professionals that aims at achieving a worldwide professional and socially responsible development and application of information and communication technologies.

IFIP Technical Committee (TC3) is one of 13 Technical Committees within IFIP; TC3 focuses on education, the uses and applications of computing in education, across the lifespan, and across educational sectors (whether primary, secondary, tertiary, vocational, further, higher, professional, or adult). In response to IFIP TC3 member concerns with how education has been continuing to integrate digital technologies for teaching and learning purposes, prior foregrounding work to this IFIP Task Force focus has explored the topic of 'Sustainable Education in a Digital Age of rapidly Emerging Technologies'. Arising from that work, IFIP TC3 presented a Zanzibar Declaration[1] – a document designed to consider and to challenge any or all stakeholders at any level in education (whether teachers, lecturers, academics, researchers, professionals, trainers or policy makers).

Subsequently, and set up by the President of IFIP in 2022, the work of the current IFIP Task Force takes the work of the Zanzibar Declaration further, seeking to gain an international perspective to support the UN, UNESCO, affiliated organisations, national societies, regional and local organisations in moving forward a focus on 'Sustaining relevant digital inclusive education for young people (5-18 years of age)'.

The IFIP Task Force reported its interim findings initially at the WSIS 2023 Forum held in Geneva, Switzerland in March 2023, and then at the IFIP General Assembly (GA) Meeting in Bratislava, Slovakia in September 2023. These interim findings identified five key areas of concern that the IFIP Task Force believe warrant specific and particular attention: aspiration; diversity, inclusion, the digital divide and the under-represented; computational thinking and its links to problem-solving; developing teacher practices; and short- and long-term plans and actions.

[1] Magenheim, J., Morel, R., Osorio, J., Passey, D. & Reffay, C. (Eds.). (2023). *Zanzibar Declaration: Sustainable Education in a Digital Age of rapidly Emerging Technologies*. IFIP: Laxenburg, Austria. DOI: 10.52545/2-4. Accessible at: hal-04061320

2. Content of the IFIP Task Force Report

This report offers an introductory section explaining the scope of the IFIP Task Force work, followed by five main sections that explore further the five areas of concern, from evidence gathered:

1. **Aspiration**
2. **Diversity, inclusion, the digital divide and the under-represented**
3. **Computational thinking and its links to problem-solving**
4. **Developing teacher practices**
5. **Short- and long-term plans and actions**

The IFIP Task Force has undertaken wide consultations, to gather important evidence about successes that local, national, regional and international organisations have achieved in enabling 'Sustaining relevant digital inclusive education for young people (5-18 years of age)'. The key questions that were asked in this consultation are shown at the end of each of the subsequent sections of this document, where responses are then presented.

Additionally, the IFIP Task Force has identified a country where long-term development has led to a range of successful outcomes that align with the five key areas of concern. A specific case study details how the key areas of concern have been considered and addressed over a long-term period, what features and factors have been recognised as being important, and what recommendations and questions this might raise for others working in this field. The case study is presented as a separate appendix document. The IFIP Task Force recognises that there are other successes worthy of being presented as case studies; it is hoped that the case study presented might provide a means either to consider how to develop further case studies that both highlight successful outcomes or that might identify features that are still to be addressed and how this might be done.

3. Scope of the Work of the IFIP Task Force

In its work, the IFIP Task Force has taken the widest possible definition and scope when exploring 'relevant inclusive digital education'. Over the past 70 years, digital technologies have been developed so that their place in education and wider societies has become increasingly ubiquitous and vital to fundamental practices across education and society. From this perspective and position, the IFIP Task Force considered four important ways in which learning environments and curricula need to integrate digital technologies if they are to sustain 'relevant inclusive digital education'. The increasing ubiquity of digital technologies within everyday functions, whether they be related to personal, social, employment or enjoyment needs, means that young people need to be increasingly aware of career paths, in the IT and computing industries, but also in how digital applications are impacting the width of businesses, enterprises and industries. There is a need for:

- All young people and citizens to develop digital literacy (so that they may be able to use digital technologies to support actions and functions in educational practice and beyond, and to be aware of future challenges and opportunities in using and developing digital technologies). In the context of this work, it is important that young people develop digital learning literacy as well as digital social literacy.
- All young people to develop understanding of the thinking and processes involved in computing through uses of digital technologies across the wider school curriculum that can include computer science or informatics education, but all supporting a basic scientific discipline (enabling deeper awareness of how digital technologies can be conceptualised, developed and applied). In the context of this work, it is important that young people develop computational and computing skills and competences.
- All those who support young people in digital education practice to have appropriate ways to implement digital technologies and their practices (through ongoing understanding of successful actions and plans, as well as awareness of those that are problematic). In the context of this work, it is important that young people are supported by teachers, parents, guardians and carers, with due consideration given to the need for mental health balance, with appropriate time and focus away from the digital environment.
- All those who develop and support digital environments to develop digital education practices recognise what young people might experience and how these experiences can both affect and positively influence digital education practices (whether related to desktop, mobile, smartboard, or robotic environments, for example). In the context of this work, it is important that cost versus investment is considered, as upfront costs to support young people's development is a necessary preliminary to ensure investment outcomes in the future. Developing appropriate digital learning literacy, computational thinking and informatics provision for young people requires appropriate support mechanisms to be put in place to plan for the short- and long-term, to provide support for those involved in educational practices, to develop appropriate curricula, and to ensure access for all.

In the report sections that follow, the IFIP Task Force sets out the context and the findings of five factors that affect outcomes of the four ways in which digital education can be considered:

- Section 1 is concerned with aspiration, as this is a key factor if young people are to positively consider sustaining their involvement in digital education and employment; young people need to be more aware of the roles of those involved in IT and digital professions, with ways that young people can understand the potential that digital technologies can offer, in terms of future education and employment, enabling them to aspire to engagement and involvement in this developing field.
- Section 2 is concerned with the need to ensure that digital education is accessible to and inspiring for all young people, positively accommodating diversity, inclusion, the digital divide and the under-represented, with ways that 'inclusive digital education' can be considered, if current limitations that are seen across the world are to be addressed.

- Section 3 is concerned with computational thinking and computing, which should be included within the curricula for young people, ensuring that activities support longer-term engagement and inspiration, as a bedrock for developing practices in uses of digital technologies across the wider school curriculum, which can include informatics or computer science, all providing access to and understanding of the language of computing.
- Section 4 is concerned with the fact that if young people are to sustain their engagement with digital education, then teachers must be supported effectively in maintaining appropriate and up-to-date ways to implement activities and understanding, within and across the curriculum, whether this support focus be all teachers, or information and communication technology (ICT) teachers ("teachers of technology", "teachers of ICT"), to develop their involvement with young people through appropriate and varied actions and activities.
- Section 5 is concerned with sustaining digital education for all young people, requiring long-term systemic actions and planning, as well as short-term actions and plans; history informs us that continuous support and involvement is essential, with long- and short-term plans and actions by local, regional and national governments and agencies that can lead to successful implementation and address the pitfalls of the four concerns that are discussed within the previous four sections.

This report explored different ways to develop curriculum opportunities and practices - digital literacy in the wider sense, digital education in a teaching and learning context, and uses of digital technologies across the wider school curriculum which can include informatics or computer science education in a subject-specific context – that all should play if we are to sustain 'relevant inclusive digital education'. Each of these three needs are complementary, but each comes with its own specific challenges and opportunities.

The IFIP Task Force seeks in this report and its appendix to identify recommendations that will support future ways of moving forward in this wide but vitally important field. As will be shown by the examples of practices illustrated in the sections that follow, there are different approaches that nations and support agencies have taken. Some have focused on digital learning literacy, others have focused on informatics or computer science, and yet others have sought to introduce both of these elements, either together or in sequence over time. Each of these approaches has its advantages, as each one focuses on practices that can lead to different outcomes (for example, digital learning literacy crosses curriculum areas and supports subject learning widely, informatics supports long-term engagement with a subject becoming more ubiquitous and requiring increasing individual agency).

4. Factor 1: Aspiration

Aspiration is a key factor if young people are to positively consider sustaining their involvement in digital education and employment; young people need to be more aware of the roles of those involved in IT and digital professions.

The challenge of diversity in the information technology (IT) - or digital - profession is not a new issue. While the industry is less than 70 years old (young in comparison to most others), a situation has been created where the overwhelming majority of employees are male, with a technical orientation. If industry leadership wants to attract more diverse young people to IT or digital professions - how do “we” do that, and who needs to be involved?

How do we “inspire” young people to want to be a “Digital Leader”? Indeed, what is a digital leader? There are some key features that stand out, worthy of initial focus: to identify and celebrate appropriate role models; to create and make available resource materials for educators, parents and students; to show how IT work is doing beneficial things for the planet and making peoples’ lives better; and to assist people trying to understand what attributes can contribute to individual success. We should ask and answer: what are IT and digital profession career paths (as well as how digital applications can impact all sorts of businesses, enterprises and industries) and how does one progress in these fields? Where does one go for insight and/or help?

Seventy years of evolution that have led us to the current situation will not be changed easily or quickly. Attracting and engaging a more diverse workforce will likely require multiple initiatives in multiple areas. Compounding the challenge is the number of stakeholders that are involved. These include children, teachers (primary, secondary and tertiary), parents, school boards, publishers, guidance councillors, employment agencies, employers, existing employees, universities and colleges, the media (of all types) and governments (at all levels).

Given the complexity of the situation and the system in which it lies, one approach would be to have each stakeholder agree on what changes might be beneficial. While this may represent considerable work in order to initially collect evidence, the benefit could be considerable.

Since the traditional education system can shape and influence children’s thinking, and is an accepted path to employment, ways to address the issues through a “systemic” education challenge are worthy of focus. Most people accept that education is most successful when the student embraces the subject matter, and they have a strong desire to learn whatever is being presented. So, how do we inspire and motivate young people to want to be digital leaders?

