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PEDAGOGICAL FRAMEWORK FOR TEACHER EDUCATION ON DISTANCE TEACHING

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O1. Pedagogical framework for Teacher Education on distance teaching

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O1.A1

Design of guidelines for distance teaching in Teacher Education

1. Introduction

This document is the first deliverable of the output 1, action 1 (O1. A1) of the Blue Arrow project. It offers an insight into different technology-based teaching practices. Thus, it works as a set of guidelines for teachers interested in applying these innovative educational methodologies in distance teaching settings.

In this context, the key role digital technologies have had, and the acceleration of its use in schools at all levels, demand to pay special attention to teachers' readiness and competencies, so to revisit the European Digital Competence framework for Educators (DigCompEdu) (Punie & Redecker, 2017) and refine its components to meet the new challenges.

The European DigComp framework (Vuorikari et al., 2016) identified four application areas for building citizens' digital skills. These are data literacy, communication and collaboration, digital content creation, and security. Subsequently, the DigCompEdu model—the ad hoc framework for educators—has identified the acquisition of skills and meta-skills as a tool aimed at mediating, in digital terms, the relationship with students. In particular, the model emphasizes greater awareness, reflexivity, and cooperation in media-education approaches. The six relevant reference areas are professional commitment, digital resources, teaching and learning evaluation, student empowerment, and the facilitation of students' digital skills. With this in mind, self-assessment by teachers is a useful tool for promoting the development of students and growth of digital skills and abilities. Educational institutions aim to train teachers in order to support the use of information and communication technologies (ICTs). This approach improves teaching through the use of innovative teaching strategies. Digital innovation in the educational context assigns the teacher a leading role in the management and monitoring of students' learning processes to achieve success. At the same time, the student is the main character of a path that corresponds to their individual training needs in an individualized and welcoming virtual learning environment.

Section 2 analyzes both teachers and students' attitudes towards the application of new online learning scenarios during the initial phases of the pandemics, and the proposed solutions

Section 3 describes the readiness of the participants' countries in terms of technological infrastructure for the potential application of new digital tools and methods.

Finally, in Section 4, we outline key technology-based teaching practices applied to teacher education both in face-to-face and hybrid environments, defining its implications, offering some reflections derived from real practice and eliciting their connections for the learning of the digital skills set by EU *DigCompEdu* (Digital Competence Framework for Educators) and also the EU Digcomp 2.0 (Digital Competence Framework for Citizens).

2. Prospective situation in the partners countries towards the application of new digital approaches at the time of pandemics. Teachers and students' attitudes

Many studies around the world have been undertaking with respect to how teachers, students and schools confronted digital learning at the time of disruption. In general, teachers' attitude towards teaching online and with digital tools in Europe (and around the world) stresses the enormous effort made, confronting very different situations, and usually with not enough help of the educational authorities, which were overwhelmed by the consequences of the pandemic.

Teachers felt isolated, as students were. The responsibilities of the teachers were diluted among colleagues. For that reason, at some point in time, teachers and the digital school teams have tried to create cooperation teams and improve communication with the parents of the children. The distance imposed by social isolation has led teachers to reconfigure their working practices, as well as teaching practices. Teachers tried their best to get used to virtual teaching, to create digital resources, to communicate and follow up their students' progress through a new course planning and with new learning resources and communication tools, including social software.

The main results of different surveys undertaken in Europe during 2020 is that students and teachers believe that the remote learning approach that arose from the pandemic situation may have not been positive for learning. Schools are now beginning to assess students' emotional and academic deficiencies. Emotional aspects are prevalent affecting to an important number of students specially in the upper grades and less in primary education (Marchesi et al., 2020). On the other hand, educators dealt with digital inequities by putting in extra work and shifting their mindsets.

Throughout the years of the pandemic, educational work has become a complicated activity for both teachers and students to carry out and develop. Gradually, students and teachers have adapted to the extent that they now consider that in the future they will combine both teaching models. Although personal interaction is still one of the aspects that need to be polished to improve remote teaching, the trend towards digitalization is unstoppable. The teachers have tried to make up for these serious shortcomings by using the technology currently available at schools, by attending training courses, in order to implement their knowledge and skills in the use of online education and on the design of the added resources.

Attitudes of teachers because of pandemics

The education sector will continue to rely on digital tools after the pandemic, as conclude a European survey among teachers in European schools and universities, involving four countries (Germany, France, Spain, and Italy) to assess the degree of adoption of digital tools and the challenges arising from the accelerated implementation of virtual solutions (Wacom, 2021). According to this study, 59% of teachers said they switched entirely to an online format at the beginning of the pandemic, 37% applied a hybrid approach, and only 16% remained physically in the classroom. The radical shift from face-to-face to hybrid or online teaching has meant that the interaction between teacher-student-students took place only via online technologies. The devices most used by teachers Germany, France, Spain, and Italy in their practice have been, in the first place, Windows computers (69%), followed by smartphones (24%). In addition, 10% have used a digital pen and 7% a pen tablet. In terms of software, the most used applications have been online meeting platforms and programs (77%), as well as those for creating presentations (67%), followed by text programs such as Word, (65%), PDF editing (55%), Google for education (42%) and digital whiteboard programs (38%).

Educators also reported a desire to maintain the reforms and the digital tools that helped their students (Williamson et al., 2021). Teachers report on three elements that emerge to be considered as priorities:

- the need to strongly support digital skills training and cooperative work for teachers, so that everyone is prepared for similar events, but most importantly now, to continue to maintain the investments made (specially in 2021) in digital education and to better integrate digital education in schools.
- the need to work for the construction of a school community culture, which includes teachers, parents, students, and the school management to confront the challenges that emerged in the first year of pandemics. We can learn that now and in the future that school life and school current and future must be founded on the idea of school community
- Planning in the future needs to consider the needs of the most vulnerable students.

Students' attitudes because of pandemics

As with respect to school children, there have been different situations which respond to the following general profile:

- Children are keen to stay more at home in a safe environment and using e-learning tools and digital learning, as compared to adolescent and teachers.
- The digital divide is still a problem. those with technological parents and those with less technological parents. Furthermore, families with several children have had the problem of not having enough computer devices in their possession.
- Children with special needs do have much more difficulties in accessing and using digital resources, especially online, without direct contact with teachers

The current situation in Albania

In Albania, schools closed on 10 March as part of the country's measures to slow the spread of the Coronavirus Disease 2019 (COVID-19). According to the ministerial guidelines of the Republican of Albania, teachers are being asked to deliver their lessons through online platforms. However, some problems occur related to the technological side. The first problem was related to the technological availability: not all teachers and students owned a device (smartphone, tablet, personal computer or laptop). The second problem was related to the internet connection because in the remote Albanian area, internet connection is not well covered and it presents, in any case, prohibitive costs in relation to the resident family's income.

For these two central problems and with the main aim to not interrupt the activities of primary and secondary education in the short term, the Independent Trade Union of Education of Albania (SPASH-ITUEA) has cooperated with the Minister of Education of the Republic of Albania by suggesting regulating the organization of training activities by using the available national TV channels. In that brief period, this allowed for a broader reach and helped to ensure that every child accessed to the educational resources[1].

Despite it all and considering the social and economic state in the remote and rural area of Albania, many children were unable to follow remote lessons, depriving them of the fundamental right to education. Thus, because many families did not have access to TV, internet connection, mobile devices, electricity, and educational resources.

Overcoming the problem of short, in April 2020 the Minister of Education had adopted new measures to ensure the re-start of the training activities in the primary and secondary school and for the academic context. The new measures have included guidelines referred to the use of technological tools such as Screen Recording, Classroom, Zoom, etc., to allow efficient distance learning for all students[2]. The phenomenon has been investigated and piece of research has been detected. In a recent study (Koçiaj et al., 2021), with the participation of 1506 students, of which 67.5% study in public schools in

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[1] https://www.ei-ie.org/en/item/23263:albania-education-union-uses-technology-to-reduce-impact-of-covid-19.
[2]https://www.coe.int/en/web/education/schools-in-albania#{%2263470963%22:[0],%2263470980%22:[0]}.

Albania, the education system was analyzed and addressed the pandemic situation, focusing on important social variables during the 2020-2021 academic year. The results show that 87.7% of the students like more traditional learning compared to online learning. A percentage of 6.6% declared that they prefer online learning. Instead, a percentage of 5.7% expressed no difference between the modalities.

Furthermore, the students did not prefer distance learning because they had many problems to adapt to distance learning (52.9%), but most of them have all the technological tools to conduct online learning (79.4%).

Finally, a percentage of 66.9% of students had more difficulties with distance learning during the academic year 2019-2020 than in the academic year 2020-2021 (Koçiaj, et al. 2021). Stress levels are constantly increasing for children because they, for health reasons, must accept the reality of staying at home for a long time in case of an increase of Covid-19 infections. Children must change their routine (e.g., closing of schools and childcare facilities, social distancing, home isolation), which can impair their sense of structure, predictability, and security[3].

The current situation in Italy

The COVID-19 pandemic has changed the relationship between teachers and distance learning. In fact, the emergency has triggered a process of rethinking school teaching. Since March 2020, practices related to digital education and new educational technologies have been central to learning at all levels and have influenced schools and academic institutions around the world. This dynamic has been studied with interest by psychologists, pedagogues, and educators around the world. Researchers have reported effects across the educational and training field in different learning contexts: in school and university training, in vocational training and internships, and in professional training. In every academic and professional field, there has been experimentation with new learning environments.

In this context, an investigation was launched to study the to study the advantages and drawbacks of digital technologies from the point of view of teachers. Digital media and new educational technologies have been observed to improve learning. This observation is supported by the

[3] For more details please visit: https://china-cee.eu/2021/11/03/albania-political-briefing-education-and-pandemic-in-2021-the-albanian-case/.

involvement of processes such as facilitating teamwork, continuous and frequent feedback, active participation, connection to the real world.

New digital technologies offer great potential for innovative development and support. A fundamental element is gamification, which increases motivation and can promote consolidated and successful learning. For example, in the acquisition of reading skills, the use of educational programs and platforms incorporating gamification elements promotes effective learning by offering continuous feedback, adaptability of levels to the skills acquired, and motivational and metacognitive components.

The correct use of digital media can increase academic success. The teacher's professional vision in Italy is a construct that has not yet been investigated; consequently, it is a subject of open debate. The technological aspects of professional vision have accentuated the dimensions of reflection and reasoning in teachers; this direction has implemented the need for didactic planning, monitoring and experimentation actions.

Studies have shown that some of the greatest challenges teachers face are difficulties related to the limited availability of technology in schools, to the ease of access, and to the adaptation to virtual learning environments. Another key aspect is perception. In fact, this cognitive aspect is directly involved in the challenges highlighted: teachers are influenced by their individual characteristics and their motivation. This has implications for the sense of self-efficacy from a professional point of view, as well as for the predisposition to use information and communication technologies (ICTs).

