

# Supporting the Development of 21<sup>st</sup> Century Skills through ICT

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**Abstract:** The growing impact of globalisation and the development of a ‘knowledge society’ have led many to argue that 21<sup>st</sup> century skills are essential for life in twenty-first century society and that ICT is central to their development. This paper describes how 21<sup>st</sup> century skills, in particular digital literacy, critical thinking, creativity, communication and collaboration skills, have been conceptualised and embedded in the resources developed for teachers in iTEC, a four-year, European project. The effectiveness of this approach is considered in light of the data collected through the evaluation of the pilots, which considers both the potential benefits of using technology to support the development of 21<sup>st</sup> century skills, but also the challenges of doing so. Finally, the paper discusses the learning support systems required in order to transform pedagogies and embed 21<sup>st</sup> century skills. It is argued that support is required in standards and assessment; curriculum and instruction; professional development; and learning environments.

**Keywords:** 21<sup>st</sup> century skills, primary education, secondary education, pedagogy, innovation

## 1 Introduction

Developing 21<sup>st</sup> century skills and competencies in schools demands pedagogical shifts away from didactic approaches together with the embedding of ICT. Whilst the majority of school heads and teachers recognise the importance of ICT use for developing 21<sup>st</sup> century skills, ICT use in classrooms is still limited (EC, 2013). Indeed, 20 % of students in secondary education across Europe rarely use ICT during lessons with the majority of European teachers using ICT primarily for lesson preparation (EC, 2013). Moreover, where ICT is used it does not always lead to changes in pedagogical practices (Law, 2009; Shear et al., 2010; Luckin et al., 2011).

Innovative Technologies for an Engaging Classroom (iTEC) is a 4-year project on supporting the scaling up of pedagogical and technological innovation in classrooms across 19 European countries. The project has developed a process for creating educational scenarios and accompanying learning activities which describe new pedagogical approaches supported by a range of digital tools. The development of 21<sup>st</sup> century skills, such as collaboration, creativity and critical thinking, is a core aim.

This paper describes how 21<sup>st</sup> century skills have been conceptualised and embedded in the resources developed for teachers in the iTEC project. The effectiveness of this approach is considered in light of the data collected through the evaluation of the pilots. Finally, the paper discusses the role of ICT in supporting the development of 21<sup>st</sup> century skills.

## **2 21<sup>st</sup> Century Skills and the Role of ICT**

21<sup>st</sup> century skills, sometimes referred to as 21<sup>st</sup> century competencies, is a complex term which encompasses skills that may be required to be successful in learning, in the workplace and to live effectively in the 21<sup>st</sup> century (P21, 2009; Binkley et al., 2012). Although frameworks and definitions of 21<sup>st</sup> century skills exist (e.g. ISTE, 2007; P21, 2009; Binkley et al, 2012), most refer to the same list of competences which includes collaboration, communication, ICT, creativity, critical thinking and problem solving (Voogt, Pareja Roblin, 2012). Voogt and Pareja Roblin (2012) suggest that as well as supporting teachers to change their pedagogy they also need to understand better how ICT can facilitate 21<sup>st</sup> century learning. As the development of 21<sup>st</sup> century skills can be enhanced through the use of ICT (Ananiadou, Claro, 2009), it is argued that their development should be cross-curricular, demanding changes in pedagogical practices (Voogt, Pareja Roblin, 2012).

It is recognised that the, “dramatic shift toward the economic aims of education” (Rutowski et al., 2011, p. 191) is one of the key drivers for the development of 21<sup>st</sup> century skills. Very few frameworks draw on educational research as part of their justification (Voogt, Pareja Roblin, 2012). This is acknowledged as a weakness, but a detailed discussion of these issues falls outside the scope of this paper. Furthermore, critics of the 21<sup>st</sup> century skills movement argue that the frameworks take no account of content (knowledge) and that the skills cannot be taught in isolation, proposing that the curriculum should be emphasised rather than the teaching of skills (see for example <http://commoncore.org/mission>; Mathews, 2009). However, Voogt et al. (2013) argue that, “most frameworks recognize the complex and cross-disciplinary nature

of 21<sup>st</sup> century competencies and thus recommend integrating them across the curriculum” (p. 407). Indeed, many countries claim that the skills are already integrated although in some countries ICT skills are taught separately (Ananiadou, Claro, 2009). Furthermore, in a review of 10 frameworks, Mishra and Kereliuk (2011) suggest that developing sound content knowledge is included as an essential component of 21<sup>st</sup> century skills.