The challenge around career paths was certainly highlighted in a recent article by Jessica Hubbert (2023)[2]; 66% of women reported they had no clear career path in IT. Using some of the accepted frameworks like SFIA (Skills Framework for the Information Age) could help individuals understand what skills are required to perform various roles successfully. Having the most popular roles “profiled” by diverse role models could clarify how one succeeds and advances a career. Such insight could stimulate more diverse choices of school subjects at transition points, leading to enrolment in university and college programmes in computer science and technology courses. However, supporting that direction will likely require more case work and projects that deal with issues that have a diversity theme. Industry, education

[2] Hubbert, J. (2023). *70+ Women In Technology Statistics (2023)*. Accessible at: https://explodingtopics.com/blog/women-in-tech

and society leaders need to be ready to mentor, with appropriate messages and role models, to support this hoped-for new cohort of diverse learners.

For existing workers, they need to see these new entrants as growing the industry (whether IT industries or other industries and businesses) and creating new products and services. The better the solution-builders represent the population as a whole, the more likely those products will penetrate the market.

In summary, we, IFIP, its associated organisation members and all stakeholders, should consider creating a shared site, with tools, assets and support materials for all stakeholders that highlight what is positive (including the issues that need to be positively addressed) about the IT and digital, to better inform the world in this context.

Examples of aspirational methods national, regional or local organisations have used that have successfully inspired young people to continue to engage with digital education or digital employment

In Eswatini/Swaziland, an ICT Fair, an event held once a year for two consecutive days, was hosted by the University of Eswatini where young people under the age of 18 years, from local high schools, would visit the University and experience digital activities and presentations from the ICT Department, acquire skills, then apply them on a set competition question such as “create a two minute video explaining the importance of digital technology in an industry of your choice”. The hosts would talk about how to use digital technology in tourism, mobile, forestry or clothing industries. Different companies including mobile companies in the country, SWAZI mobile and MTN, banks as well as industries, sponsored the initiative and provided prizes for the competition to make the two days a success. This initiative has unfortunately stopped due to lack of funding, but this was a fruitful event as students would aspire to pursue degrees in ICT and subsequently enrol as students to do ICT and other technology-related courses like computer science and programming. Consequently, since 2022, applications in the computer science programmes have dropped because the young people from high schools in the country have not been exposed to the field.

The University of Eswatini has nevertheless fostered a culture of blended learning where students and educators not only engage in the classroom but also through the University’s own learning platform, where students can do more than just access academic material; they can also engage in discussions with their educators and peers. Students can also take assessments on the platform and receive feedback online. This has encouraged the students to not only take advantage of this blended learning system but to further explore more ways in which they could draw benefits from digital education.

Some students have found that the online discussions provide a more comfortable environment for participation, allowing them to express their thoughts and ideas more freely. Additionally, the ability to receive immediate feedback on assessments has helped students identify areas of improvement and make necessary adjustments to their learning strategies.

As well as the ICT Fair, a Royal Eswatini Technology Park STEM Expo was run in partnership with the University of Eswatini, where talks about digital technology are held to reveal issues of success and non-success in engaging with digital education. Additionally, programmes such as the Eswatini Coding School, hosted by the University of Eswatini, provide hands-on training in computational thinking and problem-solving skills, equipping young people with the necessary tools to excel in digital education or employment.

In Bulgaria, there are many actions that successfully inspire young people to engage in digital education at national, regional or school levels. The Ministry of Education provides several national programmes for engaging young people and teachers in digital education and employment: "Education for tomorrow's day"[3], with more than 100,000 students and teachers involved in the project to date[4]. From this project, a "Digital backpack"[5] was created, which provides a lot of digital educational resources for teachers, students and parents. Also, the national programmes "ICT in Education" and "Innovative schools" add aspirational value[6]. Through a national programme, "Business teach in school", representatives of IT companies taught in schools, and teachers were trained in a real-world IT process.

National and regional Olympiads and competitions are run for school children, supported by the Ministry of Education and Sciences in informatics[7], information technologies[8], and computer modelling for primary school[9]. In Bulgaria, there is obligatory education in informatics/computer science from the 3rd grade (9-10-years-of-age), starting with the subject "Computer modelling", continuing in lower secondary school with the subject "Computer modelling and information technology" and in upper secondary 8th–10th grades (14-16-years-of-age) with the subject "Information technology". The specialised subjects of "Informatics" and "Information technologies" in high schools (11th–12th grades) attract students to digital technologies and future professions. Part of the national programme "Education in IT carrier"[10] provides vocational education in areas of programming, such as applied programmer.

Also, competitions are organised by some of the universities, the Institute of Mathematics and Informatics at the Bulgarian Academy of Sciences (IMI BAS), the Union of Bulgarian Mathematicians, NGOs related to the IT sector, schools, textbook publishers, etc. Textbook publishers offer a lot of interactive content in the area of ICT and other school subjects. Publishing houses have provided learning resources based on published handbooks. Each publishing house has had their own learning platform, for example, the Prosveta Publishing House[11] and the online learning resources of the KLETT Publishing House[12]. The Union of Bulgarian Mathematicians together with IMI BAS organise school student conferences in informatics and IT, where students present IT projects. National students' summer schools in informatics are also organised[13]. One of the very successful activities are the initiatives of a foundation "I can do – here and now"[14], founded by young IT specialists. The first initiative was started in the year 2011 with a competition in IT and after that a summer school for students. The organisers of the contest "I can do – here and now" organise a set of meetings

[3] https://oud.mon.bg/ (in Bulgarian only)

[4] https://aibulgaria.com/%D0%BE%D0%B1%D1%80%D0%B0%D0%B7%D0%BE%D0%B2%D0%B0%D0%BD%D0%B8%D0%B5-%D0%B7%D0%B0-%D1%83%D1%82%D1%80%D0%B5%D1%88%D0%BD%D0%B8%D1%8F-%D0%B4%D0%B5%D0%BD/

[5] https://edu.mon.bg/

[6] Tuparov, G., Tuparova, D. (2023). The Ecosystem of Computer Science Education in Bulgarian Primary School – State of the Art. In: Zlateva, T., Tuparov, G. (eds) Computer Science and Education in Computer Science. CSECS 2023. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 514. Springer, Cham. https://doi.org/10.1007/978-3-031-44668-9_26

[7] https://infos.infosbg.com/home

[8] https://edusoft.fmi.uni-sofia.bg/za_olimpidata

[9] https://comp-modelirane.com/

[10] https://it-kariera.mon.bg/e-learning/

[11] https://www.e-prosveta.bg/

[12] https://bg.izzi.digital

[13] https://infos.infosbg.com/schools

[14] https://contest.az-moga.bg/it/2024

with students in the schools called “Hike of the inspirers”[15], where successful young IT people explain benefits and necessary skills and knowledge to the students about how to be successfully employed in the IT sector.

During the Covid-19 pandemic, at the national level, online learning platforms were established[16], and these platforms provided interactive learning materials. At a local level, in 2022, one university supported a gamification element in some courses that were applied, and the success rates were improved.

Bebras[17] is an international initiative aiming to promote computer science (informatics) and computational thinking among school learners of all ages. The Bebras aspiration initiative strives to cultivate and promote computational thinking skills among K-12 students. Through interactive challenges and activities, it aims to inspire young learners to develop problem-solving abilities, logical reasoning, algorithmic thinking, and creativity. By engaging learners in diverse and stimulating tasks, Bebras encourages them to explore the world of computing and to embrace its potential as a tool for innovation and problem-solving across various domains. This initiative plays a crucial role in fostering children to engage with the digital world and focus on deeper insight behind the technology – on computational thinking concepts.

In Slovakia, computer science was introduced into school practice from 1986. Teachers have been given opportunity to spend time working in industry, so that they can become aware of how computing is involved in and supporting business, industrial and commercial practices.

In Poland, supporting wider inclusive engagement of learners, through the “E-podręczniki” (e-school books) platform, regional and local educational organisations can support their students in learning, which was particularly useful during the Covid-19 time. From EU funds, a range of educational projects to support academic staff and teachers in schools on designing accessible digital documents and educational materials have been run. Festivals with performances accessible to people with visual and hearing impairments have been organised. The MultiAccess Centre was engaged in three projects as an audio describer, in the Silesian Theatre in Katowice (performance “Spójrz na mnie” - in English “Look at me”) in which there were 3 professional actors and 5 blind people (2017–2018), the International Wertep Festival in Hajnówka (2021) (“Plan lekcji” - in English “Lesson Plan”, a pantomime), and the Accessible Night in Museums (the Silesian Museum 2023) (“Not love, or seventeen meetings”, a final performance prepared by deaf performers as a result of theatre workshops).

[15] https://inspirers.az-moga.bg/
[16] https://ucha.se/; https://pomagalo.net/
[17] https://www.bebras.org/publications.html

Examples of aspirational methods national, regional or local organisations have used that have failed to inspire young people to continue to engage with digital education or digital employment

In Eswatini/Swaziland, inadequate access to technology and Internet connectivity in certain regions or communities, as well as lack of smart digital tools, has greatly hindered young people’s abilities to fully participate in digital education, leading to disengagement and demotivation when it comes to the subject. Furthermore, a lack of awareness and understanding about potential career opportunities and benefits arising from digital education has also contributed to young people’s disinterest in engaging with the subject.

In Bulgaria, 10 years ago, a portal with lessons related to the national educational programme was designed and developed. It was full of video lessons for chemistry, for example, with experiments. However, this platform was not accepted for country-wide access.

In Poland, there is a lack of educational programmes that can allow young people to learn how to implement inclusion in their local environment. The MultiAccess Centre has organised a few activities for students in secondary schools, delivering workshops that were connected with introducing audio description, and taking part in a few projects in the Departments of Art in Warsaw and Kraków to promote audio description to support academic staff. However, the workshops ran for only 6 hours, which was insufficient in time terms, as it takes more time to support potential trainers how to describe paintings, sculptures, trailers, etc., to support end-users. It should be underlined that topics connected with inclusion and digital accessibility are not generally promoted among students; they are only implemented at philology departments as translations of subtitles/captions and audio description.