The current situation in Spain

To some extent the major disruption happened at the beginning of the pandemics and until the end of the course. The academic course 2020-21 was already face-to-face to children and adolescents (initial education to secondary education), with excellent results in terms of coming back to normal, something that continues the current year 2021. All children received a laptop to be used both at home and in the classroom, and they keep it in the present year. Some schools provide the schoolbooks in the digital format.

In Spain, although 28% believe that classes will go back to the way they were before, 49% think that hybrid classes will be more common from now on. In addition, technology in the classroom is positively received in our country: in Spain, 60% believe that digital tools bring flexibility to teaching, a percentage higher than the European average (53%).

In a recent evaluation study (Marchesi et al., 2020), with the participation of 1.000 schools of different levels, social variables were analyzed:

- Students from more disadvantaged backgrounds had 10% fewer personal computers. They spend less time studying - 35% of the total spent more than four hours a day during the confinement, a percentage that rises to 46% in the more affluent neighborhoods - and the percentage of their parents who lost their jobs exceeds 20%, a figure that is reduced by half - 11% - in the richer neighborhoods. In addition, children in poorer neighborhoods felt more lonely and sadder: 15% did not feel supported by their family; 20% perceived little emotional support in coping with confinement; 30% did not feel support from their teachers; and 19% did not maintain regular communication with their peers.
- Fifty-four percent of the teachers who participated in the interview stated that they went far beyond their workday schedule. Thirty-eight percent dedicated between four and seven hours a day to teaching. The vast majority, 96%, began the current academic year with a great desire to teach. Eighty-nine percent felt very well supported by their colleagues and 82% by the management team.
- Regarding face-to-face teaching: 95% of teachers prefer it. Although in primary school the percentage of students who would choose to teach at home is surprising, 25%, probably because that a high percentage of children has improved its relationship with the family: 40%. For some primary school children, the family environment is the one that gives them the most security, and online education benefits children who go at a different pace, because it is more flexible.
- Teachers highlight as priorities for this course the emotional wellbeing of students and the reinforcement of the basic competence of learning to learn, that is, to enable students to be able to learn autonomously, as well as to promote the use of technology.

According to the mentioned Spanish survey, the priorities now are:

1. Differential attention to each center. The same resources cannot be allocated to all. They should be provided according to their difficulties. It cannot be that there is a center where one out of every four students have no devices, and that receives the same as one where 100% is covered.

2. Emotional well-being must be a priority. Emotional education should be incorporated at least one hour a day, even if it is in tutorials, because it is essential.
3. Adapt methods and evaluation to the reality of the students. Centers should have more room for maneuver to use innovative methods and evaluate their students according to their needs.
4. Support, develop and promote the professional development of teachers. Programs should be implemented that politically and economically recognize the effort that teachers make every day to guarantee students' right to education.

Although an enormous effort has been made to provide digital technologies and good Internet connection to all students, other aspects need more attention, especially in what respect to new active learning methodologies and the adequate digital resources, as we will see in the next section. As a conclusion, we see that schools, teachers and children are better fit for using digital tools and hybrid education. Spanish schools have more and better technologies, and the attitudes of the educational community is much more positive towards e-learning in general. However, attention should be given to the above-mentioned general priorities, and continue to make more efforts for both preservice and in-service training.

The current situation in The Netherlands

The Netherlands compared to other countries, such as Italy, on the first wave of the virus took very mild precautions. In February 2020 Duches were in the 'denial phase'. "People who warned of the seriousness of the virus were accused of scaremongering" (de Boer, 2021, p. 97). It was only in the beginning of March 2020 that the government and people started to grap the seriousness of the situation. On March 12, the Dutch Cabinet announced the start of the 'intelligent' lockdown[4]. "Schools, catering, and sports clubs were closed, working from home became the norm, major events were banned, and basic rules on hygiene and social conduct were strongly advised. Later that month, these measures were tightened up: meetings were banned, gatherings in the street were not allowed and the national exams for secondary schools were cancelled" (de Boer, 2021). In campus education for universities was not possible and "in essence, from one day to the next, staff and students sat at home" (de Boer, 2021).

Readiness of Dutch teachers

To understand the readiness of teachers in facing the pandemic, it is fundamental to figure out how much they were used to technologies/ICT support, in their teacher practice, before COVID-19. "Results from the 2018 Teaching and Learning International Survey (TALIS) prior to the crisis show that on average across participating OECD[5] countries and economies, only slightly more than half of lower-secondary teachers (53%) reported letting students use ICT for projects or class work "frequently" or "always". Looking at the Dutch situation, this was the case for half of the sample representing the Netherlands (51% of Dutch teachers).

As far as their teacher training is concerned, and the preparation towards the use of ICT tools in teaching, "49% of teachers reported that use of ICT for teaching was included in their formal education or training [..]. At the time of the survey, 73% of teachers in Netherlands felt that they could support

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[4] Ths type of lockdown gave to people some freedom of movement. People could go out without wearing masks and keeping the distance (1,5 miters). Outdoor activities (running ans so on) were allowed and there was no curfew. Despite restorants and bars were closed many could deliver their goodies at their customers home, leaving them on the door step.

[5] "The Teaching and Learning International Survey (TALIS) is an international survey of teachers and school leaders on different aspects affecting student learning. The international target population for TALIS 2018 is lower secondary teachers and their school leaders in mainstream public and private schools. For the 2018 survey, 31 OECD and 17 partner countries and economies participated in the study. The TALIS average represents the arithmetic mean across all OECD countries with the exception of Germany, Greece, Ireland, Luxembourg, Poland and Switzerland" (OECD, 2020).

student learning through the use of digital technology (e.g. computers, tablets, smart boards) 'quite a bit' or 'a lot'" (OECD 2021).

Overall, could be deduced that teachers were ready to deliver online education. However, this was not the case as what was delivered to students was emergency teaching and not proper online education. Even the online distance institute placed in the Netherlands: The Open Universiteit struggled to keep up with the amount of work and needs that the pandemic required. The biggest straggle for the Open University of the Netherlands was for instance the exames, which needed all to be handled safely online, (for more detail related to the OUNL check this article https://www.scienceguide.nl/2020/06/omarm-digitale-didactiek-en-ga-het-gesprek-aan-met-de-techgiganten/). While for traditional university teachers there was the need of adopting to a new methodology and design of learning, without no time to do any research on it and have guidance. As a result, in the Netherlands what the majority of teachers delivered was emergency teaching which is far from online distance education. Investments, however, have been allocated to speed up the digitalization of education , more details about it can be found in the following links (https://www.versnellingsplan.nl/en/about-acceleration-plan/ and in the dedicated section of this document

Readiness of Dutch students

The readiness of students is strictly connected with availability of a computer to study from home as well as to the availability of the parents to support. "In Netherlands, 92% of students "agreed" or "strongly agreed" that their parents support their educational efforts and achievements[..]". Nevertheless, in some specific socio-demographic groups, the academic support of parents to students might be hindered by language barriers. In Netherlands, 10% of the students reported that the language used at home most of the time is different thank dutch.

As far as the availability of a computer per each student, according to data collected prior to the crisi (2018). "In Netherlands, 95% of students reported having a computer they could use for school work[...] 97% of students reported having a quiet place to study at home, which is higher than the OECD average (91%)[...]. Much like access to computers, access to a quiet place to study may also have deteriorated during the crisis due to similar needs by parents for teleworking, and siblings for home schooling" (OECD 2020)

In the summer 2020 many Dutch university students manifest for going back to campus and for their right to access to quality education, furthermore many lamented a delay in their carrier that will impact on their study loan. Opposite case was reported by van der Velde, M., Sense, F., Spijkers, R., Meeter, M. & van Rijn H. (2021) for the secondary education level.

3. Technological infrastructure for digital teaching and learning

As a results of the pandemic, innovative approaches were introduced in the use of digital technologies. In the above-mentioned European survey, results indicate that radical shift from face-to-face to hybrid or online teaching has meant that both teachers and students have had to replace blackboards, notebooks and pens with digital tools. The devices most used by teachers to teach at the European level are, primarily, Windows-based laptop computers (69%), followed by smartphones (24%). In addition, 10% make use of a digital pen and 7% of a pen tablet. In terms of software, the favorites are online meeting platforms (77%) and the creation of presentations (67%), followed by text programs such as Word, (65%), PDF editing (55%), Google for Education (42%) and digital whiteboard programs (38%). Most of this digital culture remains, to the point that certain digital and communication tools continue to be used in very innovative ways when back to face-to-face.

Below we present a brief overview of the current situation in the partners' countries.

The case of Albania

The academic year 2021-2022 is the third consecutive year that Albanian students do not have the opportunity to have a regular education. Starting from the restrictive measures of March 2020, which suspended almost an entire academic year in presence and also creating difficulties for distance learning due to the lack of technological tools owned by Albanian families, today primary and secondary school uses distance learning as the main tool to allow education for all children and adolescents. Despite this, the start of the academic year 2020-2021 had several interruptions caused by a series of announcements and counter-announcements caused by the dynamic of the health emergency.

In order to ensure continuity in primary, secondary and academic education, the Minister of Education implemented three scenarios to allow a return to normal:

- combined teaching;
- in school and online; and
- online learning only.

By following these guidelines, the lessons are conducted depends on the spread of the virus and on the infrastructures provided by the schools by the Government.
According to Susanto et al. (2020) the use of information technology in teaching and learning activities appropriately is expected to be able to make the learning process more meaningful, given the various potential of information technology to support teaching and learning activities. By following this approach, with the presence of technology there is no other choice for the world of education than taking part in utilizing it, which now allows for a wider communication process.

Today, in Albania school education needs a more availability (in quantity and quality) of technological tools to support distance learning.

In Albania, after the lockdown of March 2020, schools re-opened physically in September 2020, but with the growth of infections by COVID-19, during the academic years 2020-2021 and 2021-2022, several pre-university classes have combined online and face-to-face teaching. The Minister of Education drafted new guidelines to assist school leaders and teachers in lower secondary education and in upper secondary education, which will guide them in relation to the period of development of teaching topics for repetition:

- teachers' flexibility in developing repetition topics;
- curriculum planning for the school year 2021-2022;
- facilities, number of students per class, teaching aids for the development of repetition topics;
- cooperation with parents;
- creating a supportive and encouraging climate for students during the development of repetition topics;
- the methodology that can be followed by teachers during the development of repetition topics;
- teaching aids that can be used by students and teachers;
- attendance and assessment of students during the development of repetition topics.
- The documentation that teachers can keep for students' achievements and for their attendance during the development of repetition topics;
- repetition topics for each class and subject.