It is noteworthy that more recent frameworks attempt to broaden the notion of skills, referring, for example, to ‘learning literacies’ (Beetham et al., 2009); or to a ‘Frame-work for 21<sup>st</sup> Century Learning’, which incorporates skills, content knowledge, expertise and literacies (P21, 2009). This demonstrates that the importance of teaching 21<sup>st</sup> century skills as a holistic cognitive process, rather than as a set of discrete functional skills is becoming widely recognised.

The following section outlines each of the skills normally included within definitions of 21<sup>st</sup> century skills.

Critical thinking has been theorised, debated and defined by many (Kennedy et al., 1991) but broadly refers to making informed decisions on the basis of analysing, synthesising and evaluating information. When employed in a practical context, it is often referred to as problem solving. Both concepts are closely related to reflection, which is ‘central to critical thinking and deeper learning’ (Quinton, Smallbone, 2010, p. 126). The potential of portfolios and social media tools such as blogs supporting student reflection in school contexts has been noted (Crook et al., 2010).

Communication skills have been important in education for centuries (Voogt et al., 2013). Students need to have the ability to “exchange, criticise, and present information and ideas” (Ananiadou, Claro, 2009, p. 10). ICT has become an important tool for supporting communication both in education and also in a wide range of social practices (National Research Council, 2012) making it easier to reach a wide audience and communicate at a distance, faster and more ubiquitously. Students need to have well-developed communication skills in order to collaborate and work in teams. Collaboration is one of the skills clearly demanded by the twenty-first century workplace, particularly with the shift away from manual work (Dede, 2010). Team working is increasingly being facilitated by digital tools, which allow geographically dispersed team members to collaborate.

Creativity has long been considered an important component of education, however, since the 1990s, there has been a growing recognition of the importance of learner creativity. ICT can support learner creativity in many ways including developing ideas, making connections, creating and making (Loveless,

2002) with more recent developments such as web 2.0 increasing opportunities for creative activities.

Digital literacy does not simply refer to technical skills, but to “the ability to use information and communication technologies to find, evaluate, create, and communicate information, requiring both cognitive and technical skills” (ALA, 2011). It includes, for example, internet safety and an understanding of the ethical and legal issues relating to the access and use of ICT. Digital literacy is sometimes conflated with the closely related terms, information literacy and media literacy. In addition, other 21<sup>st</sup> century skills, for example, communication, collaboration and creativity are included as components of some definitions of digital literacy.

While the integration of these 21<sup>st</sup> century skills in classrooms is encouraged by theorists and policymakers, in practice, teachers often lack the skills and the space to teach their students 21<sup>st</sup> century skills (Voogt et al., 2013). Furthermore, their development requires substantial changes to pedagogical approaches and assessment practices (Binkley et al., 2012; Voogt, Pareja Roblin, 2012). The iTEC project has endeavoured to provide support and resources for teachers to enable them to develop their students’ 21<sup>st</sup> century skills through new pedagogical approaches that make substantial use of technology. The resources have been designed to be generic and applicable to a wide range of curriculum areas, thus enabling the development of 21<sup>st</sup> century skills to be integrated within curricula.