5. Factor 2: Diversity, inclusion, the digital divide and the under-represented

It is essential that digital education is accessible to and inspiring for all young people, positively accommodating diversity, inclusion, the digital divide and the under-represented.

Diversity

Aspiration should be an inclusive feature for all. Diversity in digital education refers to ways to define how to empower humans, by respecting and appreciating their backgrounds, experiences and perspectives that might make them different from others in terms of race, age, gender, ethnicity, religion, disability, sexual orientation, education, socio-economic status or national origin.

Various initiatives have and still need to be put in place to support diversity in education. Some of these include means of affordability, which continues to be a key barrier to Internet access, particularly in low-income economies, as evidenced by the limited access that arose for some populations during the Covid-19 pandemic. Through means of affordability, broadband Internet/connectivity for everyone will mean that all schools and students can enjoy the benefits of digital education. However, educators need to be supported, trained in some specifics, to gain competencies and be reskilled to use digital technologies to deliver lessons and activities.

In terms of accommodating diversity, addressing challenges like affordability can positively affect women and girls in accessing information and communication technologies (ICT), for example. Advancements in programmes and policies that promote digital literacy amongst women and girls can transform education. In this respect, policies that help address a digital gender divide in education (especially the divide of access to technology), affordability of digital tools and means and digital skills development and training for both students and educators are key to sustaining relevant digital inclusive education for young people.

Further actions to address diversity in digital education include:

- Promoting an inclusive and equitable digital learning environment for all students.
- Integrating diverse perspectives into digital curricula and instruction.
- Creating a safe and supportive learning environment free from any form of discrimination and bullying.
- Utilising technology to bridge the digital divide and provide equitable access to quality digital education.
- Developing strong partnerships with families and communities to ensure student success.
- Offering professional development for educators to increase cultural competences of students.
- Implementing policies and practices that support diversity and address the digital (including gender) divides in education.
- The advancements of programmes and policies that promote digital literacy amongst women and girls to transform digital education.
- Broadband Internet/connectivity for everyone, so that all schools and students can enjoy the benefits of digital education.

Diversity in education prepares students for the increasingly diverse world they will encounter after graduation. It helps students develop cultural competences, empathy, and the ability to communicate effectively with people from different backgrounds in education.

Inclusion

The UN's Sustainable Development Goals (SDGs)[18] include a strong commitment to 'Leave No One Behind', with special focus on the most marginalised demographics and digitally excluded people. Of fundamental importance is ensuring that all students, regardless of their background, abilities, or circumstances, have equal access to and benefit from online learning opportunities. Inclusion in digital education is crucial because it can help eliminate barriers that might prevent some students from accessing or engaging with digital learning models.

Disability inclusion is crucial in digital education, to uphold human rights and sustainable development. According to UNESCO[19], in third world countries, almost 90% of the children with disabilities are outside the education system. Inclusive education is a challenge and an unfulfilled dream for those children and their families. Nations around the world face their own barriers to accessible and inclusive education, including socio-economic, cultural, physical, and legislative factors.

Inclusivity in education should seek to improve access to digital technologies that enhance the educational performance and outcomes of students. Plans and strategies to promote inclusion in digital education should explore how to incorporate:

- Accessibility: To ensure all students can have access to e-learning and online digital resources.
- Affordability: Digital learning devices should be affordable by all people.
- Usability: Learners must be supported and know how to use digital tools for the purposes of their own application and their own development.
- Increased access to digital resources for all students, including those with special needs and disabilities.
- Ensuring digital education is accessible to everyone regardless of location, financial status, or physical ability by using technology such as online learning platforms, virtual classrooms, and interactive learning tools.
- Enabling personalised learning experiences tailored to individual students and situations.
- Offering flexible learning schedules that can accommodate different learning approaches and needs.
- Promoting digital collaboration and communication between students and teachers.
- Encouraging self-directed learning and exploration to promote digital literacy and critical thinking skills.
- Providing a safe and secure digital learning environment, with all learners in mind, to ensure that all students have the opportunity to learn, grow, and succeed in the digital age.

Digital Divide

The digital divide refers to inequalities that arise due to the presence or absence of technology. It is the gap between individuals, households, businesses, and geographic areas of different socio-economical levels, with regard to both opportunities to access ICT and the use of the Internet in education. In digital education, it refers to the gap between students who have access to digital technologies for education and those who do not. This gap can negatively impact students' abilities to learn and succeed in education, as well as negatively impacting their access to future career prospects.

The digital divide can arise as a result of several factors, including socio-economic status, geographic location, and inadequate school funding. Students from low-income families or

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[18] United Nations Department of Economic and Social Affairs (n.d.). *The 17 Goals.* Accessible at: https://sdgs.un.org/goals

[19] United Nations Department of Economic and Social Affairs (n.d.). *Factsheet on Persons with Disabilities.* Accessible at: https://www.un.org/development/desa/disabilities/resources/factsheet-on-persons-with-disabilities.html#:~:text=Ninety%20per%20cent%20of%20children%20with%20disabilities%20in,developing%20countries%20do%20not%20attend%20school%2C%20says%20UNESCO

rural areas may not have access to the same digital resources as their peers from wealthier or urban areas, which can put them at a disadvantage when it comes to learning and accessing educational opportunities.

The extent of the digital divide was clearly highlighted during the Covid-19 pandemic, as many students were forced to transition to online learning when schools and universities closed. Some students could not continue learning during the lockdown due to lack of digital technologies.

To address the digital divide in youth education, it is important to provide equal access to digital technology and resources to all students, regardless of their background or location. This can be achieved through initiatives such as:

- Providing schools with funding for technology upgrades, offering low-cost or free broadband to students, and providing training and support for teachers to effectively integrate technology into teaching practices.
- Increasing global connectivity for developing and least-developed countries.
- Promoting digital literacy and providing digital education access to women and girls, migrants, rural and indigenous people.

It is also important to address the digital literacy skills of students, so that they can effectively use digital technology for learning and career advancement. This can be achieved through digital literacy programmes and curricula that show students how to use technology safely and effectively for educational purposes.

The under-represented

This term often refers to situations where certain groups of individuals, which could include women and girls, people of colour, rural communities, individuals living with disabilities, or those from low-income backgrounds and minority groups, may not be adequately supported through digital education in their school system. It is crucial to address these disparities in digital education to ensure that all students have equal opportunities to learn and succeed in the digital age. This can involve increasing access to technology and broadband, providing language support tools, increasing support for under-represented and minority students in digital learning environments, improving access and support for digital education for under-represented and minority students in rural and remote areas, and addressing systemic inequities that contribute to these disparities.

If the set of underlying issues outlined in this section are not addressed, under-representation in digital education will limit potential advancement and participation in society, in technology and in innovation.

Examples of methods national, regional or local organisations have used that have successfully addressed diversity, inclusion, or the digital divide to enable under-represented young people to continue to engage with digital education or digital employment

In Poland, the MultiAccess Centre has worked with education providers in supporting diversity and inclusion. There are new legal obligations in the European Union, and the public sector now needs to implement the Harmonised European Standard EN 301 549 Accessibility Requirements for ICT products and services[20], and the EU Directive (2016/2102)[21] (which aims to ensure that websites and mobile applications of public sector bodies are made more accessible on the basis of common accessibility requirements), W3C

[20] https://www.etsi.org/deliver/etsi_en/301500_301599/301549/03.02.01_60/en_301549v030201p.pdf
[21] https://eur-lex.europa.eu/eli/dir/2016/2102/oj

Recommendation Web Content Accessibility Guidelines (WCAG)[22] (and in the near future WCAG 2.2[23]), the European Accessibility Act[24], and Universal Design (Accessibility, Usability and Inclusion) promoted by the W3C Consortium[25]. Since 2015, the MultiAccess Centre has organised 'Days of Digital Accessibility' to promote the issue of inclusion and accessibility in a range of product sectors, e.g., computer games, digital documents, multimedia, educational materials, etc. The Centre has cooperated with a spectrum of non-profit organisations and institutions such as museums, theatres and galleries, also supporting those in other countries, including Canada, Germany, Belgium, and Austria to promote digital accessibility in the educational process. As a result of its successes in this field, the MultiAccess Centre took part in the large Polish project "E-school books for general education" in 2014-2015 and in 2022 as a certified accessibility expert, being responsible for implementation in books on biology, chemistry, geography, physics, security and first aid (all for primary and secondary education). In 2022, the MultiAccess Centre was responsible for designing and implementing multimedia on medical activities among students who had visual impairments.

In New Zealand, working with indigenous peoples to develop IT practices has carefully considered issues of language and questions of cultural appropriateness. Practices have involved non-digital computational thinking approaches as well as digital computational thinking approaches.

In Zimbabwe, support for underserved communities has focused on developing necessary infrastructure, but engagement has arisen through young people's innate inquisitiveness.

In Eswatini/Swaziland, some successful methods employed include implementing targeted outreach programmes that specifically cater to under-represented young people. These programmes aim to provide access to digital education and employment opportunities through initiatives such as scholarships, mentorship programmes, and partnerships with community organisations. Additionally, some organisations have focused on creating safe and inclusive spaces for under-represented individuals by fostering inclusive initiatives. These initiatives include events such as the Royal Eswatini Technology Park STEM Expo, which includes talks that also tackle issues such as the digital divide amongst youth in digital education and employment.

In Austria, the TU Wien Informatics eduLAB[26] runs about 100 workshops per year for school classes, across primary and secondary schools. Topics concern informatics presented in an appealing way, which is more game-like than 'traditional' learning. Inclusion is achieved, since whole school classes (boys and girls), and also schools with more underprivileged students, participate.