Digital technology promotes a new vision for students based on a more dynamic and knowledge-based model rather than a centralized, one-size-fits-all, knowledge-based model (Gros, 2016). According to Alfoudari et al. (2021) digital technology transforms classrooms into intelligent classrooms, which structures learning pathways to meet the needs of students. Obviously, to use technology in the classroom, an elementary level of ICT infrastructure (a computer system - video projector with Internet access) is required in order to be able to adopt digital material and create benefits for the teacher and students (Apostolou, 2020) .

The new school year in Albania foresees, as in previous years, the obligation on the part of students and teachers to use masks, to measure the temperature before entering school, to disinfect the environment and to ventilate the classroom frequently. According to Che et al. (2021) the design of the airflow deflectors installed on the windows is critical to ensure efficient airflow distribution and reduce the risk of covid infection.

The case of Italy

In Italy the situation regarding the technical infrastructure in schools is very jeopardized and the authorities are going to monitor this phenomenon in order to provide the picture of the digital approach in schools. Two main studies are delivered by the Authority of Communication Guaranties (AGCOM) supported by Esri Italia and from INDIRE.

Esri Italia, in collaboration with the Authority of Communication Guaranties (AGCOM), has published the "Connected Schools" map, which tells the state of digitization in Italian schools. The data made available by AGCOM concern 73,351 Italian Institutes of all kinds and levels and are open-data.

The digitization of the school system in Italy is an extremely complex process. From the analysis conducted by AGCOM which aims to measure the level of digital infrastructure in schools, the existence of significant gaps related to the territory, grade and size of the school complexes emerged.

In order to create a digital school development, at least three main issues must be considered:

1. The existence of an ultra-broadband internet connection.
2. The creation of an efficient telematic network.
3. A maintenance and updating activity to monitor the effect of technological aging.

From the analysis it appears notable that simple Internet connections are not enough but it is necessary to focus on ultra broadband lines: in this regard it is striking that there are still 3% of school buildings - mainly belonging to primary school and located for the most part in southern Italy, which are devoid of any connection.

For a complete view of the map please use the following link:
https://esriitaliatm.maps.arcgis.com/apps/opsdashboard/index.html#/6f8c72aed0ee46738c2c29aa8482db7c

Regarding the number of Institutes mapped, the most evident data that emerges is that on a national level only 17% use an FTTH connection, compared to 42% of use of FTTC technology.

For the terminology we better describe the concepts of FTTH and FTTC. FTTH stands for Fiber To The Home and indicates the fastest option. With FTTH technology, the user has access to optical fiber and, in this case, in the Institute and in every environment, you can have very high performance. It is also called hyperfibre and reaches speeds of 1 Gigabit per second in download and upload, allowing for very fast transmission of even files.

FTTC stands for Fiber To The Cabinet, or “fiber up to the cabinet” (ie the street cabinet, from where the copper cables leading to the individual buildings then unravel). The FTTC technology is therefore mixed, it is presented in fiber up to the street cabinet and continues in copper up to the school. Much more common in school complexes, it does not offer the performance of "pure" fiber, as it still requires a piece of path (usually 300-500 meters) on the old cables. It is therefore clear that in order to allow teachers to operate with maximum technological performance, it is necessary to equip all institutes with an FTTH fiber.

Another particularly relevant study was developed in June 2020 by a research group of INDIRE (National Institute of Documentation for Innovation and Educational Research) which conducted a survey aimed at Italian teachers, in order to know the didactic practices implemented. from schools during the spring lockdown.

3,774 teachers responded voluntarily to the survey - 3,195 women and 579 men - distributed as follows by school order: 10% belonging to kindergarten; 29.8% in primary school; 21.8% in lower secondary school and 38.4% in upper secondary school.

The results of this survey were published in two successive moments: at the end of July 2020, a first preliminary report was released with the aim of providing the Ministry of Education and school institutions, in the shortest possible time, with the answers of the teachers to the in order to better evaluate the decisions to be taken for the start of the 2020/21 school year; at the beginning of December 2020, an additional report was published which, through a more in-depth data processing, correlates the types of teachers' answers and identifies useful trends to make a more complete picture of the "DaD phenomenon". In Italy is used the acronym DaD (Didattica a Distanza – English translation: Distance Teaching).

Among the most significant results of the study certainly emerges the extensive use of "videoconference lessons", widespread in all levels of school, (89.7% in primary school, 96.7% in lower secondary school and 95.8 % in upper secondary school), combined with the "allocation of resources for study and exercises" to be carried out independently (79.8% in primary school, 78.7% in upper secondary school, 80% in lower secondary school). The frontal lesson is more popular in the higher orders, with 73% of teachers practicing this modality in lower secondary school and 71% in upper secondary school, and it is less in lower levels, in line with the cognitive commitment of the little ones.

It is evident, at least in the initial phase, the attempt to replicate the transmissive model of the face-to-face lesson, with the assignment of tasks for individual study and study at home.

Another interesting result that emerged relates to the teaching methods used by the teachers during the lockdown. The study denotes a group of teachers as “laboratory teachers”. The group of laboratory teachers corresponds to 14.5% of the sample (549 subjects based on 3,774 data), which grows with the increase in school grades, placing themselves above all in lower secondary schools. In the category of "laboratories" are placed teachers who declare that they have simultaneously carried out "research and laboratory activities" in a digital and offline environment: these are more expressive practices than an active, collaborative type of teaching aimed at the development of critical thinking and metacognition. Attention to the development processes of metacognition, the critical spirit and self-regulation methods represent a specificity of the laboratory teachers that has a consequent impact also on the evaluation aspects.
The study also shows a mix between the use of teaching methods through formal and informal channels. This is one of the issues that forced distance teaching has brought to the attention of the scientific community. The intertwining of formal and informal, which is widely desired and recognized internationally, was consolidated during the pandemic period. In the disorientation of the initial phase of distance learning, many teachers have often used the communication channels that best suited their educational needs and their specific target of learners, sometimes even overcoming the rules relating to privacy and the processing of sensitive data, especially in the case of underage students.

A very interesting case is the one that emerges from the use of Whatsapp as the most used technological application during the lockdown: 61.7% of respondents declared that they had used this application. This is a very high rate, especially when compared with 77.6% of the answers reported in reference to the use of the electronic register, the "official" tool used by the schools even before the lockdown and obviously strengthened during the emergency period.

Clearly WhatsApp cannot be considered as a suitable tool for structuring distance learning. WhatsApp represents a valid system for joining formal and informal learning, therefore in practice to quickly send a file, share information. But often the use of WhatsApp has occurred above all given the initial emergency and the lack of confidence with learning platforms.

Those schools that already had a good technical infrastructure, were able to cope better with the situation caused by the pandemics. Not to mention the double scheme present in Spain, in which compulsory education (pre-primary, primary and secondary school) can be run publicly or privately (in all cases teachers' salary is paid by the regions). Infrastructure can be better in the private schools but not necessarily.

As previously mentioned, children received during the course 2021-22 a laptop (usually a PC with 12" screen, sometimes a tablet) to be used both at home and in the classroom. This means that both the public and private sector is fully digital in this respect. However, the quality of access to Internet at home, varies, according to the socio-economic differences of families. Some schools provided access to the schoolbooks in digital format, but usually books continue to be on paper since parents had to pay the license.

Technological infrastructure was a huge challenge for schools during the outbreak of COVID-19. Educational institutions had to ensure the connectivity and the access to hardware for students in their homes and on premises. According to Trujillo et al. (2020) on their report on education in Spain, it was one of the biggest concerns for primary education teachers (67,2%) along with having more teachers to meet the health recommendations or hygiene and security. For kindergarten teachers, it was the other way around. This was felt more in public schools than in the private ones. In the report "Escoles confinades" (2020) that focused on Catalonia region (Spain), Tarabini and Jacovkis (2020) found that the volume of technological infrastructure could not be understood without considering the socioeconomic composition of schools, as student from low-income communities attended schools with less technological resources as their peers from medium or high-income families. They also noticed that secondary education schools had more technological infrastructure than K-12 schools.

They found that cellphones were the most extended hardware among families (more than 89%) whereas having more than one computer at home was only the case of 34,5% of students, and having a laptop, a cellphone or tablet per student was the case of 31,5% of students, according to the surveyed teachers.

Schools had also to adopt new organizational measures to meet the health requirements. Trujillo et al. (2020) suggested operational and social actions in this regard. The first ones are the adjustments of time and spaces in schools, teacher training and the use of open-air spaces for teaching -we must bear in mind this suggestion was made before massive vaccination-, and a digitization plan or assessment. The latter are proposed to make schools as a social learning ecosystem to enhance relationships with families and their engagement in learning processes, collaboration and knowledge exchange within schools and establishing collaboration networks among teacher and other agents, to detect teacher champions that serve as role-models among others.

The case of The Netherlands

The Netherlands is a compact, highly developed, and well-organised country with excellent physical and digital infrastructures. This special combination of characteristics gives to this country the unique opportunity to be at the forefront of educational innovation worldwide. Investment from the government have been provided to speed up the digitalization of education, which was already on a good level in 2011[6].

The availability of information and communication technologies (ICT) made possible distance teaching. However, both teachers and students need to be very familiar with these technologies and their use in order for them to be effective. As illustrated above despite the good infostructure and the previous training on the use of educational technologies, both online and traditional teachers faced big challenges in performing quality online education.

Overall these investments aim at improving the infrastructure of Duch schools and universities as well as supporting the investment that teachers in training sustain (more info here: https://www.government.nl/topics/secondary-vocational-education-mbo-and-higher-education/tuition-fee-refund-and-loan/plan-to-halve-higher-education-tuition-fees).

In the next future all educational institutions in the Netherlands will make (substantial) investments in digitisation and educational technologies. The reasons that move this choice are not only related to the pandemic, even though the situation has accelerate this movement.

"Technology can contribute to the realisation of more accessible and tailor-made education" [7], furthermore enable a more flexible education for students in need to combine work, life and study. Lasty but not less important the use of

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[6] https://ec.europa.eu/information_society/newsroom/image/document/2018-3/netherlands_country_profile_2FE28D05-0DDC-4AEB-3400625E40C86921_49448.pdf
[7] https://www.versnellingsplan.nl/en/about-acceleration-plan/

learning analytics or data in general can be or great use for research and the improvement of education as a whole.

This Acceleration Plan involves Dutch universities, colleges and SURF in a four-year programme (2019 to 2022). It is and is based on three ambitions:

a) Improving the connection to the labour market;
b) Stimulating the flexibility of education;
c) Smarter and better learning with technology.

The Acceleration Plan also strengthens the position of Dutch higher education in an international context when it comes to educational innovation with technology. Especially the national cooperation that characterises the Acceleration Plan is unique in an international context.