### **3 How 21<sup>st</sup> Century Skills have been conceptualised and embedded in ITEC**

iTEC was conceptualised as a project focusing on ‘Learning in the 21<sup>st</sup> century’ and innovation in the classroom through effective uses of technology. A process of visioning, development and piloting was put in place, developed over four cycles and subsequently produced as toolkits which stakeholders (including classroom teachers) used themselves in a fifth and final cycle of activity, thus shifting from a supplied approach to a demand-led one. As part of the visioning process developed within the iTEC project to support teachers, socio-economic, technological and educational trends likely to impact on learning and teaching were identified and prioritised. The trends identified include references to 21<sup>st</sup> century skills both as a key trend but also embedded in the descriptors of other trends (for example, collaboration, problem-solving) (Cranmer, Ulicsak, 2011). The trends informed the development of educational scenarios (narratives of innovation in the classroom). The educational scenarios

generated were prioritised, and a subset developed further. This prioritisation process was formalised through the development of scenario selection criteria to ensure that those put forward for further development were likely to lead to innovation in the classroom. One of the six dimensions of the selection criteria is ‘Does the Scenario (or Learning Story) provide sufficient opportunities for learners to develop and demonstrate 21<sup>st</sup> Century Skills?’ This exemplifies the perceived importance of 21<sup>st</sup> century skills in the project’s conceptualisation of what makes a scenario innovative.

Next, through participatory design workshops with teachers and desk-based analysis of the scenarios, ‘design challenges’ were identified. Design challenges are potential barriers and issues that might prevent new pedagogical approaches and/or digital tools from being implemented in the classroom. For example in cycle 1, several design challenges such as ‘Team work is not familiar’ were identified in relation to team work/collaboration (Keune et al., 2011). Further analysis revealed a number of design opportunities or ways of overcoming the design challenges. Learning activities were then developed to address the design challenges and harness the design opportunities. These were pre-piloted and then a coherent package of 6–8 learning activities put forward for testing in large-scale pilots.

ICT is an integral part of each learning activity. Each package of learning activities presented to teachers is exemplified through a learning story, a narrative describing how the learning activities might be used in the classroom, supported by ICTs. Each participating teacher was presented with the package of learning activities and accompanying learning stories. They selected and adapted the ideas including the specific digital tools used, ensuring the implementation met their individual needs.

The learning activities created for cycle 4, exemplify the use of ICT and the underpinning 21<sup>st</sup> century skills.

- ‘Dream’: Introduce, understand and question a design brief using ICT to support reflection, team formation, collaborative editing, publishing and blogging.
- ‘Explore’: Collect information in relation to design brief using ICT to support browsing, social bookmarking, collaborative editing and media recording.
- ‘Map’: Create a mindmap to understand the relations between collected information using mindmapping software.
- ‘Reflect’: Record audio-visual reflections and feedback using ICT to support reflection.

- ‘Make’: Create a design using ICT to support media editing, programming, construction, 3D editing and 3D printing.
- ‘Ask’: Perform workshops with end-users using ICT for media recording.
- ‘Show’: Publish and present designs to an audience using ICT to support video editing, media recording, video publication and media sharing.
- ‘Collaborate’: Form ad-hoc collaborations with learners from other schools using ICT to support online discussion, media publication and blogging.

This is further exemplified in the following vignette from Spain in cycle 3. Firstly, the tools were set up, for example blogs and Dropbox<sup>1</sup> accounts, and students were instructed in their use, thereby developing their digital literacy skills. Then students searched for relevant games on the Internet, and evaluated each to gauge its advantages and disadvantages. This activity required both critical thinking and digital literacy skills. Based on this information, teams of students designed their own games, first on paper and then electronically using SMART Notebook. Working in teams required collaboration and communication skills; designing a game required creativity skills; and presenting their game in SMART Notebook required digital literacy skills. Students presented their games to the class for feedback, making use of communication skills and digital literacy as they used the interactive whiteboard to present. They used the feedback to revise their designs, using critical thinking and creativity skills, as well as collaboration. Throughout the project, students maintained a blog to reflect on, and evaluate, their experiences, developing critical thinking, digital literacy and communication skills.

## 4 Methodology

Each country has a national coordinator who oversees the project, supports teachers and co-ordinates data collection in their country. The evaluation was led by a team from a UK university.