At the University of Education Weingarten, Germany, the development of a learning tool for training reading fluency has made it possible to handle diversity more effectively in school contexts by using digital media, resulting in possibilities for personalisation and individualisation. Effective reading fluency is essential for personal and professional life, so it is important that learners acquire this skill at school. However, primary school learners can have significant needs in school-language reading competence[27]. The percentage of fourth grade students (9-10-years-of-age) in Germany with reading difficulties increased from

[22] https://www.w3.org/TR/WCAG21/
[23] https://www.w3.org/TR/WCAG22/
[24] https://ec.europa.eu/social/main.jsp?catId=1202
[25] https://www.w3.org/WAI/fundamentals/accessibility-usability-inclusion/
[26] edulab.ifs.tuwien.ac.at
[27] OECD (2016). *PISA 2015: Ergebnisse im Fokus*. Accessible at: https://www.oecd.org/berlin/themen/pisa-studie/PISA_2015_Zusammenfassung.pdf

16.9% to 18.9% between 2001 and 2016[28]. One study found a continuing decline in reading competency between 2016 and 2021. This decline may be related to school closures and distance learning due to the Covid-19 pandemic[29], but, in addition, the heterogeneity of students is increasing, which can also be observed in the area of reading competence. Differences in the school context are also related to students with migration backgrounds; the reading competence of a student whose native language is not the national language is on average one school year behind that of their classmates[30]. A proven method to practice reading fluency is repeated reading aloud methods such as the Readers' Theatre. In this, students cooperatively practice reading dialogical texts, which are divided into different reading roles[31]. However, for intensive reading fluency training, students should also practice reading outside the classroom. But not every student has a reading partner outside the classroom, because parents may be working or have a low level of knowledge of the language. This problem can be solved through the use of an appropriate media-based learning tool that includes a digital reading partner and serves as a reading model. In addition, the media-based learning tool can allow students to train their reading fluency in an individualised and personalised way. This is possible by combining two different concepts in the tool. On the one hand, aspects of interactive storytelling are integrated to increase and maintain learning motivation, and on the other hand, aspects of adaptive learning are integrated for (partially) automated, individualised and personalised training. Through these two approaches, the student can influence the story of the learning tool and decide how the story will continue. In addition, the future learning content is dynamically adapted to the student's performance and the student receives direct feedback. For example, a student who solved a quiz task effectively will receive a different task from the system than that from a student who did not solve a quiz task so well. The tool was prototypically implemented and tested with students. The target group of the application was third grade students (8-9-years-of-age) with specific needs in school reading fluency. A qualitative evaluation of the prototype with 15 primary school students showed that the combination of the two approaches was feasible and the students accepted it. The aspects of interactive storytelling motivated students to learn and they enjoyed learning with it. In addition, students indicated their willingness to use the learning tool for individualised and personalised reading fluency training in the future. Further evaluations are planned.

In the United Kingdom, computing as a school subject has been within the statutory National Curriculum[32] since 2014. The British Computer Society has been an instrumental body in supporting the education of teachers since that time and has undertaken extensive workshop and school onsite activities to encourage practice that supports diversity. In 2023, a major shift in the numbers of girls taking computing subjects, and in gaining admission to universities to undertake computing degrees, was noted. As the BCS reported[33]: "More young women than ever before will start computing degrees this September, amid the rising profile of AI, according to figures released today. Computing degrees have seen an 11%

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[28] BMBF (Bundesministerium für Bildung und Forschung). (2017). *Stabile Ergebnisse bei zunehmenden Herausforderungen – Lesen muss gestärkt werden*. Accessible at: https://www.bmbf.de/de/stabile-ergebnisse-bei-zunehmenden-herausforderungen---lesen-muss-gestaerkt-werden-5232.html

[29] Ludewig, U., Kleinkorres, R., Schaufelberger, R., Schlitter, T., Lorenz, R., König, C., Frey, A. & McElvany, N. (2022). *COVID-19 Pandemic and Student Reading Achievement – Findings from a School Panel Study*. Accessible at: https://psyarxiv.com/hrzae/

[30] Krauß, B. (2017). *Iglu-Studie belegt Defizite: Vom Lesen hängt der ganze Schulerfolg ab*. Accessible at: https://www.stuttgarter-zeitung.de/inhalt.iglu-studie-belegt-defizite-vom-lesen-haengt-der-ganze-schulerfolg-ab.72eacc8d-f8c5-49a4-bca8-45598ad317fa.html

[31] Nix, D. (2006). Das Lesetheater. Integrative Leseförderung durch das szenische Vorlesen literarischer Texte. *Praxis Deutsch, 33*(199), 23–29.

[32] https://www.gov.uk/government/publications/national-curriculum-in-england-computing-programmes-of-study/national-curriculum-in-england-computing-programmes-of-study

[33] https://www.bcs.org/articles-opinion-and-research/record-numbers-of-women-will-start-computing-degrees-this-year-new-figures-show/

growth in the numbers of 18 year old UK women due to start at university, compared to last year… The total number taking Computing A level have also risen by almost 17% this year, rising from 15,693 to 18,306 according to figures released today by the Joint Qualifications Council (JCQ). This is the second highest rate of growth for any subject and the third largest increase in overall candidates. In England, the number of female candidates for computing A level has grown by 92% since 2019, and males by 62%, according to data from Ofqual also released today. In Wales, female entries for A-level Computer Science rose by over 30% year-on-year, comprising almost all of the growth in uptake of computing this year (WJEC data). In Northern Ireland, over 800 candidates took A levels in Software Systems Development and Digital Technology, with almost half of the entrants for the latter being female (CCEA data)."

However, this outcome, according to Kemp, Wong, Hamer and Copsey-Blake, needs to be considered in a longer-term context. In their study[34], it was shown that "In 2023, girls constituted only 21% of the GCSE Computer Science cohort, compared to 43% in 2015 in the previous ICT GCSE".

At an international level, the Bebras Challenge[35] is provided for all school learners; therefore, inclusion is important and the implementation of Bebras has been shown to be successful in this respect. The Bebras Challenge motivates learners to think computationally; therefore, it supports successful computational thinking. Worldwide, the Bebras Challenge involves more than 3,000,000 students per year; in Austria, in 2022, there were more than 40,000 involved. The tasks are all published and are used by teachers in schools.

In Bulgaria, activities for students involve all, irrespective of gender. This may well be one of the reasons why Bulgaria has the highest percentage in Europe of women involved in the IT sector (31.5% for 2022). Teachers offer additional hours for individual consultations for students who may have some specific needs. For the inclusive education of students, SEN teachers develop individual plans for working with the students with SEN.

Schooling up to the age of 16 years is compulsory for everyone and there is gender equality throughout education, especially in STEM education. Observations have shown that, in the early school years, girls gain higher results in mathematics than boys, but later, in secondary school, boys are better at this subject. At the university level, the enrolment depends on choice, but usually in mathematics and IT there are more boys than girls who participate, in the region of a maximum ratio of 2:1. Girls' enrolment is high by comparison to other countries across Europe, and mandatory IT education for all has been identified as an important factor in this success. "More than 1.3 million people were studying Information and Communication Technologies (ICT) in the European Union (EU) in 2018. Overall, considering upper secondary and tertiary education, girls and women were still under-represented in this field, accounting for only 17% of all ICT students in the EU. Among the EU Member States, Belgium stood out as 37% of the ICT students in Belgium were female in 2018. The share of female ICT students were close to one third also in Romania (32%), Bulgaria (31%), Greece and Sweden (both 30%). In contrast, female students accounted for less than 10% in the Netherlands (8%) and Luxembourg (9%)."[36]

[34] Kemp. P., Wong, B., Hamer, J. & Copsey-Blake, M. (2024). The Future of Computing Education: Considerations for Policy, Curriculum and Practice. King's College London and University of Reading. https://www.kcl.ac.uk/ecs/assets/kcl-scari-computing.pdf

[35] www.bebras.org

[36] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/EDN-20200423-1

Examples of methods national, regional or local organisations have used that have failed to address diversity, inclusion, or the digital divide to enable under-represented young people to continue to engage with digital education or digital employment

In Poland, generally, there are conferences, festivals or workshops to promote the idea of inclusion and diversity. However, they are organised by the same centres or non-profit organisations, which limits the potential for wider awareness throughout the country.

In Eswatini/Swaziland, due to market limitations, some organisations have not been able to address the digital divide by providing access to reasonably priced Internet or technology devices and services. This is made worse by the widespread practice of focusing digital education programmes primarily on larger cities, where there is greater availability of Internet-connected devices. As a result, under-represented young people in rural or remote areas often face significant barriers in accessing digital education or employment opportunities. These young people from local high schools have even failed to attend the Royal Eswatini Technology Park STEM Expo to talk about the issues failing their engagement with digital education.

6. Factor 3: Computational thinking and its links to problem-solving

Computational thinking and computing should be included within the curricula for young people, ensuring that activities support longer-term engagement and inspiration.

In a broad sense, and from an historical perspective, computing is an area of knowledge from which popular and effective digital technologies (such as standalone computers and video recorders) emerged long before a solid, specific, scientific methodology, let alone formal foundations, had been put forward. On the one hand, this might explain some of the weaknesses in the software industry, as well as, on the other hand, an excessively technology-oriented view which might unfortunately dominate some computer science education at pre-university and even undergraduate teaching.

In terms of approaches to thinking, modelling, understood as the ability to choose the right abstractions for a problem domain, is consensually recognised as essential for the development of true engineering skills in this area, as it is in all other engineering disciplines. But should not the basic problem-solving strategy that can arise from learning in school physics - *understand the problem, build a mathematical model, reason within the model, calculate a solution* - be adopted (and taught) as the standard in computer science education?

It is worth considering the current situation in relation to this proposition. Digitalisation is sometimes used as a ‘magic word’, to describe the digital applications underlying vibrant, computerised societies in an era of intense and progressive dematerialisation of activities, from social to industrial. The rise of *everyware*, an expression capturing the fact that digital devices are increasingly part of our personal ecosystem, is leading not only to flexible production schemes, customisation of products and highly competitive markets operating via digital platforms, but also to a huge amount of data, as well as new ways of living, and more heterogenous societies. The speed of this unprecedented transformation is due to an exponential increase in computing power, but also to the development of software as a vehicle for orchestrating a myriad of interconnected devices to engineer complex systems.