4. Teaching practices in teacher education

Since the widespread of digital technologies, several pedagogical methods have been sought to integrate them and enhance educational processes. All of them have been identified and explained in different yearly reports such as Innovating Pedagogy (the Open University, UK) or Horizon Report (formerly developed be The New Media Consortium, and currently carried out by Educause).

The pandemic had an impact on teaching and on students' learning as has been identified in several international reports (Sianes-Baptista & Sánchez-Lissen, 2021). School lockdowns in 2020 had brought what is known as Emergency Remote Teaching (ERT) where there is a lack of techno pedagogical, organizational, and infrastructural planning (Hodges & Moore, 2020). Nevertheless, K-12 teachers have expanded their digital teaching skills and have been able to participate and get familiar with fully on-line learning settings and blended learning, the latter being the one that combines presence with different kinds of virtual learning (Hrastinski, 2019).

Next, we outline eight teaching practices that can be used in such virtual educational settings, flipped classroom (or flipped learning), inquiry-based learning (IBL) practices, lecturing and direct instruction, Interactive digital resources (& computer assisted instruction), Interactive digital resources (& computer assisted instruction), Computer-supported collaborative learning (CSCL), Gamification & Game-based learning, synchronous and asynchronous discussions, and cloud learning. Although there are presented separately, they can be mixed in many ways. On section 3 -on creativity- some insights will be outlined regarding how to use digital technologies following different pedagogical methods.

Flipped classroom

Concept

Flipped classroom, also known as flipped learning, is a teaching practice that takes advantage of the blended learning approach. It displaces direct instruction, that traditionally occurred in classrooms, outside of the classroom. Teachers prepare and/or select different teaching materials - instructional videos, screencast recordings, tutorials, lectures, readings...- so that students can watch them at home, at their pace, individually. And in the classroom, students can talk about together about these materials doing group work, discussions, and promoting peer feedback, under the teacher guidance. According to Tourón (2021) the traditional classroom has been flipped and the role of the teacher is not the "sage on the stage but a guide on the side" (King, 1993).

Innovating pedagogy report from 2014 (Sharples et al., 2014) points out that this practice would have a high impact between 2 to 5 years. As the CoVID 19 pandemic implied some sort of blended learning, flipped classroom has become more popular in formal education settings, from Primary Education to Higher Education.

Experiences

In a study of Campillo Ferrer et al. (2019), flipped classroom has been used in primary education for teaching social science courses and it showed better results than the traditional classroom approach. Similar results were found in a study of Van Wyk (2019) in Teacher Education which adds that such a teaching approach empowers self-directed learning skills among teacher education students. They also found it can be a driver for an alternative assessment strategy that provides consistent ongoing feedback.

Digital Competences (DigCompEdu)

Area 1: Professional Engagement

- 1.2- Professional collaboration

Area 2: Digital Resources

- 2.1-Selecting
- 2.2-Creating and modifying
- 2.3-Managing, protecting, sharing

Area 3: Teaching and Learning

- 3.1-Teaching
- 3.4-Self-regulated learning

Area 5: Empowering Learners

- 5.1-Accesibility & inclusion
- 5.2-Differentiation & personalization
- 5.3-Actively engaging learngers

Area 6: Facilitating Learners' Digital Competence

- 6.1-Information & Media literacy

Digital competences (Digcomp 2.0)

1. Information and data literacy

1.2 Evaluating data, information, and digital content to analyze, compare and critically evaluate the credibility and reliability of sources of data, information and digital content. To analyze, interpret and critically evaluate the data, information and digital content.

1.3 Managing data, information and digital content to organize, store and retrieve data, information and content in digital environments. To organize and process them in a structured environment.

Inquiry-based learning (IBL)

Concept

Inquiry-based learning (IBL) is an umbrella term used to describe inquiry-based learning approaches. It is an active learning approach where student exploration and inquiry guide the learning experience and all learning resources and activities are designed to support the inquiry process (Levy, 2014). Thus, the IBL is based on questions and on the scientific process so that students acquire a personal experience with scientific research: identifying and asking questions, designing, and conducting investigations, analyzing evidence, using models and explanations, and communicating results.

This approach may include problems (problem-based learning or PBL) or case studies, fieldwork investigations, experiential learning, project work, and research projects of different types from smaller to larger scale.

Inquiry-based learning environments can be characterized in an increasing range of openness going from more structured and directed to more guided and open. In the former, the inquiry question and even the methods are provided by the teacher themself, while in the latter, it is the students who choose the resolution methods and can even formulate the questions. They can be classified as follows, from more directed inquiry to less directed inquiry: Confirmatory inquiry, directed inquiry, guided inquiry, open inquiry

Experiences

In a study of van Uum et al. (2017) results show that after the introduction of scaffolds by the teacher, pupils were able and willing to apply them to their inquiries, promoting pupils' scientific understanding. Scaffolding is necessary in IBL processes as young pupils haven't yet developed enough autonomy and self-directed learning skills. IBL was used with positive results to foster Physics learning among 6th graders in the study of Petropoulou et al. (2017) where they used the digital laboratory device 'Labdisc Enviro'. IBL approach can be adopted with a flipped classroom modality as it was studied by Loizou and Lee (2020).

Digital Competences (DigCompEdu)

Area 1: Professional Engagement

- 1.2- Professional collaboration

Area 2: Digital Resources

- 2.1-Selecting
- 2.2-Creating and modifying
- 2.3-Managing, protecting, sharing

Area 3: Teaching and Learning

- 3.1-Teaching
- 3.2-Guidance
- 3.3-Collaborative learning
- 3.4-Self-regulated learning

Area 4: Assessment

4.1-Assessment strategies
4.2-Analysing evidence
4.3-Feedback & Planning

Area 5: Empowering Learners

- 5.1-Accesibility & inclusion
- 5.2-Differentiation & personalization
- 5.3-Actively engaging learners

Area 6: Facilitating Learners' Digital Competence

- 6.1-Information & Media literacy
- 6.2-Communication
- 6.5-Problem solving

Digital competences (Digcomp 2.0)

1. Information and data literacy

1.1 Browsing, searching and filtering data, information and digital content To articulate information needs, to search for data, information and content in digital environments, to access them and to navigate between them. To create and update personal search strategies.
1.2 Evaluating data, information and digital content To analyse, compare and critically evaluate the credibility and reliability of sources of data, information and digital content. To analyse, interpret and critically evaluate the data, information and digital content.
1.3 Managing data, information and digital content To organise, store and retrieve data, information and content in digital environments. To organise and process them in a structured environment.

2. Communication and collaboration

2.1 Interacting through digital technologies To interact through a variety of digital technologies and to understand appropriate digital communication means for a given context.

2.2 Sharing through digital technologies To share data, information and digital content with others through appropriate digital technologies. To act as an intermediary, to know about referencing and attribution practices.

2.4 Collaborating through digital technologies To use digital tools and technologies for collaborative processes, and for co-construction and co-creation of resources and knowledge.

Lecturing and direct instruction

Concept

Lecturing and direct instruction is related to the traditional teaching method where teacher provides content to students through explanations (a lecture). This method can be complementary to discovery learning or to more constructivist approaches such as IBL. Barack Rosenshine (2010) established 10 principles of instruction: Daily review (of previous learning), present new material using small steps, ask questions to check comprehension, provide models (examples, demonstrations), guide student practice, check for student understanding, obtain a high success rate, provide scaffolds for difficult tasks, require and monitor independent practice, engage students in weekly and monthly review of taught contents.

Experiences

In blended learning situations that the pandemic has created, this kind of practices have occurred online using videoconferencing tools (i.e. Zoom, Google Meet, Jitsi Meet, etc.). According to the study of Jiménez-Olmedo et al. (2020), this lecturing approach through video can be improved by fostering team learning and collaboration

Digital Competences (DigCompEdu)

Area 1: Professional Engagement

- 1.2- Professional collaboration

Area 2: Digital Resources

- 2.1-Selecting
- 2.2-Creating and modifying
- 2.3-Managing, protecting, sharing

Area 3: Teaching and Learning

- 3.1-Teaching
- 3.2-Guidance
- 3.4-Self-regulated learning

Area 4: Assessment

4.1-Assessment strategies
4.2-Analysing evidence
4.3-Feedback & Planning

Area 5: Empowering Learners

- 5.1-Accesibility & inclusion
- 5.3-Actively engaging learners

Area 6: Facilitating Learners' Digital Competence

- 6.2-Communication

Digital competences (Digcomp 2.0)

1. Information and data literacy

 1.3 Managing data, information and digital content to organize, store and retrieve data, information and content in digital environments. To organize and process them in a structured environment.

2.Communication and collaboration.

 2.1 Interacting through digital technologies To interact through a variety of digital technologies and to understand appropriate digital communication means for a given context.

 2.4 Collaborating through digital technologies: To use digital tools and technologies for collaborative processes, and for co-construction and co-creation of resources and knowledge.

Interactive digital resources (& computer assisted instruction).

Concept

There is a plethora of digital educational resources for teachers to use in their lessons. Some of them are open educational resources (OER) that can be accessed at no cost. These can be found in several databases that have them classified with metadata to optimize their search. We find them in databases such as OER commons or Khan Academy at an international level, or resources (INTEF in Spanish or XTEC in Catalan).

These resources can be very helpful when following a flipped classroom methodology because teachers can select already existing resources as teaching materials for students to check out at home. But they can also be helpful for IBL approaches as preselected resources can be preferable to give to primary education students, which are still not yet skilled in digital information literacy. Having these resources available to students can offer a clear learning path and even help fostering formative assessment. Some of them offer even autocorrective questions that teachers allow the possibility to monitor students' comprehension individually.

Experiences

Programs such as *Exelearning* which are open source let teachers create their own instructional sequences that following instructional design principles (Merrill, 2001), can guide learners through the learning contents and even include drilling and practice assessment activities: 1- involve a pedagogically designed task (Task-centered Principle), 2- activate previous knowledge or relevant experiences (Activation Principle), 3- Give a demonstration, example or model (Demonstration Principle), 4- Apply new knowledge (Application Principle), 5- Integrate new knowledge into students' daily practice (Integration Principle).

Programs like Nearpod allow these sequences to happen fully online in a synchronous or an asynchronous mode. These resources can integrate different kinds of learning activities to activate prior knowledge, for prompting, to give experience, to facilitate, to make demonstrations or give models and to ask questions (Hung et al., 2018)

Digital Competences (DigCompEdu)

Area 2: Digital Resources

- 2.1-Selecting

- 2.2-Creating and modifying
- 2.3-Managing, protecting, sharing

Area 3: Teaching and Learning

- 3.1-Teaching
- 3.2-Guidance
- 3.3-Collaborative learning
- 3.4-Self-regulated learning

Area 4: Assessment

4.1-Assessment strategies
4.2-Analysing evidence
4.3-Feedback & Planning

Area 5: Empowering Learners

- 5.1-Accesibility & inclusion
- 5.2-Differentiation & personalization
- 5.3-Actively engaging learners

Digital competences (Digcomp 2.0)

1. Information and data literacy

1.2 Evaluating data, information and digital content To analyze, compare and critically evaluate the credibility and reliability of sources of data, information and digital content. To analyze, interpret and critically evaluate the data, information and digital content.
1.3 Managing data, information and digital content To organize, store and retrieve data, information and content in digital environments. To organize and process them in a structured environment.