At the end of each cycle, teachers completed an online questionnaire about their experiences, focusing on their use of the iTEC technologies, enabling factors, challenges encountered and potential for innovation. Teachers were only asked to comment on the impact of iTEC on 21<sup>st</sup> century skills directly in the cycle 4 questionnaire although there were questions on collaboration,

<sup>1</sup> <https://www.dropbox.com/home>.

communication, creativity and ICT use in the questionnaires administered in cycles 1–3.

National coordinators conducted one or more case studies in their country each cycle, involving lesson observation and interviews with teachers, head teachers, ICT coordinators and students. They provided case study reports (cycles 1–3 only, two per cycle) or transcripts (all cycles, one per cycle) to the evaluation team. In cycle 4, national coordinators also conducted a focus group with a sample of teachers from their country. In addition, members of the evaluation team gathered data through observing project activities (e.g. training sessions, webinars). The focus of the evaluation altered during each cycle to adapt to the needs of the project, so the precise questions asked within the survey and interviews have changed, meaning direct comparison between cycles is not possible for all measures.

Qualitative data were analysed using Nvivo. Transcriptions were coded thematically using a conceptual framework from the SITES2 study (Kozma, 2003), modified to incorporate new codes to reflect emerging themes. The surveys comprised both open-ended and closed questions; the open-ended questions were translated into English using Google Translate and then coded, while the closed questions were analysed using SPSS.

## **5 The Realisation of 21<sup>st</sup> Century Skills in the Classroom**

Drawing on data from the evaluation of each cycle, we now consider the effectiveness of this approach for embedding 21<sup>st</sup> century skills in the classroom, focussing in particular on critical thinking and problem solving, communication and collaboration, creativity, and digital literacy.

### **5.1 Critical thinking and problem solving**

As exemplified above, many of the learning activities provide opportunities for developing critical thinking and problem solving. In addition, reflection has been central to all four cycles, originally developed as a learning activity called ‘Team newflash’ and subsequently labelled Reflection/Reflect.

TeamUp, is a prototype tool developed initially in response to the design challenges noted by teachers in participatory design workshops. Groups of students can record 60-second audio ‘newflashes’ responding to specific questions: what they have done, what they will do next and any problems encountered. Recordings are available for other groups and teachers to access at any time. In cycle 4, a second prototype tool, ReFlex, was offered which enables

students to build up a series of reflections about their learning activities which are then displayed on a timeline. Alternative widely available audio/visual reflection tools, blogs, mindmapping tools and note-taking tools (online sticky notes) were also suggested to teachers.

The evaluation results suggest that the use of technology to support critical thinking, problem solving and reflection had a positive impact. In cycle 4, 73 % of participating teachers (n=326) agreed that their implementation of iTEC improved their students critical thinking skills (linked to improvements in self-reflection skills) whilst 80 % agreed that their students' problem solving skills had improved. Facilitating student reflection, supported by tools such as TeamUp, ReFlex and blogs, was seen to be particularly innovative among case study teachers. The perceived benefits included enabling teachers to monitor progress, developing students' metacognition and self-evaluation skills, and supporting peer learning. Case study data supported these findings in various ways although teachers did not mention critical thinking or problem solving specifically very often.

[The learning story has] fostered the development of metacognitive processes, critical thinking and autonomy. (head teacher, Italy, cycle 3)

[Being able to record reflections using technology] forces students to think about their work, become aware of the work we have been able to do, and skills they have developed. (teacher, Spain, cycle 3)

Students also perceived benefits to be gained from using technology for reflection. In cycle 4, students from Israel noted that whilst reflection could be achieved using pen and paper, they believed that the act of recording (and listening back to) their reflection made them think about their statement more and encouraged them to make their points more clearly than they might do in a written document.

Of course, supporting student reflection was not without its challenges in relation to time pressures, student attitudes, skills and technical problems associated with the use of prototype tools. In cycle 2 for example, it was noted that students were not always comfortable recording reflections.