As E. W. Dijkstra[37] put it several decades ago, the underlying driving force of what is now called the digital transformation is essentially a “*mathematical technology*”. Much beyond the mere use of specific devices or languages, computational literacy, broadly understood as the ability to reason in terms of abstract models and the effective use of logical arguments and algorithmic reasoning in normal, daily business practice, is increasingly in demand. Actually, this concerns not only highly skilled IT professionals, but everyone (age-appropriately, for learners of all ages, from early years onwards) who, surrounded by increasingly ubiquitous and interacting computing devices, has an unprecedented computational power at their fingertips to turn on effective power and self-control of their own life and work.

This is why *computational thinking* (as outline and discussed by Jeanette Wing[38], for example) has become a fundamental skill for everyone. It denotes a specific way to

[37] Dijkstra, E.W. (1973). *Programming as a discipline of mathematical nature.* Accessible at: https://www.cs.utexas.edu/~EWD/transcriptions/EWD03xx/EWD361.html

[38] https://eur02.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.ifipnews.org%2Fwomen-take-the-spotlight-at-the-ifip-world-computer-congress-2015%2F&data=05%7C01%7Cpassey%40live.lancs.ac.uk%7C33a9d60afb6942bf15fc08dbba84dac3%7C9c9bcd11977a4e9ca9a0bc734090164a%7C0%7C0%7C638308851983818092%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C3000%7C%7C%7C&sdata=Y%2F6Y%2Fqc%2FRwe7j4yX1rm0o5YzJ%2BRLXJLGRP2oGo7YtAE%3D&reserved=0

approach problem-solving, and does not suppose proficiency in particular machines, programming languages or systems. It:

- uses abstraction and separation of concerns to attack a large complex problem;
- models the relevant aspects of a problem to make it tractable;
- calculates (i.e., derives, rather than guessing) solutions, for example, algorithms or programs;
- resorts to computer science conceptual tools, like reduction, recursion, type-checking, modular decomposition, simulation, invariance, transformation between different levels of abstraction, etc., as key enablers in problem-solving.

In the context of computational thinking, abstraction in particular, is a fundamental issue. As put by E. W. Dijkstra[39], "*The purpose of abstracting is not to be vague, but to create a new semantic level in which one can be absolutely precise*".

Informatics or computer science in this respect can be regarded as a formal study of computation, inquiring on what can be computed, or not, and how to compute it. It is a mathematical, highly conceptual discipline, which goes far beyond computer construction or programming: "*No more about computers than astronomy is about telescopes*", to quote Dijkstra[40] again. In fact, we are beginning to collect the fruits of more than five decades of intensive, even if sometimes neglected, basic research on the foundations of computation and programming semantics, upon which a true engineering discipline for software design can be based. Such research helped, in particular, to shed light on the underlying mathematical structures and reasoning principles, and to establish the connection between mathematics and computing at a foundational, rather than applicational (as, for example, in numerical analysis) level[41].

Educating *everyone* to think computationally could be achieved through establishing informatics or computer science as a rigorous, fundamental, and independent domain of knowledge (whether through uses of digital technologies across the wider school curriculum or through a single computer science subject). That is, to create a pedagogical corpus for teaching computational thinking or computing as a core subject alongside other basic disciplines. However, the role of unplugged activities should not be under-estimated, not only as a low-cost solution, but also as a means to complement digital activities[42].

Computing initiation can and should start from the first years of education, without the need for large resources in equipment. A concept-first approach is essential to the development of computational thinking: understanding computation is much more important than mastering the technology. As we all know very well in computing, technologies quickly fade away, but concepts remain. Paper, pencil, and… grey matter are all one needs to start, as the successes of numerous projects worldwide[43] witness. We need to take account also of those

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[39] Dijkstra, E.W. (1973). *The humble programmer.* Accessible at: https://www.cs.utexas.edu/~EWD/transcriptions/EWD03xx/EWD340.html

[40] IEEE (n.d.). *Edsger Dijkstra: Award Recipient*. Accessible at: https://www.computer.org/profiles/edsger-dijkstra

[41] The emphasis on the central role of formal logic, not only in foundations, but also in applied mathematics and as part of any basic education curriculum, is perhaps the main consequence to mathematics of computing science development.

[42] Chen, P., Yang, D., Metwally, A.H.S. et al. (2023). Fostering computational thinking through unplugged activities: A systematic literature review and meta-analysis. International Journal of STEM Education, 10, 47. https://doi.org/10.1186/s40594-023-00434-7

[43] For example, www.computingatschool.org.uk (UK), www.facebook.com/ensico.pt (Portugal), and www.csunplugged.org (New Zealand).

sometimes-ambitious initiatives that have not led to success, such as Elon Musk's AdAstra school[44].

Computational thinking generates immediate synergies with two other core disciplines: *mother tongue*, because whatever fails to be articulated through language cannot be shared; and *mathematics*, the domain of knowledge that best expresses and manipulates abstract and dematerialised information. As discussed in the ENSICO initiative[45], perhaps a new instance of the classical *trivium* is emerging: *grammar* (i.e., the linguistic ability) represented by the study of the mother tongue; *logic* (i.e., the reasoning ability), by that of mathematics; and *rhetoric* (the communication ability), by computer science. Indeed, if interpersonal communication requires mastery of written and spoken language, communication with the machine requires mastery of *computational thinking*, which presupposes a clear domain of logic, the ability to abstract from complex real-life situations and organise information in simple models that computers understand.

Teaching how to think computationally can therefore become a vehicle for equity and promotion of scientific and technological literacy. It also shows potential for stimulating creativity and learning in a multidisciplinary way, as well as for developing oral and written communication skills, and the mastery of mathematical arguments. Introducing computer science early in the curriculum (either through a multi-disciplinary approach or through a single subject) would entail a reinforced familiarity with concepts, such as abstraction, decomposition, pattern recognition and algorithms, which facilitate the development of reasoning skills. Applied to the resolution of problems, the latter will enable students to face progressively more complex challenges, and to understand what drives the digital transformation.

Every citizen has the right to know the principles and the advantages, but also the risks taken in using technology and the duty to use it responsibly. This is why this debate has also a clear *citizenship* dimension.

Examples of methods national, regional or local organisations have used that have successfully implemented computational thinking and its links to problem-solving for young people to engage with digital education or digital employment

The Bebras international initiative offers concise, thought-provoking problems (named as Bebras tasks) to stimulate computational thinking. These challenges encourage learners to unravel complex puzzles, hone their logical reasoning, and foster algorithmic creativity. By solving these succinct tasks, learners develop essential skills of problem-solving and engage in innovation in the digital age.

In Lithuania, there is a long history of teaching computer science (informatics) in grades 5 to 12 (aged 12-19 years)[46]. The new general curricula of Lithuanian were approved on 30th

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[44] Hollier, S. (2022). Elon Musk Created A Private School For His Kids; Now, It's Been Shut Down. Accessible at: https://eur02.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.thethings.com%2Felon-musk-created-private-school-shut-down%2F&data=05%7C01%7Cpassey%40live.lancs.ac.uk%7C81cc4f0e0bd54a5ad03d08db8d9f75d4%7C9c9bcd11977a4e9ca9a0bc734090164a%7C0%7C0%7C638259488400194946%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C3000%7C%7C%7C&sdata=k0cvLTn%2BC%2BmOvoG0qtKGA2cmxdXShX6smRS6Zs%2BOxms%3D&reserved=0

[45] Founded in 2019, ENSICO (www.ensico.pt) is a Portuguese non-governmental, non-profit organisation for Teaching Computing at School.

[46] Dagienė, V., Laanpere, M., & Borzovs, J. (2023). Computing Education Research in Baltic Countries. In: Apiola, M., López-Pernas, S., & Saqr, M. (eds.). *Past, Present and Future of Computing Education Research*. Springer. https://doi.org/10.1007/978-3-031-25336-2_14

September 2022, and informatics education is included in all grades from primary education through to upper secondary education[47]. An important agreement was reached between teachers, policy makers and other educators to teach computer science (CS) from primary education, the 1st grade. It was agreed that:

- CS education in primary school (grades 1 to 4) would be integrated with other subjects, mainly mathematics and languages.
- CS in middle school (grades 5 to 10) would be compulsory with an allocated time of 1-hour per week.
- CS in high school (grades 11-12) would be an optional subject with a minimum of 3-hours per week.

The main objectives of the updated CS curriculum were to teach computational thinking and to develop digital competence. There are 6 stated areas of students' achievements: 1) digital content, 2) algorithms and programming, 3) data mining and information, 4) technological problem-solving, 5) virtual communication and collaboration, and 6) security and safe behaviour.

In Bulgaria, IT is a compulsory subject in school. Teaching continues through to the 10th grade, and every year knowledge is upgraded, and recent applications are introduced.

Informatics education in Bulgarian schools has a long history[48]. It started at the end of the 1960s in mathematics gymnasiums. From 1986-1987, informatics was introduced as an obligatory course in all schools, in the year 2000 it was introduced as a subject of information technology for upper secondary schools, from 2006-2007 the subject information technology was started as an obligatory subject for lower secondary schools (from the 5th grade – 11-12-years-of-age), and from 2008-2019 the subject computer modelling was launched in primary schools in the 3rd and 4th grades (9-11-years of age). From 2021, the subject computer modelling and IT was proposed for students in lower secondary schools with extensions of topics related to programming in block-based environments and script text-based programming languages (Python, JavaScript, etc.). However, it is still too early to draw any conclusions about the involving of text-based programming languages from the 6th grade, whether successful or not.