Computer-supported collaborative learning

Concept

Computer-supported collaborative learning is defined by Suthers (2012) as "the activity of peers interacting with each other for the purpose of learning and with the support of information and communication technologies (ICT)".

Under a sociocultural perspective, learning happens socially (Dillenbourg et al, 1996). Students must be active to interact with learning materials and between peers, and even work in groups to collaboratively build knowledge. According to Roschelle and Teasley (1995), cooperation entails the division of tasks among participants, where each is responsible of a portion of a problem to be solved. Collaboration refers to the mutual implication of participants to solve a problem in together.

Experiences

In a study of Barajas et al. (2018), they found that the use of wiki environments (collaborative edition, discussion, content development tracking, and version management) fostered collaboration. Students became involved in problem solving and collective decision making where democratic classroom practices were developed. Moreover, wikis fostered learner-centered teaching practices and teachers' classroom role changed, from a leading role to observers and moderators. This practice helped students strengthen their information literacy skills.

In a study based in Estonia, Rannastu-Avalos (2020) found that the technologies available to teachers for distance education, as well as current pedagogies do not social presence (the ability to communicate socially with technology tools), and thus are unhelpful in facilitating collaborative activities online.

Digital Competences (DigCompEdu)

Area 1: Professional Engagement

- 1.2- Professional collaboration

Area 2: Digital Resources

- 2.1-Selecting
- 2.2-Creating and modifying
- 2.3-Managing, protecting, sharing

Area 3: Teaching and Learning

- 3.1-Teaching

- 3.2-Guidance
- 3.3-Collaborative learning
- 3.4-Self-regulated learning

Area 4: Assessment

4.1-Assessment strategies
4.2-Analysing evidence
4.3-Feedback & Planning

Area 5: Empowering Learners

- 5.1-Accesibility & inclusion
- 5.2-Differentiation & personalization
- 5.3-Actively engaging learners

Area 6: Facilitating Learners' Digital Competence

- 6.1-Information & Media literacy
- 6.2-Communication
- 6.4-Responsible use
- 6.5-Problem solving

Digital competences (Digcomp 2.0)

2. Communication and collaboration

2.1 Interacting through digital technologies o interact through a variety of digital technologies and to understand appropriate digital communication means for a given context.

2.2 Sharing through digital technologies. To share data, information and digital content with others through appropriate digital technologies. To act as an intermediary, to know about referencing and attribution practices.

2.4 Collaborating through digital technologies. To use digital tools and technologies for collaborative processes, and for co-construction and co-creation of resources and knowledge.

Gamification & Game-based learning

Concept

Games (and videogames are very popular among kids and teenagers. Although they are used in the free time and in informal contexts, they have been appraised for being integrated in educational formal contexts to enhance learning processes. Games and videogames were considered in the 2012 and 2014 Horizon Reports (Johnson et al, 2014) and in 2016 Innovative Pedagogy Report (Sharples et al., 2016) as an innovative trend in education.

Gamification is the use of game-like features into a context different than a game, such as educational activities. Example of game features/elements are rewards (points, perks), badges to acknowledge skills, time limits to finish tasks, collaboration, a problem to be solved in some sort of mission, competition amongst groups and individuals, etc.

Experiences

Serious Games such as Minecraft Education Edition or Assassin's Creed Discovery Tour have been adopted in formal education for teaching curricular concepts, facts and cross curricular skills using a story that unfolds a problem to be solved through strategy and decision making and fostering motivation and engagement. As long with Minecraft we find Roblox as a platform for creating and sharing videogames.

In a study of Pozo Sánchez et al. (2020), they found that integrating gamification-based assessment using a flipped classroom methodology enhanced motivation and interactions with secondary education students and with teachers in the face-to-face phase. Sánchez-Rivas et al. (2018) applied gamification strategies in examination of primary education students of a science course and found that it improved teachers' perception of their students' motivation towards assessment tests and increased the engagement with the tests outside the school context.

Digital Competences (DigCompEdu)

Area 2: Digital Resources

- 2.1-Selecting
- 2.2-Creating and modifying
- 2.3-Managing, protecting, sharing

Area 3: Teaching and Learning

- 3.1-Teaching

- 3.2-Guidance
- 3.3-Collaborative learning
- 3.4-Self-regulated learning

Area 4: Assessment

4.1-Assessment strategies
4.2-Analysing evidence
4.3-Feedback & Planning

Area 5: Empowering Learners

- 5.1-Accesibility & inclusion
- 5.2-Differentiation & personalization
- 5.3-Actively engaging learners

Area 6: Facilitating Learners' Digital Competence

- 6.1-Information & Media literacy
- 6.2-Communication
- 6.5-Problem solving

Digital competences (Digcomp 2.0)

3. Digital content creation

3.1 Developing digital content to create and edit digital content in different formats, to express oneself through digital means.

3.2 Integrating and re-elaborating digital content to modify, refine, improve and integrate information and content into an existing body of knowledge to create new, original and relevant content and knowledge.

3.4 Programming To plan and develop a sequence of understandable instructions for a computing system to solve a given problem or perform a specific task.

5. Problem solving

5.3 Creatively using digital technologies To use digital tools and technologies to create knowledge and to innovate processes and products. To engage individually and collectively in cognitive processing to understand and resolve conceptual problems and problem situations in digital environments.

Synchronous/asynchronous discussions

Concept

Blended learning and on-line learning modes enable synchronous and asynchronous discussions using videoconference and forum tools. Both modes of discussion have their benefits and limitations. The first enables students to catch all the nonverbal and social cues during communication. This can help social bonding and students' interaction (Peterson et al., 2018). The latter gives more flexibility for students' participation as they can prepare their messages before posting them. As a drawback, in asynchronous discussions, feedback is not immediate and social cues can only be perceived from what it has been written.

Discussions must be guided and scaffolded by teachers. For instance, to facilitate a reading guide can be useful to start a discussion about a reading. It can introduce the text, putting it in context, and ask questions to students so that they can have them in mind during the reading. Moreover, it can help structure the online discussion or debate. Also, a set of rules to participate in asynchronous discussions can be very helpful to guide participation (number of words, use of discussion threads, replies, deadlines to participate, netiquette, etc.).

Experiences

Wang & Wang (2021) provided evidence supporting the importance of interaction in online learning and the synchronous mode was seen as an important factor related to the pre-service teachers' connection to peers.

According to Swaggerty & Broemmel (2017), course design should enable opportunities to communicate and collaborate synchronously and asynchronously in various configurations (one-on-one, small group, whole group). Teachers can elicit the value and purpose of these interaction opportunities afforded by discussion spaces to facilitate the creation of a community.

Digital Competences (DigCompEdu)

Area 1: Professional Engagement

- 1.2- Professional collaboration

Area 2: Digital Resources

- 2.1-Selecting
- 2.2-Creating and modifying

- 2.3-Managing, protecting, sharing

Area 3: Teaching and Learning

- 3.1-Teaching
- 3.2-Guidance
- 3.3-Collaborative learning
- 3.4-Self-regulated learning

Area 4: Assessment

4.1-Assessment strategies
4.2-Analysing evidence
4.3-Feedback & Planning

Area 5: Empowering Learners

- 5.1-Accesibility & inclusion
- 5.2-Differentiation & personalization
- 5.3-Actively engaging learners

Area 6: Facilitating Learners' Digital Competence

- 6.1-Information & Media literacy
- 6.2-Communication
- 6.3-Content creation
- 6.4-Responsible use
- 6.5-Problem solving

Digital competences (Digcomp 2.0)

2. Communication and collaboration.

2.1 Interacting through digital technologies to interact through a variety of digital technologies and to understand appropriate digital communication means for a given context.

2.4 Collaborating through digital technologies to use digital tools and technologies for collaborative processes, and for co-construction and co-creation of resources and knowledge.

Cloud learning

Concept

Bai et al. (2011) defined cloud learning as a "concept inspired by cloud computing, emphasizing learner-centered, resource sharing, collaboration among learners, to jointly build personalized learning environment" (p. 3461). Cloud computing enables different kinds of software as a service that can be accessed and used ubiquitously. Learning Management Systems (LMS) can be set on cloud servers (such as Microsoft Azure).

Cloud learning is closely related to mobile learning (m-learning), making it easier for students to access to learning materials and courses using their mobile devices. It makes it easier for teachers to manage virtual classroom settings (Wang et al., 2014).

Experiences

According to Chang et al., (2018), "cloud services can provide great value and impacts in various learning and teaching settings, from individual self-directed learning scenarios to group learning activities in MOOC environments"[8]. The same authors cite several cloud-based applications (MOOCMAKER, 2016) that are used in education such as course design tools, content creation tools (i.e., Google docs), collaboration tools (i.e., Google apps, Mindmeister, Whatsapp, etc.), assessment and feedback tools (i.e., Quizlet).

We also find platforms such as Nearpod that allow teachers to design their learning sequences or lessons that integrate learning analytics to monitor students learning. Also, we find applications such as Kahoot help teachers gamify assessment processes in online or mobile learning settings.

Digital Competences (DigCompEdu)

Area 1: Professional Engagement

- 1.1-Organisational communication
- 1.2- Professional collaboration

Area 2: Digital Resources

- 2.1-Selecting
- 2.2-Creating and modifying

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[8] MOOC is intended for Massive Open Online Course. More in particular, MOOC is the first example of the fast adoption of new technologies for distance learning described by the Gartner Hype model (Baggaley, 2014; Daniel, 2013)

- 2.3-Managing, protecting, sharing

Area 3: Teaching and Learning

- 3.1-Teaching
- 3.2-Guidance
- 3.3-Collaborative learning
- 3.4-Self-regulated learning

Area 4: Assessment

4.1-Assessment strategies
4.2-Analysing evidence
4.3-Feedback & Planning

Area 5: Empowering Learners

- 5.1-Accesibility & inclusion
- 5.2-Differentiation & personalization
- 5.3-Actively engaging learners

Area 6: Facilitating Learners' Digital Competence

- 6.1-Information & Media literacy
- 6.2-Communication
- 6.3-Content creation
- 6.4-Responsible use
- 6.5-Problem solving

Digital competences (Digcomp 2.0)

2. Communication and collaboration

2.1 Interacting through digital technologies to interact through a variety of digital technologies and to understand appropriate digital communication means for a given context.