## 5.2 Communication and collaboration

Communication and collaboration are required for many of the learning activities developed in the iTEC project from working in teams to conducting participatory design workshops. Suggestions for appropriate technologies include TeamUp (described above), blogs, Facebook and wikis. For example, in cycle 1 the ‘Working with outside experts’ learning activity suggests the use of instant messaging or Skype to communicate synchronously with experts. In cycle 2 the ‘Ad-hoc collaboration’ learning activity suggests the use of Twitter or Facebook to communicate their activities to and collaborate with students at other schools.

Teachers from the first three cycles (n=826) felt that students expressed their ideas in new ways (87 %), and communicated in new ways with each other (81 %), the teacher (78 %) and the wider community (59 %). Most teachers agreed (n=826) that the iTEC process increased opportunities for collaboration (93 %), enabled students to develop new skills in collaboration (91 %) and enabled students to use ICT to support collaboration (87 %). In cycle 4, teachers (n=326) agreed that students improved their communication skills (86 %) and their collaboration skills (87 %).

In cycles 1–3, 71 % of teachers reported using communication tools such as email, conferencing or instant messaging when implementing the learning activities. Indeed, communication tools were in the top 3 tools used in each cycle, perhaps reflecting the ready availability of such tools in European classrooms. Some teachers commented that the way in which they interacted with students changed through the use of technology, for example, they communicated and commented on students’ work via blogs instead of providing written comments in exercise books.

Students also used digital tools to communicate and collaborate with other students, both in their class and in other schools. The iTEC Facebook group page was set up to enable teachers and students to find other iTEC participants to collaborate with and to share what they had been doing. During Cycle 2 many students posted links to the artefacts that they had created and received ‘likes’ and comments from others. Further examples of the use of digital tools for communication and collaboration include the following:

An unexpected outcome of the blogs is that students from other classes and schools left comments and suggestions for the class’ students. All of the posts were encouraging and constructive and students appreciated this feedback. (case study report, France, cycle 2)

Students have done a lot of work at home, working and communicating together and with me by using Facebook, and documenting the process by using a blog. They were not used to this kind of activity ... and me too. I had already used blogs, but not in the normal curricular activities (only in special extra-curricular activities), and not in this way: it's a new kind of homework, in which students have to reflect on what they do in the schoolwork. (teacher, Italy, cycle 4)

Students came to appreciate the value and benefits of team working:

We found iTEC more enjoyable than our other lessons because we worked as a group and everybody in our team always help each other and we learned a lot of things and we shared our experiences with each other. (student, Turkey, cycle 4)

Again, this has not been without challenge with some teachers feeling that some students struggled to write to a standard and in a format suitable for a blog whilst others noted that school policies prevented them from using communication tools such as Twitter. An Italian teacher in cycle 2 also noted that it was a challenge to facilitate primary students collaborating with secondary students, attributed to the lack of ability to respond to complex communications.

### **5.3 Creativity**

As the learning stories for each cycle indicate, iTEC supports creativity in a variety of ways. For example, in cycle 4, the learning stories were 'create a game', 'create an object' and 'tell a story', all clearly creative acts. Learning stories from previous cycles involved students redesigning their school; creating a maths game; and creating a guided walk. During the first three cycles of iTEC, 91 % of teachers (n=826) agreed that the process enabled students to both engage in creative activities and to develop creative their skills. In cycle 4, 89 % of teachers (n=326) agreed that their students' creativity skills had improved.