For some students, there is specialisation in upper secondary schools from the 8th grade through an obligatory course "Informatics", which is directed to the introduction of programming. The specialised subjects "Informatics" and "Information technologies" in high schools (11th–12th grades – 16-18-years-of-age) attract students to digital technologies and future professions. Informatics and IT are usually offered by the mathematics and natural sciences gymnasiums, but specialisation in IT is offered by a wide number of schools, because it is possible to combine an IT specialisation with natural sciences, entrepreneurship, art and music, and languages. In fact, schools that include information technology or informatics in their school plans are more attractive for the students. Also, vocational education offers areas of programming, such as applied programmer.

The school curricula in informatics subjects are directed to the development of all key competences and establishment of cross-curricular relationships. Most textbooks contain a set of different tasks which require implementation of knowledge and skills from informatics in other subjects. The curricula are focused on project-based learning and from the 3rd

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[47] The updated K-12 curricula with informatics as an attachment (N21) can be accessed at: https://www.e-tar.lt/portal/legalAct.html?documentId=06c1f24040b711edbc04912defe897d1

[48] Tuparov, G., Tuparova, D. (2023). The Ecosystem of Computer Science Education in Bulgarian Primary School – State of the Art. In: Zlateva, T., Tuparov, G. (eds) Computer Science and Education in Computer Science. CSECS 2023. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 514. Springer, Cham. https://doi.org/10.1007/978-3-031-44668-9_26

grade, propaedeutics of an IT project are developed. In the 7th grade (13-14-years-of-age), phases of an IT project development are involved and used in the next grades.

Parents show great interest in informatics education. Therefore, some IT companies and private educational institutions start to offer courses in programming, robotics and STEM for students at all educational levels – from primary to high school.

In Portugal, the ENSICO Association was formed in 2018 to alert Portuguese society to the importance of widespread access to quality education in computing, through which children and young people could learn and exercise what will become a vital capacity, to act in the digital world in which many experiences and cultures are built.

A wide range of pilot projects have been conducted in a number of schools, promoting the teaching of computing for all primary and secondary school students through a comprehensive syllabus, with goals across the 12 years of compulsory schooling in Portugal. The curriculum emphasises an approach to problem-solving based on the mental tools of a computer scientist (e.g., abstraction, separation of concerns, logical reasoning, type discipline, recursion, mathematics of programming), rather than proficiency in particular technologies, programming languages or systems.

In Austria, media and informatics education has been introduced into all schools, which is mandatory for all learners across grades 5-8 from 2022. Many teachers have been supported, and in the future, grade 9 classes will have more emphasis on informatics. However, there is still no CT or informatics education in grades 1-4.

In Eswatini/Swaziland, one successful method employed by national organisations is the establishment of coding boot camps and workshops that specifically target all youth, including under-represented individuals in both urban and rural areas. These programmes, such as the Eswatini Coding School, provide hands-on training in computational thinking and problem-solving skills, equipping young people with the necessary tools to excel in digital education or employment. Additionally, regional and local organisations have collaborated with schools and community centres to integrate computational thinking into their curricula, ensuring that all young people have access to digital education regardless of their location.

In terms of inclusivity with computing education, there have been some projects in Poland to promote digital inclusion in digital education, e.g., “Enter lesson”. However, this project has generally been connected with ICT, but it would be difficult to find elements referring to accessibility. The National Digital Committee (NDC) sent a short manifest (in July 2023) to the Ministry of Education. The members of the NDC underlined the new system of implementing accessibility in the school curricula.

Examples of methods national, regional or local organisations have used that have failed to implement computational thinking and its links to problem-solving for young people to engage with digital education or digital employment

In Bulgaria, it is found that the complexity of the learning content, abstraction of the concepts, and disparity between concepts in computer science subject curricula and concepts in other subjects leads to some problems in the implementation of the informatics curricula, depending on students’ ages. In terms of specific areas of content of computer science education, spreadsheets have been recognised as a problem area found in teaching in schools, for example, and teachers have been found to miss the teaching of this topic from the curriculum.

In Eswatini/Swaziland, the lack of funding and resources provided by national organisations is one example of failure by local organisations in this regard. Without sufficient financial support, schools and community centres continue to struggle to offer comprehensive digital education programmes. This is because most initiatives that tackle this issue focus more on the start-up finances, without regard for any further maintenance that may be required in the future. Additionally, the lack of appropriate training and professional development for educators further hinders the effectiveness of digital education programmes. Without adequate support and guidance, teachers may struggle to effectively integrate technology into their teaching methods, limiting the impact of digital education on students' learning outcomes.

Considering inclusivity when implementing computer science, in Poland, it has been found that there are very few professional trainers/educators who can conduct classes in accessibility in digital education. To address this, the idea of implementing accessibility could be based on training accessibility educators. Since 2019, there are generally projects or postgraduate studies for accessibility coordinators, but they are only trained to support accessibility in architecture, communication and digital environments in the municipal halls or in the public sector. Thus, it is only based on legal requirements.

7. Factor 4: Developing teacher practices

If young people are to sustain their engagement with digital education, then teachers must be supported effectively in maintaining appropriate and up-to-date ways to implement activities and understanding, within and across the curriculum.

Introduction
Technology is a rapidly changing field, and it is essential for teachers to maintain their relevance by keeping up to date with innovative pedagogies. From the IFIP Task Force's initial consultation, responses identified key features to support teachers, including suggestions for lessons, tools to use, science, technology, engineering and mathematics (STEM) promotion, and kits.

Background
Teachers of technology (which can include all teachers due to the width of uses of digital technologies) need to be supported in terms of both established and new resources. The need to maintain relevance in a rapidly changing discipline is critical. Teachers are becoming increasingly aware of the need for inclusive practice, to ensure that a diverse range of students is inspired to pursue further studies and careers in ICT. Additionally, the challenges of online teaching of ICT and reducing reliance on face-to-face classes are emerging.

Key features
The IFIP Task Force requested examples of effective teaching of digital education and ICT by engaging with digital education and ICT teaching partner organisations in their countries. Responses to the activity were categorised into five major key features:

- Support
- Lessons
- Tools
- STEM promotion
- Kits

Support
Most responses received by the IFIP Task Force described methods of supporting teachers. This support included practices that allow for collaboration, networking, mentoring, training, and professional development. Many respondents highlighted the importance of providing opportunities for teachers to learn and develop new skills through workshops, conferences, and training programmes. For example, the South Africa Department of Basic Education's Professional Development Framework for Digital Learning was mentioned as an initiative that can empower teachers to use digital resources in their teaching practices.

Collaboration was another example of support identified. Programmes like the Australian Computer Society (ACS) ICT Educators offer community networking opportunities for teachers to connect with others in their field and to learn from each other. Responses have also highlighted the importance of teacher mentoring and coaching.

Resources highlighted in responses were:

- Google Classroom for Teachers[49], which provides an easy-to-use platform for connecting teachers and students in and out of the classroom.
- CSIRO STEM in Schools Professionals[50], which offers mentoring programmes to schools throughout Australia.

[49] https://www.youtube.com/watch?v=u-8nJj1EXhw
[50] https://www.csiro.au/en/education/programs/stem-professionals-in-schools

- CSIRO Generation STEM[51], which provides resources and support for STEM education, including lesson plans and activities for teachers.

Lessons

The second key feature was lessons, which included lesson plans, activities, examples, online training, and curricula. Teachers can use example resources to develop their own lesson plans, or use them exactly as provided. However, publishing lesson plans widely can be a step to standardising the teaching of ICT.

Resources highlighted in responses were:

- ACS ICT Educators[52], a website that provides lesson plans, professional learning resources, and other teaching materials for teachers using ICT. There is also a YouTube channel with informative videos about teaching ICT.
- Digital Learning and Teaching Victoria (DLTV)[53], a professional association for teachers and educators in Victoria, Australia. They provide a wide range of resources for teaching digital technologies, including lesson plans, professional learning opportunities, and events.
- Digital Technologies Hub[54], a national resource portal for teachers and students in Australia. It provides a range of resources for teaching digital technologies, including lesson plans, case studies, and other teaching materials.
- Grok Learning[55], a website providing online coding and technology courses for students, teachers, and parents. It offers a variety of courses, including a course on quantum computing, with resources such as lesson plans, activities, and assessments.

Tools

The third key feature was tools, which included software and games, excluding lesson plans. Responses indicated that using technology tools in teaching widely and in teaching ICT specifically can make it more engaging and interactive for students.

STEM promotion

The fourth key feature was STEM promotion. All teachers using ICT are charged with promoting STEM and uses of digital technologies. They do this through promoting technology as a career, promoting women in IT, through school programmes, and internships.

Resources highlighted in responses were:

- ACS Queensland Gateway to Industry Schools Program[56], which connects students with industry professionals and provides them with valuable career guidance.
- STEM Career Wheel[57], which offers guidance on careers in STEM and related fields.
- Internships[58], which provides students with internship opportunities to gain real-world experience in technology and related fields.
- Women of STEM Scholarships[59], which provides scholarships for women pursuing careers in STEM fields.

[51] https://bit.ly/40u3I8y
[52] https://www.acs.org.au/ict-educators.html; https://www.youtube.com/watch?v=yIn7PomdDTY
[53] https://dltv.vic.edu.au/teaching-digitech
[54] https://www.digitaltechnologieshub.edu.au/
[55] https://groklearning.com/; https://groklearning.com/course/quantum-computing/
[56] https://qldictgisp.acs.org.au/
[57] https://www.careersfoundation.com.au/
[58] https://www.acsfoundation.com.au/internships
[59] https://www.womenofstem.com.au/

Kits
The fifth key feature was kits, which included robots and electronics, with supporting lesson plans. Teachers are able to use these kits to provide hands-on learning experiences for their students.

Resources highlighted in responses were:

- Digital Technologies Institute[60], which offers kits, lesson plans, and downloadable instructions for teaching various topics in technology, including cybersecurity and artificial intelligence.
- Ozobot[61], which is a product that uses robots to teach children the basics of coding in a fun and engaging way.