2.2 Sharing through digital technologies to share data, information, and digital content with others through appropriate digital technologies. To act as an intermediary, to know about referencing and attribution practices.

2.4 Collaborating through digital technologies to use digital tools and technologies for collaborative processes, and for co-construction and co-creation of resources and knowledge.

O1. A2

Design of BLUE ARROW pedagogical framework

1- Introduction

Based on the results achieved in the O1.A1, a first proposal is elaborated for the model of application of Tangible User Interfaces and digital creativity for distance learning. The pedagogical model is drafted considering a general approach re-applicable in more context of teacher education, but mainly devoted to pre- primary and primary education applying digital creativity and the Tangible User Interfaces approach. The pedagogical framework is aimed at the improvement of competences of pre-primary and primary teachers about distance teaching, as a response to the COVID-19 situation (O1).

The primary target of the pedagogical framework are the teacher educators in HEIs, but it considers the impact on pre-service and in-service teachers of kindergartens and primary schools in improving their competences in teaching with distance and innovative tools. This framework is aimed to represent a guideline in order to implement digital creativity and tangible games using different methodologies in the distance teaching. This pedagogical framework stimulates the development of new courses in Teacher Education boosting distance and blended teaching for children between 4 and 7 years old, something fundamental in response on COVID-19 situation but appliable also in normal periods.

Section 2 introduces a set of guidelines for the application of digital creativity in teacheing and learning that can be applied to manipulative technologies such as TUI.

Section 3 sets a framework that connects these creative practices for teaching and learning with the EU teachers' digital competences framework DigcompEdu.

Section 4 extensively describes the use of TUI in pre-primary and primary education, eliciting their educational advantages. The framework includes the application of exercises performed with a multisensory approach that are directly connected with the digital tool; thus, a student will perform exercises (also at home). S/he will experiment practical learning using the real objects that are recognized by the digital component.

Section 5 identifies the inclusion aspects in the application of TUI, namely with a multisensory approach that could involve different senses including smell, taste and touch. The idea is to create inclusive games with a high degree of accessibility.

Section 6 defines the co-creation and co-design approach in order to identify the steps of the co-creation and co-design process of learning activities with TUI.

Finally, section 7 establishes the Blue Arrow project co-creation strategy for the design of learning activities with TUI. The exercises for practical and procedural learning will be drafted by teacher educators, lecturers, and professionals in the specific sector, defining templates that will simplify the collection of ideas and will help the sharing of OERs (exercises).

This pedagogical framework wants to be useful for course developers aimed at application of Tangible User Interfaces (TUIs) and digital creativity in MOOCs.

2- Application of digital creativity in teaching and learning

Creativity is critical for facing the social and economic changes of today's society (Craft, 2013; Beghetto, 2010), as well as for attaining personal development, social inclusion, active citizenship and employment (European Commission, 2008). In addition, the labour market depends increasingly on employees' abilities to work with technologies, as well as to generate innovative ideas, products, and practices (Sefton-Green & Brown, 2014). In this context, digital and creative skills have gained the attention of worldwide policies, and have become important educational objectives (Ferrari, Cachia & Punie, 2009).

Educational research and policies acknowledge the need of enhancing students' creativity. Indeed, it is important that all citizens develop creative skills which would allow them for facing the complexity of the modern society (Beghetto, 2010). Nevertheless, a gap remains between policies and practices, as education often fails to keep pace with creative and digital economies (Sefton-Green & Brown, 2014; Beghetto & Kaufman, 2014). This is mainly because teachers are not prepared for adopting pedagogical strategies that foster creativity.

As mentioned by Beghetto (2010), teachers play a key-role for integrating creativity in the curriculum. Nevertheless, the author identified a series of obstacles to the implementation of creative practices in the classroom, including convergent teaching practices and teachers' negative beliefs towards creativity. Furthermore, educators are not prepared to apply creative teaching strategies which match their institutional and curricular requirements (Lin, 2011).

Creative pedagogies

Creativity and education literature highlights a series of creative pedagogies, i.e. teaching practices which contribute to the development of students' creativity. In a review of 210 pieces of educational research, Davies et al. (2013) mentioned the flexible use of space and time, the study outside the classroom, collaborative and game-based learning approaches, as well as respectful relationships, non-prescriptive planning, and the participation of educators as learners in the classroom activities.

Barajas and Frossard (2018) proposed a set of four main creative pedagogies, each one characterised by different components: (a) learner-centred approaches (matching curricular objectives with students' interests, making learning relevant and engaging, encouraging students' ownership and problem solving, value learning processes above outcomes so to promote students' reflection on their learning trajectory); (b) open-ended ethos (providing space for uncertainty, exploration, and spontaneity in a safe classroom environment); (c) synergistic collaboration (rich collaborative practices based on joint problem solving and collective decision making), and; (d) knowledge connection (linking content to real life situations, bridging different domains and disciplines, and placing knowledge in a wider context).

Manipulative technologies

Manipulatives, in the context of education, are physical tools that engage students in hands-on learning. Based on constructivist theories, the manipulation (i.e. organisation, combination, comparison, etc.) of objects, such as blocks, figures and puzzles, is central to the learning process, as it stimulates multi-sensory experience. Commonly, manipulatives are used to teach STEAM to young students and to bring fun to the learning process (Moyer, 2001). Recent studies show a high level of acceptance of digital manipulatives by teachers and students, as well as a positive impact on learning (e.g., Miglino et al. 2013).

For example, Magic Blocks (Di Ferdinando, Di Fuccio, Ponticorvo, & Miglino, 2015) are RFID tagged logical blocks which children can manipulate in order to perform educational tasks set by a real or a virtual teacher, to stimulate learning of mathematical and logical concepts. LittleBits[9] are small electronics objects, each one with a distinct function (motion, light, sound, sensor, etc.), that easily fit to each other through magnets, used to create electronic circuits. They stimulate the inventive nature of children to create numberless projects, while they learn logic, maths, electronics, but also product design, prototyping and entrepreneurship. Furthermore, digital manipulatives stimulate a Makers attitude, turning students into active creators. Learning in a Makers environment provide opportunities for disrupting students' conventional practices of invention, exploring through play, failure, risk-taking, and refiguring creation as remix and craft (Faris et al., 2018).

[9] https://www.littlebits.com/

Virtual manipulatives, such as WOLFRAM Demonstrations Project[10], Shodor Interactive Activities[11] and Geogebra[12], completely substitute the physical elements. Empirical studies show that virtual manipulatives encourage creativity and increase the variety of solutions that students encounter (Moyer-Packenham & Westenskow, 2013), which is in line with the constructivist theory.

Cubelets[13] and RoboWunderkind[14] enable young children to design and construct robots through manipulatives – mountable blocks that contain the functions of a robot (a switch, a motor, a sensor, etc.). These tools demonstrated to positively change students' attitudes towards STEM and computer science (Correll, Wailes, & Slaby, 2014), as well as to foster critical thinking skills (Gross & Veitch, 2013).

Educational robotics

Educational robotics uses tangible materials to teach a variety of topics, including STEM, literacy, social studies, dance, music and art (Eguchi, 2014). Such teaching strategy enhances students' learning experience through hands-on / mind-on activities integrated with technology. Nowadays, many educational robotics tools are available on the market, including LEGO WeDo[15] and LEGO Mindstorms[16], mBot[17], BeeBot[18], Ozobot[19], Dash and Dot[20]. For the younger learners (age below six years) educational robotics often focuses on learning the basic programming principles, simple logics and mathematics concepts. Commonly, the creation of both hardware and software parts of a robot encourages children to think imaginatively, stimulates them to analyse situations and apply critical thinking in solving real-world problems.

Ina addition, robots can be involved in teaching and learning social skills (Ray & Faure, 2018). Indeed, robotics activities are usually organised in a

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[10] http://demonstrations.wolfram.com/

[11] http://www.shodor.org/interactivate/activities/

[12] https://www.geogebra.org/

[13] https://www.modrobotics.com/

[14] https://robowunderkind.com/en/

[15] https://education.lego.com/en-us/support/wedo

[16] https://education.lego.com/en-us/support/mindstorms-ev3

[17] http://www.makeblock.com/mbot

[18] https://www.bee-bot.us/bee-bot.html

[19] http://ozobot.com/

[20] https://www.makewonder.com/dash

collaborative manner, with small number of students working together to achieve the proposed objectives (Denis & Hubert, 2001). Hence, teamwork and cooperation are an integral part of any robotics project: students learn to express their ideas and listen to those of their peers; all can offer arguments and reach conclusions jointly. Students focus on resolving problems for achieving the goals of their projects and learn from their errors on the way.

Game design and coding

Since Papert first introduced the Logo Programming language and the "Logo Turtle", coding and developing computational thinking skills has become more and more important in today's world, and particularly in education (Bers, 2017). Mass acceptance is enabled by the availability of programming tools which are appropriate for younger learners. Indeed, several visual programming languages using puzzle-like blocks appeared in recent years, such as Scratch[21], Kodu[22] and Alice[23]. Students focus on learning programming concepts and practice a variety of skills (Lye& Koh, 2014), instead of solving syntax problems. Those programming environments, when appropriately integrated in teaching practices, promote exploration, risk-taking and autonomous learning, as well as increase students' motivation (Fowler & Cusack, 2011) and spark students' imagination (Tsur & Rusk, 2018).

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[21] https://scratch.mit.edu/

[22] https://www.kodugamelab.com/

[23] https://www.alice.org/

3- Digital competences (DigcompEdu) and creativity

In order to include the digital creativity component, an adapted version of teachers' competence framework (the well-known DigcompEdu) was proposed by Barajas & Frossard (2018) in project DOCENT[24].

Based on the structure of the DigCompEdu framework, the adapted version considers the professional and pedagogical competences of educators, as well as the development of students' competences. As shown in Figure 1 below, it is divided into six areas and includes a total of 19 competences:

1. Area A refers to teachers' professional environment, i.e. their use of technologies to collaborate with the different members of the educational community, as well as for their professional development;
2. Area B focuses on the competences required to identify, select, create and share digital creative resources;
3. Area C addresses digital creative pedagogies, i.e., the use of digital technologies in teaching and learning;
4. Area D relates to the use of digital strategies to assess and foster students' creativity;
5. Area E refers to the potential of digital technologies for promoting learner-centered strategies.
6. Area F focuses on the competences required to enhance students' digital creative competences.

   Areas 2 to 5 constitute the pedagogical core of the model: they describe the competences required to promote creative, innovative, effective and inclusive learning strategies using digital tools.

   The different areas of competence and their respective components are described below.