It was both the types of outputs which students were expected to produce (e.g. videos, products, games) and the tools they were expected to use which were frequently thought to promote creative skills. Using a range of digital tools to support the entire design and creation process, rather than simply to undertake research and present findings, was new for a number of teachers and students:

The devices are being used a lot. What we see now is that students use them more to create things rather than use them to look up or produce texts. (head teacher, Belgium, cycle 3)

Furthermore, some students felt that the digital tools provided them with ways to express themselves, which were not available with more traditional tools:

It also helps us to be more creative because sometimes a pencil and a piece of paper aren't enough to show what is in my mind in real terms. (student, Turkey, cycle 3)

#### **5.4 Digital literacy**

While implementing their iTEC learning stories, teachers were encouraged to experiment with digital tools which they, and their students, had not used before. During cycles 1–3, teachers reported the use of an average of 8.2 (SD=2.7) different types of ICT (for example collaboration tools, communication tools, media recording tools), with 60 % (n=826) agreeing that they used digital tools that they had not used before, thus exposing students to a wider range of digital tools. It was clear that, prior to iTEC, some students had very limited experience of the use of new technologies in a learning context, for example:

We have made a PowerPoint presentation once or twice, but we don't use computers in our lessons very often. (student, Estonia, cycle 3)

The differences are that during this project all the students have used a computer not like the rest where only the teacher uses the computer. (student, Spain, cycle 3)

Exposure to a wide range of technologies during iTEC therefore helped them to appreciate how new technologies could be used for learning and the benefits and potential challenges of doing so, along with the technical skills required to use these technologies effectively. In cycle 4, 87 % of teachers (n=326) agreed that their students' digital literacy skills had improved. Students themselves were also clearly aware that their digital literacy skills were improving:

I knew some basic things on the computer, but since the project I know a lot more about file sharing and GoogleDocs (student, Israel, cycle3)

I never worked with Google SketchUp before and because of this project I know how to use it and I also learned how to develop my own blog. (student, Slovakia, cycle3)

Crucially, iTEC provided an opportunity for students to develop digital literacy skills in a practical context. This allowed them to learn about the full range of social, inter-personal and ethical issues around the use of digital tools, not simply the technical skills required:

... before the project, in ICT class, they've used blogs but not with a real use, the project has allowed them to really see what means to publish information and work through a blog, they could see how many people would visit them and really understand that their information was public. (ICT coordinator, Spain, cycle3)

## **6 Discussion and Conclusion**

As Rutowski et al (2011) acknowledge, “significant challenge remains in integrating ICT into the pedagogical practices aimed at developing 21<sup>st</sup>-century skills”. The importance of learning support systems for the transformation of pedagogies and to facilitate the development of 21<sup>st</sup>-century skills is well-recognised (Cuban et al., 2001; Pelgrum, Law, 2003), although as Voogt and Pareja Roblin (2012) point out, most frameworks pay little attention to these practical considerations. Results from iTEC indicate that support is, indeed required in the four areas identified by P21 as: 21<sup>st</sup> Century Learning Support Systems, namely, ‘Standards and Assessment’; ‘Curriculum and Instruction’; ‘Professional Development’ and ‘Learning Environments’. These are considered in turn below.

### **6.1 Standards and Assessment**

In common with other research on ICT in education, rigid summative assessment practices and curricula were identified in iTEC as significant barriers to the types of pedagogies, which support the development of 21<sup>st</sup> century skills. As the majority of assessment frameworks are subject- and knowledge-based, they do not cover 21<sup>st</sup> century skills (Dede, 2010) although many countries claim that their assessment policies do address this (Ananiadou, Claro, 2009). This was a challenging area for iTEC to address especially as the project in-

volved a large number of countries each with their own standards and assessment procedures. The evidence from iTEC supports that of others (e.g. Voogt et al., 2013) suggesting assessment frameworks need to be revised to meet the needs of 21<sup>st</sup> century teaching and learning and ensure skills, or competencies, as well as knowledge are assessed. Teachers were overwhelmingly positive about the impact of iTEC on students' development of 21<sup>st</sup> century skills, and frequently assessed these skills using formative, peer and self-assessment methods. As one teacher commented, "it allowed me to assess some things which are not always easy to measure in a normal class. For example, autonomy, creativity, critical thinking ..." (teacher, Portugal, cycle 3). As this comment indicates, these were not reflected in formal assessments.