Examples of methods national, regional or local organisations have used that have successfully supported the development of teacher practices to enable young people to engage with digital education or digital employment

In Bulgaria, many support sessions are organised for teachers, to address any digital education gaps. Digital content platforms have also been developed, both nationally and by individual publishers.

A lot of short-term in-service teacher training courses, with possibilities to obtain professional development credits, are run. The courses are organised by the universities with accredited specialities in areas of teaching of informatics and ICT or by IT companies, NGOs, private educational institutions, and textbook publishers with approved qualification programmes.

Two Facebook groups of teachers in informatics and teachers in computer modelling have been established, which provide peer support for the teachers.

The textbook publishers also provide teachers with special methodological guides – a teacher's book with precise explanations of lessons and suitable activities to achieve learning outcomes. Some publishers develop video lessons that help teachers.

In Greece, increased co-operation between teachers and parents via emails, and teacher willingness for further ICT support and training has been successful in developing digital education in kindergartens/preschool (for children aged 4-6 years) and in elementary schools (ages 6-12 years). In secondary school (ages 12-18 years), teacher willingness for further ICT support and training, raising teacher awareness of a variety of digital tools, and increased group work with utilisation of digital tools have all been seen to be successful.

In Germany, a large-scale project, "lernen:digital"[62] has been launched, which works through a collection of centres to support digitally-focused teaching and learning. There are four centres (for STEM, language and society, arts, and school development), each of which comprises several sub-projects, bringing together researchers and practitioners from different universities. The key focus is teacher education, and the structure is designed to overcome aspects of the digital divide.

In Poland, on 1st July 2022, the MultiAccess Centre started a project to implement a new professional qualification in the field of the European Qualifications Framework (EQF)[63]. Since 30th March 2023, it has been reviewed and judged by the Ministry of Digitization in Poland.

[60] https://www.digital-technologies.institute/
[61] https://ozobot.com/
[62] https://lernen.digital/
[63] https://en.wikipedia.org/wiki/European_Qualifications_Framework#Structure

In Eswatini/Swaziland, there is provision of training sessions, workshops, or online courses that equip teachers with the necessary skills and knowledge to effectively integrate digital tools and resources into their teaching practices. Government organisations such as the Ministry of Education have sponsored such initiatives; additionally, organisations such as the University of Eswatini have started providing Certificates in Online Teaching for Educators, which have been well-received by teachers and have resulted in improved digital education practices.

Examples of methods national, regional or local organisations have used that have failed to support the development of teacher practices to enable young people to engage with digital education or digital employment

In Greece, it has been seen that in some kindergartens/preschool (for children aged 4-6 years) and in some elementary schools (ages 6-12 years) initiatives including working with teacher groups to address the digital divide have not continued after the end of the Covid-19 pandemic. In secondary schools (ages 12-18 years), tablets (or laptops) provided to schools during the Covid-19 pandemic have not always been utilised afterwards.

In Bulgaria, fear of technology by some teachers/educators is still an obstacle. The changes in school curricula are very dynamic, happening often, and some teachers are not prepared to implement new changes in, and challenges associated with, the curricula, even though there are short-term courses organised for teachers in informatics and ICT. Usually, the courses are provided by the Ministry of Education during the summer, before new learning content in the schools is implemented. In some cases, some courses have been provided in parallel, during the school year in which new content is involved.

In Eswatini/Swaziland, many organisations have not prioritised providing teachers with the necessary skills and knowledge to effectively integrate digital tools into their teaching. This has hindered their ability to effectively engage students in digital learning experiences. Additionally, limited access to technology and Internet connectivity in certain regions or schools has also posed a significant challenge for teachers, preventing them from fully embracing the culture of digital education and employment.

8. Factor 5: Short- and long-term plans and actions

Sustaining digital education for young people requires long-term systemic actions and planning, as well as short-term actions and plans; history informs us that continuous support and involvement is essential.

Considering past experiences of developing education through and for IT and digital technologies, and the past history of the development of IT and digital technologies, it is clear that long-term plans and strategies are needed if we are to develop sustainable digital education effectively. As a part of these long-term plans, we should avoid relying upon projects that last for a limited period of time, when there is no continuity strategy or planning beyond pilot or project phases (as discussed in Passey et al., 2016)[64]. Importantly, it is well recognised that sustainability requires stakeholders' voices to be known and considered; taking account of teachers', young people's, parents', guardians' and carers' views and voices can be crucial to long-term success.

Accommodating changes to digital technologies and to the education of digital technologies in a sustainable way requires vital, systemic change. A systemic approach needs to consider who is involved and how they will be involved, and this requires a gathering of detailed information, to support effective and long- and short-term strategy and planning. The strategy and planning should also consider enabling evolutionary rather than transformational approaches, as evolutionary approaches work from the status quo, developing from the position that exists, rather than confronting individuals with an unexpected and uncertain future. For example, a draft Policy for Digital Transformation of Education in Sri Lanka was developed over a 2-year period, involving many public consultations, leading to policy formation that addresses many of the five key factors highlighted in this report[65].

However, this does not mean that digital education should not be a mandatory and an integrated element of at least K9-K12 education (and indeed some nations, such as England in the United Kingdom (UK), have integrated digital education or computing education in their curricula for children from 5 years of age[66]). It is also recognised that from early ages there should always be a focus on inclusion (including gender and special needs). Indeed, it has been noted that some young people can become proficient in digital skills, while in other subject areas they might not have gained similar successes. Fully understanding why this is important and how this is being approached are two key questions that have not been researched and identified widely at this time. To share the benefits of digital education from those who have advanced in this respect with nations at earlier stages means that policy interventions may offer potential for reaping positive outcomes of technology advancements, supporting sustainable inclusive education for all.

Ensuring schools have infrastructures to support learning is clearly vitally important; and indeed, this is often considered the most urgent action for any nation developing and narrowing a digital gap/digital divide. Indeed, the importance of underpinning infrastructure in

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[64] Passey, D., Laferrière, T., Ahmad, M. Y. A., Bhowmik, M., Gross, D., Price, J., Resta, P., & Shonfeld, M. (2016). Educational Digital Technologies in Developing Countries Challenge Third Party Providers. *Educational Technology & Society, 19*(3), 121-133. Accessible at: http://www.ifets.info/journals/19_3/12.pdf

[65] Ministry of Education and ICTA (2022). *Policy for Digital Transformation of Education*. Ministry of Education and ICTA: Sri Lanka.

[66] Department for Education (2013). *National curriculum in England: computing programmes of study*. Accessible at: https://www.gov.uk/government/publications/national-curriculum-in-england-computing-programmes-of-study

supporting a more inclusive accessibility is often recognised in reports and research articles (for example, this report[67] that considers digital technology development in Northern Ireland).

But when school education is considered in this respect, it is also important to recognise that schools are themselves systems, and that all stakeholders and players in those systems need to be informed, to be aware, and to be involved when change is being implemented. It is important, therefore, to consider the importance of parents, governors or school board views, and how these can affect aspiration. In this context, making IT more human(e) is likely to be important, as IT is often seen as 'hard' or a 'hard technology subject'. It is necessary to address perceptions of the digital versus IT; the soft versus the hard; the intelligent versus those who have unfortunately been termed 'the nerd'. Affecting aspiration and engaging the wider population will be important in effectively sustaining digital education. In addressing this, could IFIP with its partner organisations and all stakeholders consider creating a "Hall of Fame" that celebrates "difference makers" from all backgrounds as diverse as possible? These role models could be profiled, perhaps on an IFIP website, using videos to interview each member of the "Hall". It would be possible to engage students, perhaps through mechanisms that could include voting on the nominees, with categories for nominations including "sustainability", healthcare and justice, for example. In this context, since technology is a critically important element in all businesses in all industries, showing what career paths are available across multiple industries would be helpful for all stakeholders. At the same time, it will be important to consider how to agree to use the same language and terminologies worldwide, so that we can generate necessary understanding to the fullest extents.

When considering short- and long-term actions and planning, there are some key questions to consider:

- Are there more girls entering the 'digital field' in some countries than in others? And if so, why is this the case?
- Are there examples of successfully implemented long-term plans and actions to sustain digital education for young people?
    - Across a 30-year or longer endeavour?
    - Initially focusing on infrastructure?
    - Building the 'digital' in relation to industry, such as creative industries?
    - Linking the relationships of industry to the curriculum?
    - Providing ongoing guidance; supporting schools in change and development?
    - Supporting continuous innovation and monitoring?
    - Sharing and working across the system?

Examples of methods national, regional or local organisations have used that have successfully developed and implemented short- and long-term plans and actions that have enabled young people to engage with digital education or digital employment

Lithuania has a long history of teaching computer science (informatics) in grades 5 to 12 (for children aged 12-19 years). From its longstanding foundation, there is a newly established curriculum. For the short-term, the plan is to develop more interesting learning resources with open access and localised to Lithuanian learners. At the same time, there is a need to train more computer science teachers, and better education online platforms are needed. A collaboration with Turku University, Finland, has been established, to adapt their ViLLE platform for teaching CT in grades 1 to 7. For the long-term, there are plans to collaborate

[67] Passey, D., Taggart, S., Anderson, J. & Campbell, A. (2023). *Inspiring Digital Learning: a synthesis of research related to digital learning in Northern Ireland's schools: Briefing Report for the Department of Education Independent Education Review*. Accessible at: https://www.independentreviewofeducation.org.uk/key-documents/inspiring-digital-learning-synthesis-research-related-digital-technologies-northern

more with IT companies, and to develop more learning resources for CT and learning analytics-based learning platforms.

In Bulgaria, from 2018, there has been a national strategy for the introduction of ICT in Bulgarian schools[68]. From this strategy, the various national programmes have been developed. National educational requirements have been developed with the help of experts and teachers. In these requirements, long-term plans for building the students' knowledge and practice from grades 1 to 12 are embedded, with the learning developed through a spiralling and upgrading approach every year.