[24] Barajas, M. & Frossard, F. (2019). *Framework of digital creative teaching competences. Project DoCENT – Digital Creativity ENhanced in Teacher Education*. Erasmus + Strategic Partnerships for higher education, 2017-20192017-1- IT02-KA203- 036807

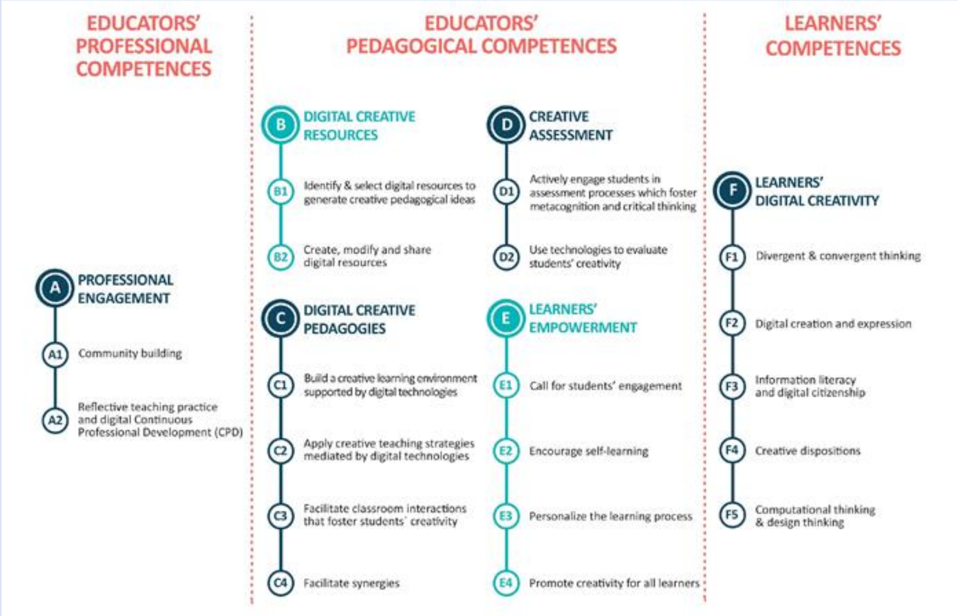

Figure 1. Teachers' competence framework, *Barajas & Frossard (2018)*

This model has been adopted by the project BLUE ARROW for teacher education activities that will undertake the project, especially for the initial teachers training and the design of the TUI learning scenarios. On the next figures (Figure 2; Figure 3; Figure 4; Figure 5), we have adapted this creativity framework for TUI regarding competence Area C, D, E and F:

Area C: Digital creative pedagogies with TUI

Use digital technologies to support creative teaching & learning

C1. Build a creative learning environment supported by digital technologies

Create of a positive climate: establish a non-judgmental and ethical social climate, in which all students are supported and accepted; encourage open communication and trusting relationships; accept new ideas.

Promote exploration and invention: make a flexible use of space and time; make time and space for exploration processes where students freely interact, investigate, create, look for and try out solutions; use the classroom as a lab; promote risk-taking opportunities where students try before getting it right; use failure as a positive learning factor; accept ambiguity and uncertainty.

C2. Apply creative teaching strategies mediated by digital technologies

Plan, implement and experiment with digital teaching strategies which may enhance students' creativity (e.g. inquiry-based learning, project-based learning, design-based learning, game-based learning, modelling-based learning); use multimodal approaches, including physical, digital and hybrid environments; keep record of the classroom activities (e.g. taking pictures, keeping a diary, creating a digital portfolio with students).

C3. Facilitate classroom interactions that foster students' creativity

Foster synergistic collaboration: encourage students to define, distribute and complete tasks towards a common objective; allow them for evaluating and negotiating each other's contributions and solutions through collective decision making; promote students-students, students-teacher and teacher-teacher collaboration.

Stimulate expression and dialogue: settle and manage digital teaching & learning environments (e.g., using social media) where all students can freely express their opinions, share their perspectives and exchange resources; manage group processes and effectively communicate to promote and mediate debates.

Encourage democratic practices in digital teaching & learning environments: promote students' fair-minded and equal participation, sense of group responsibility, respect for others and for other perspectives.

C4. Facilitate synergies

Create authentic learning opportunities by linking curricular concepts to real life situations: connect new knowledge to existing contexts and perspectives.

Bridge between certain subjects, themes and concepts: create cross-curricular learning opportunities where students can bridge different disciplines and see the relationships between them.

Relate different sources of information, media & tools: encourage students to build knowledge based on different perspectives; link and form associations between different sources of digital information.

Figure 2. Area C – Digital creative pedagogies with TUI

Area D: Creative assessment

Use digital technologies and strategies to assess and foster students' creativity

Source, create and share digital creative tools and resources.

D1. Actively engage trainees in assessment processes which foster metacognition and critical thinking

Involve students in self-evaluation and peer-evaluation; focus on both the learning process and the outcome, so to encourage students to critically reflect on their learning path, competences, mistakes and progress; use a variety of assessment formats and approaches; use digital technologies to carry out formative and summative assessment (e.g., learning analytics).

D2. Use technologies to evaluate trainees' creativity

Apply criteria (e.g., fluency, flexibility, originality, elaboration) and tools (e.g., digital rubrics) for evaluating trainees' little-c (personal) creativity.

Figure 3. Area D: Creative Assessment

Area E: Empowering Learners using TUI

Use digital technologies to enhance inclusion, personalisation and learners' active engagement.

E1. Call for students' engagement

Select and use digital tools and strategies which call for learners' interest and motivation, as well as create an inspiring and stimulating learning environment; work from students' experiences.

E2. Encourage self-learning

Encourage learners to take an active role in learning, work on their own learning needs, organize tasks, self-regulate and solve problems autonomously through digital and physical fabrication; view them as creators, inventors and tinkerers; promote their sense of initiative and decision making; support them to become active, responsible members of the digital society.

E3. Personalize the learning process

Use digital technologies and strategies which address students' specific needs, as well as enable them to learn according to their own level, rhythm, pathway and objectives; transform explicit knowledge into tacit knowledge (i.e., help students to internalize new mindsets through meaningful, active learning experiences).

E4. Promote creativity for all learners

Ensure accessibility to learning resources and activities, for all learners, without regard to gender, physical, intellectual, social, emotional, linguistic, cultural, religious, or other characteristics; consider and respond to learners' expectations, abilities, physical or cognitive constraints to their use of digital technologies.

Figure 4. Area E: Empowering Learners using TUI

Area F: Learners' digital creativity with TUI

Foster students' digital creative competences

F1. Divergent & convergent thinking	F2. Digital creation & expression	F3. Information literacy & digital citizenship	F4. Creative dispositions / F5. Computational thinking and design thinking
Encourage students to identify and solve real-world problems using creative thinking skills, i.e., generate and apply original ideas and solutions by forming remote associations, conceptual combinations, and approaching problems from different angles; evaluate and select ideas using decision-making strategies, so to produce the best possible answers.	Adopt a "maker culture" which fosters students' creative expression of ideas, experiences and emotions in a range of media, through the creation of digital or tangible objects; allow for knowledge construction processes and expression based on students building, making, storytelling, prototyping, engineering and sharing objects that are relevant to a larger community.	Encourage students to articulate information needs, find information and resources in digital environments; organise, process, analyse and interpret information; compare and critically evaluate the credibility and reliability of information and its sources; participate safely, effectively, critically and responsibly in the digital world.	**F4. Creative dispositions** Use digital technologies to promote students' openness to experience, responsible risk taking, tolerance of ambiguity, learning from failure, and viewing challenges as possibilities for learning. **F5. Computational thinking and design thinking** Stimulate students to solve problems and model systems, as well as understand mindsets and behaviors, by drawing on the concepts fundamental to computer science and design thinking.

Figure 5. Area F: Learners' digital creativity with TUI

4- The use of TUI in education (pre-primary & primary). Advantages for teaching and learning

Children know their living environment throughout the hands. At the age of few months a child points something to guide an adult to bring an interesting object in his/her reaching distance; when the object is in own hands, he/she starts to handle, touch, and manipulate it trying to understand the object's features and functions (Miglino et al., 2013).

The theoretical approach of the "Embodiment Cognition" (Borghi & Cimatti, 2010) has organized a relevant corpus of experiments, clinical observations, empirical studies, computational modeling (Ponticorvo & Miglino, 2010) in order to demonstrate how knowledge is captured in our neurocognitive structures, and to describe and explore the interaction between mind and body. This theoretical framework represents the base for the application of tangible interfaces. During the cognitive development and learning processes the "concrete" manipulative acts are gradually embedded and represented in our neurocognitive structures where they are performed as "simulated" actions (symbolic acts) in a virtual (mind) space (Frick & Newcombe, 2012). In addition, the hands and their use are coupled with a cognitive representation of the physical space are the latent and essential psychological biases of our learning/developmental processes. These biases are the main reasons why we think about digital tools as a geometrical (virtual) space or why the "mouse" of the PCs and the "touch screens" are immediately intuitive (Miglino et al., 2013).

Recently, new technologies are natural candidates to enhance our attitude to knowing by manipulating or with a multisensory approach. They are composed by common objects equipped with sensors and connected in wireless mode with a remote computer. The tools that join the educational experiential aspects and a physical-digital stimulation with a senso-motorial interaction with the learning ecosystem (Giovanella, 2014) are the called Tangible User Interfaces (TUIs) (Ishii & Ulmer, 1997). These exploit the tangible environment, as the physical materials connecting them with a digital component. Using the TUIs, the user interacts with a digital tool, managing real and physical materials scattered in the environment. In this way, the user is able to lead, manage and coordinate the virtual side. These systems strongly connect the physical and digital sides, creating a sort of bridge that connects these two worlds, allowing a natural interaction that the user could understand easily, enabling a learning (Di Fuccio & Mastroberti, 2018).

This kind of materials keeps some features of traditional manipulatives, such as the chance to attract children and favour learning, for example, in mathematics and have specific advantages as the flexibility or the opportunity to record data. But they lose an important feature underlined above: they mainly rely on sight, sometimes on hearing and touch, whereas smell and taste are completely lost.

This constitutes, in our opinion, a drawback of digital materials, because, smell and taste, the so-called chemical senses, are indeed important in everyday life (and have been important in human phylogenetic story), have special neuro- cognitive features and can help the learning process. Olfaction, for example, has strong links with emotions and can therefore affect behaviour, thanks to emotional associative learning to odours. Moreover, the olfactory network has the uniqueness to do not pass through the thalamus and go directly to the cortex, thus providing the neural basis for the strong connection between olfactory stimuli and emotional memory. For this reason, in the following sections, a platform to design and implement multisensory learning materials is introduced, an example of learning system is provided, together with data, to show the effectiveness of this approach on cognitive functions as learning and memory. (Ponticorvo et al., 2018).