## **6.2 Curriculum and instruction**

Curricula need restructuring to accommodate 21<sup>st</sup> century skills, which are often dis-connected from subject areas (Voogt et al., 2013). However, evidence from iTEC suggests that new pedagogical strategies such as collaboration and creativity can be embedded across the curriculum. The development of generic learning activities and exemplar learning stories supported this. Teachers were able to use the resources as sources of inspiration in order to redesign their classroom pedagogies. Through the iTEC process teachers were involved in the collective design of new learning activities underpinned by 21<sup>st</sup> century skills and a wide range of ICTs. iTEC provided opportunities to incorporate 21<sup>st</sup> century skills in subjects where this was not usual practice, in particular, the integration of digital literacy in subjects which traditionally made little use of technology. As a school ICT coordinator commented, "It has been a nice change. The pilot here has been done in maths and usually ICT is not used in maths classes." (ICT Co-ordinator, Spain, cycle 3). Changing the curriculum and instruction methods is far from easy, however. The iTEC process offered teachers ways to adapt and develop their teaching, but also demonstrated that this needs to be undertaken as a whole school process.

## **6.3 Professional development**

ICT technical support and ICT pedagogical support were identified as important enablers for iTEC teachers to support them in the delivery of 21<sup>st</sup> century skills. In Cycle 1 access to technical and pedagogical support were noted to be essential for main-streaming. Alongside support from iTEC national co-ordinators, informal professional development opportunities such as the support of

other teachers (either face-to-face or through online communities) was found to be important to teachers.

Whilst the iTEC process ensures that 21<sup>st</sup> century skills are embedded in learning activities, it does not address the specific skills required by teachers and students. Key aspects of the delivery of 21<sup>st</sup> century skills, such as students working in teams, the use of a range of digital tools and supporting student reflection were all areas where teachers felt they required additional support. For example, in Cycle 3, basic technical problems which could have been resolved with adequate technical support were noted in 31 of the 47 case studies. There is a need for additional resources, training and support to help teachers and students to adapt to these new pedagogical approaches, as Dede (2010) indicates. Currently such support is lacking or optional rather than mandatory (Ananiadou, Claro, 2009).

#### **6.4 Learning environments**

The development of 21<sup>st</sup> century skills also requires changes to traditional learning environments, in particular the provision of new technologies and infrastructure. Among schools in the iTEC project, ICT infrastructure, including the provision of reliable and sufficient access to the internet, requires further development in many countries. For example, in Cycle 2, insufficient access to ICT was the second most commonly identified barrier. Changes such as the introduction of Bring Your Own Device policies whereby students are encouraged to bring their own mobile phones and other electronic devices to use in the classroom represent one way in which this problem can be overcome. This development can facilitate not only the development of digital literacy skills, but also collaboration and communication skills as students can work together in new ways, both in the classroom and beyond.

This notion of extending the traditional boundaries of the classroom is critical to the development of 21<sup>st</sup> century skills. This was evident in iTEC as students communicated and collaborated with peers and experts outside the school, often using digital tools to do so, and devised creative solutions to ‘real life’ problems. Indeed, Voogt and colleagues (2013) argue that the development of 21<sup>st</sup> century skills can take place outside formal education and could prove useful if teachers are able to capitalise on this. The traditional boundaries should not be extended but made permeable.

The increasing use of social media is another way in which the learning environments are changing to facilitate the development of 21<sup>st</sup> century skills. As reported above, this can impact on digital literacy, collaboration and com-

munication skills, creativity and critical thinking as students are presented with new ways to work together, create new types of learning output.

## **7 Concluding Remarks**

The approach developed through iTEC, enabling teachers to become learning designers and embed 21<sup>st</sup> century skills and ICT in their pedagogical practices, has proved to be flexible and adaptable across a range of curriculum areas. As a result teachers and students perceive that there has been a positive impact on students' 21<sup>st</sup> century skills. However, the process does not currently support teachers who have limited experience of 21<sup>st</sup> century skills themselves and thus there is a need to provide further support on the specific skills to ensure that teachers do not spend their time solving known problems and that the benefits are maximised.

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