In Eswatini/Swaziland, methods undertaken to promote digital education and employment among young people include providing subsidised or free Internet access in underserved areas, equipping schools with necessary technology infrastructure, and offering training programmes for both students and teachers. These initiatives have not only bridged the digital divide but also empowered young individuals to acquire the skills needed for a digital future, opening up new opportunities for their personal growth and career development.

Northern Ireland provides another example where long-term and short-term planning and actions have been integral to their success. Northern Ireland is a relatively small nation; it covers just over 14,000 km^2 with over 1,100 schools.

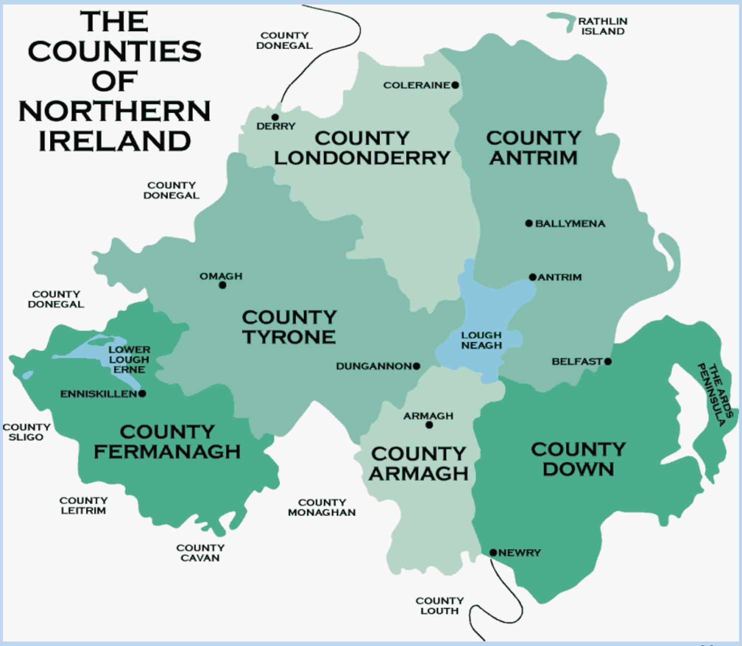

Figure 1: *Counties of Northern Ireland (Source: Pinterest[69])*

The development of IT, computing and digital education across schools in Northern Ireland has been continuously supported through long- and short-term actions and plans for at least the last 30 years. The five key factors identified in the IFIP Task Force work, important for

[68] https://www.mon.bg/nfs/2018/01/strategia_ikt.pdf

[69] https://www.bing.com/images/search?view=detailV2&ccid=oPkoSXUs&id=BCD027FB5C9EFA58E1C1113EAB4FB5B7072D3F01&thid=OIP.oPkoSXUszi7W6XlstqClIAHaGa&mediaurl=https%3a%2f%2fs-media-cache-ak0.pinimg.com%2foriginals%2fa0%2ff9%2f28%2fa0f92849752cce2ed6e9796cb6a0a520.jpg&cdnurl=https%3a%2f%2fth.bing.com%2fth%2fid%2fR.a0f92849752cce2ed6e9796cb6a0a520%3frik%3dAT8tB7e1T6s%252bEQ%26pid%3dImgRaw%26r%3d0&exph=796&expw=920&q=pinterest+counties+of+northern+ireland&simid=608018901207362102&FORM=IRPRST&ck=8ADF3587F81252075734A032AEB60524&selectedIndex=0&idpp=overlayview&ajaxhist=0&ajaxserp=0

developing sustained digital education for young people, have been addressed, albeit to different extents, but have nevertheless all been considered across that 30-year period. Aspiration is in part developed through the presence of creative industries, that are well known and recognised in Northern Ireland. Indeed, the work of these industries is linked to Nerve Centres (that offer linked practice and support to schools), and to the development of specific examinations at 16 years (General Certificate of Secondary Education-level). The digital divide has been considered and accommodated through the development and provision of a single complete across-nation managed service, which offers hardware and software provision, and a networking infrastructure begun in 2000, using radio connectivity in parts, to all schools. Diversity is still regarded as an ongoing issue and challenge; but schools have and are encouraged to develop programmes that address diversity in STEM areas, for example, where girls might not have traditionally been involved to the same extent as boys. Computational thinking has been developed and integrated through and across the curriculum since 2014. And importantly, teacher development has been a continuous focus since 2000, through the work of professional learning, advisory and inspection services.

At an international level, the Bebras Challenge was established in 2004, so has a long history with 78 countries involved. The success of the Bebras Challenge has depended on short- and long-term plans. In the short-term, Bebras develops a wide range of diverse and engaging computational thinking Bebras-like tasks to cater for the various skill levels and age groups, also focusing on teacher training by offering workshops and resources for educators, for example, CSIRO[70], to effectively integrate Bebras-like tasks into classrooms, enhancing students' problem-solving skills, and enhancing online platforms, continuously improving the online Bebras platforms for seamless participation and user-friendly navigation including platforms for translation of the Bebras-like tasks. In the long-term, Bebras seeks to expand globally, collaborating with educational organisations worldwide to establish Bebras as a staple in promoting computational thinking, across Africa, researching and developing through conducting studies to assess the impact of Bebras on learners' cognitive development and problem-solving abilities, refining the programme based on findings.

In Poland, the MultiAccess Centre has run short-term planning events, seeking to develop long-term outcomes. These have involved organised workshops and webinars at the Silesian University for Children in Katowice (2011-2014). Additionally, classes on adding audio description and transcription to films and performances have been run, as well as working directly with secondary students at the International Wertep Festival in 2021.

Examples of methods national, regional or local organisations have used that have failed to develop and implement short- and long-term plans and actions to enable young people to engage with digital education or digital employment

In Eswatini/Swaziland, the lack of collaboration between different stakeholders, such as government bodies, educational institutions, and industry leaders, has hindered the development and implementation of effective plans and actions. Additionally, the lack of adequate funding and resources allocated towards digital education and employment initiatives has also contributed to the failure of these organisations to enable young people to engage with digital opportunities. Digital education is still one under-appreciated sector that has the potential to make improvements across the spectrum of education and employment.

[70] https://www.csiro.au/en/education/Programs/Digital-Careers

9. Conclusion

It is clear from the evidence provided in the previous sections that the five key factors associated with sustaining inclusive digital education for 5-18-year-old young people are dynamically linked. One of these factors might drive development at any one time, but this factor will also support the other four factors, and in time, another factor might be seen to be the factor that predominantly drives development.

In summary, the IFIP Task Force visualises sustainable inclusive digital education for 5 -18-year-old young people as shown in Figure 2.

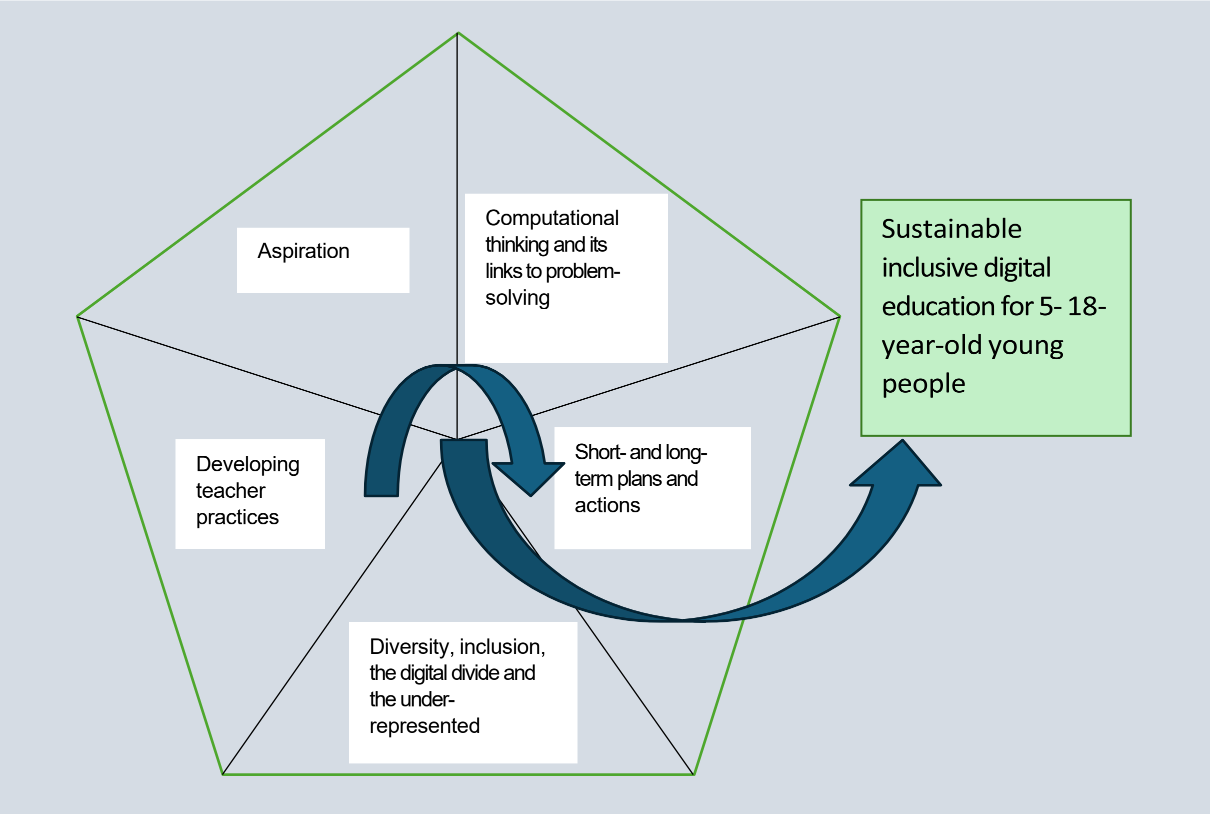

Figure 2: *Driving sustainable inclusive digital education*

How outcomes have been achieved, as well as how weaknesses have been identified, are illustrated in a case study appendix, to be published at a later time.