In addition, the TUI could be a powerful tool for bridging the multisensory learning with storytelling approach. Digital storytelling has emerged in recent years as a powerful teaching and learning tool (Sadik, 2008). Among the advantages of use this practice in educational and learning contexts, there is certainly that of let young students create their own digital story, individually or in groups and developing digital, technological and computer literacy, but also global literacy, the ability to understand, produce and communicate through visual images (Robin, 2008; Yang & Wu, 2012).

The technologies that exploit TUIs, thanks to their intrinsic characteristic, seem to offer great potential for storytelling. Thus, for a long time, TUIs for storytelling have been developed and one example is MIT Media Laboratory's Storymat (Ryokai & Cassel, 1999) which offers the ability to record children's stories and their movements as they play on an augmented mat. Stories can be played back on the playmat when other children tell other stories. Storymat requires children to play freely and use soft plush toys. Playback of the previous story can be stopped at any time, allowing the child to edit or find an alternative ending to the story (Somma et al., 2021).

Narrative experience must be aimed at exploring and understanding the individual elements of a story, in order for it to be a meaningful experience. TUIs could be valuable tools for facilitating and enhancing an effective storytelling experience for children with visual impairments, not only because they are more dynamic and flexible than the representations in relief, traditionally used by people with visual impairments, but because they can be a versatile tool that can be used in different contexts, such as the educational one building an innovative TEL environment, and facilitate the inclusion process. Some limitations of TUIs need to be considered and addressed, including user fatigue resulting from manipulating physical objects or that only a limited number and type of elements can be represented, since tangible objects are usually relatively large.

Next, we identify some TUI solutions for the target group defined (3-8 years old) (Krestanova et al., 2021).

Campos et al. (2011) from the University of Madeira Interactive Technologies Institute developed a combination of a TUI and augmented reality for the study of animals and their environments (sea, river, land, air). This approach can be used for kindergarten children. The system (Figure 6) consists of a wooden board with printed images, which is divided into nine blocks. Each block has its marker. This system evaluates the correctness of the image selection. It can be used to arouse greater interest and motivation in new knowledge through games.

Figure 6. TUI and augumented reality system, *Campos et al. (2011)*

Almukadi et al. (2007) from the Florida Institute of Technology proposed BlackBlocks to support language and education math (Figure 7). The BlackBlocks were used for the education of children aged 4 to 8 years. The technical concept consists of a laptop with interface software, a transparent box with a web camera, ReacTIVision for recognition of fiducial markers, tangible blocks with fiducial markers on the bottom, and with letters, numbers, or mathematical symbols on the top (see next figure). The children are motivated in their education and have a positive mood and a good experience. These are the advantages of the proposed tangible system.

Figure 7. BlackBlocks, *Almukadi et al. (2007)*

Woodward et al. (2020) from Nottingham Trent University proposed tangible toys called TangToys for children's communication about their wellbeing through toys (Figure 8). Each toy has a few embedded sensors, a microcontroller, and a microSD card for recording all interactions. When children play with the toys, the sensors sense touch, motion, heart rate, or electrodermal activity and the toys based on these parameters give visual feedback (happy, sad). Toys generate haptic feedback, giving feelings about someone's presence when a child is not happy. The children can share their well-being with the toys together because the toys can communicate through Bluetooth, and haptic and visual feedback can be actuated on a friend's device (see next Figure). In the future, toys can be used in schools for young children or parental monitoring by a mobile app.

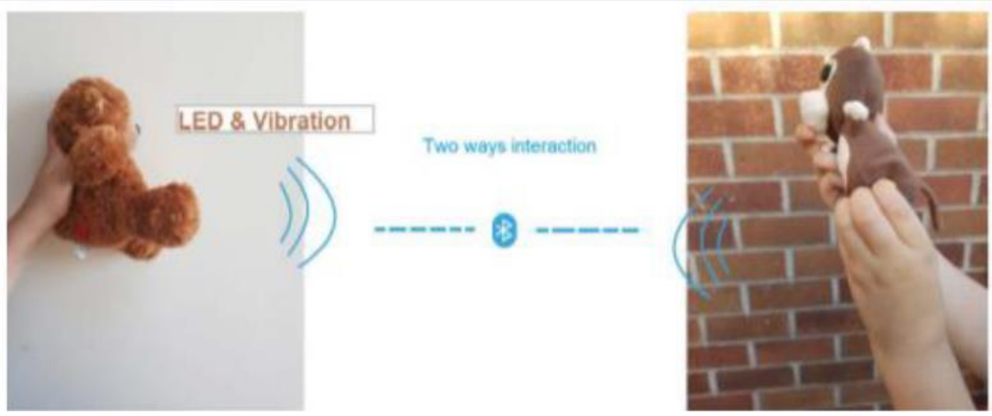

Figure 8. TangToys, *Woodward et al. (2020)*

Di Fuccio et al. from the University of Naples Federico II (2020) proposed Activity Board 1.0 for educational and rehabilitation purposes of children 3–7 years old. Tangible objects are tagged with a specific RFID tag and they are detected and identified by an Activity Board (Figure 9). The software in the main device controls the Activity Board. The tangible objects are letters, numbers, blocks, dolls, jars with perfume, jars containing candies with a specific flavor. Each object has a specific RFID tag, the RFID reader reads the tag, and the software evaluates the process. The software offers different activities. The concept allows connecting different active boards to the main devices.

Figure 9. Activity Board, *Di Fuccio et al. (2020)*

Somma et. al (2021) proposes a multisensorial TUI for immersive storytelling, used for visually impaired child. The storytelling kit (Figure 10) was then composed of: the storytelling app running on a PC, the Magic Board (of the previous study) connected to the PC through a USB port, and the objects related to the story: a bracelet, a fairy doll, four lizards (all covered with different skins: normal lizard, feather, synthetic grass, and wool), three jars with smells (apple, soap, burnt), two candy containers (one with cherry and one with strawberry candies).

The story proposed with the prototype has a central topic, which is that of the transformation of the main character, a lizard, which allows children to explore various textures of the different skins of the character and to train their tactile discrimination skills. The story's main character is Smilzon, a lizard who dreams of changing its skin and having it soft like that of a sheep, to make his friends like him more. Smilzon asks Sugar Fairy for help; after some mistakes caused by her cold, Sugar Fairy grants his wish. Eventually, Smilzon realizes that the new skin does not suit him, so he asks to have the same skin as before. The story, in addition to various descriptive elements of animals and textures, has a final moral, encouraging to always be oneself. So, it is a prototype of a story that lends itself to many learning activities by children with, but also without, visual impairments.

Figure 10. Multisensory Storytelling kit, *Somma et al. (2021)*

The TUI environment is also suitable for understanding the basics of programming (Figure 11). This attitude is described in this subsection.

Figure 11. TUI kit for programming.

Sullivan et al. (2016) from Tufts University worked with the KIWI robotics kit combined with the tangible programming language CHERP, the same as in previous research (Figure 12). The programming skills were monitored in the pre-kindergarten class for 8 weeks. From the results, it follows that the youngest children can program their robot correctly.

Figure 12. KIWI robotics kit combined with the tangible programming language CHERP, *Sullivan et al. (2016)*

Sapounidis & Demetriadis (2013) from Aristotle University developed a TUI programming system for a robot by children. The system consists of 46 cubes, which represent simple program structures and can be connected in the form of programmed code. This code programs the behavior of the Lego NXT robot (Figure 13). The program is started when the user connects to the master box of the command cube. After pressing the Run button, the master box is started and communication between the connected cubes is initiated. Each cube communicates with two adjacent cubes. Data was sent to the first cube and received data from the last line. The results show that tangible programming is more attractive for girls and younger children. On the other hand, for older children with computer experience, the graphical system was easier for programming.

Figure 13. TUI programming system, *Sapouniidis & edmetriadis (2013)*

Wang et al. (2011) from the Chinese Academy of Sciences developed a tangible programming tool called T-Maze. T-Maze is a system for the development of the cognitive and knowledge skills of children aged 5 to 9 years. Thanks to this system, children can understand the basics of programming. The advantage, as with most such systems, is that this process is associated with entertainment. It increases the children's interest and comprehension of the problem. The whole concept consists of programming wooden blocks with the command (Start, End, direction blocks, loop blocks, sensor blocks), a camera, and a sensor inside the device. The maze game contains two parts: a tool for creating a maze and an escape from the maze. The child creates the program using wooden cubes, which are scanned by a camera, and the semantics of the program are analyzed (Figure 14). The sensors of temperature, light, shaking, and rotation inside the device are built on the Arduino platform. This solution improves the children's logical thinking abilities and increases the efficiency of learning.

Figure 14. T-Maze tangible programming tool, *Wang et al. (2011)*

Motoyoshi et al. from Toyama Prefectural University proposed a TUI called P-CUBE. P-CUBE is used as a tool for teaching basic programming concepts to control a mobile robot. The design concept consists of a mobile robot, a programming panel, programming blocks: a motion block with RFID tags on each face representing movement and instructing the robot to move (forward, back, rotate), timer block (set the movement duration), IF block (two infrared sensors mounted in the mobile robot) can create a line trace program, LOOP block corresponds to WHILE function (repeats the movements of blocks positioned between two LOOP blocks). Different positions of cards and cubes with RFID tags are used for programming. This is all without a PC. The user places wooden blocks on the programming panel. The system uses LEDs, batteries, an infrared receiver, and transceiver, and wireless modules. The system is composed of three block types: initial and terminal blocks, sensor blocks, and motion blocks. RFID (radiofrequency identification) is used for detecting cards and cubes. Using this technology is suitable, but it is not exactly like a microcontroller. Users can create a program simply by

Also, interesting the applications of the TUI in the storytelling context, very close to the Blue Arrow project aims. In the scientific and commercial panorama are present different tools in these field.

Smith et al. (2011) from CSIR Meraka Institute proposed a storytelling modality called StoryBeads and Input Surface. The BaNtwane people in South Africa used beads for storytelling and need a system for storing stories. The technical concept consists of physical objects (beads, self-made jewelry) with embedded RFID capsules called e-Beads. StoryTeller consists of a laptop, microphone, loudspeaker, and RFID reader. All these components are encapsulated in 'the hides' in the input surface looking like a rectangle table. The manipulation with beads and input surface were easy because they used components that they know. This system allows for preserving their cultural heritage.

Another application is proposed by Wallbaum et al. (2017) from OFFIS—Institute for IT in Germany proposed a tangible kit for storytelling. The storytelling system was proposed to help children and their parents in exploring emotions. The technical concept of this system consists of a board with an embedded microphone and speakers, a servomotor and tactile motors, and the interaction controller, while there is a control panel outside of the board. On the board, there are interactive puppets and behind the board, there is an illuminated background. The child recreates scenes based on a storyline. To create the scene, the child uses the interactive puppets as male/female figures with different emotions, the characters of the house, background, scenery, scene elements, and figures of animals (Figure 15). The storytelling kit is suitable for storytelling between parents and children.

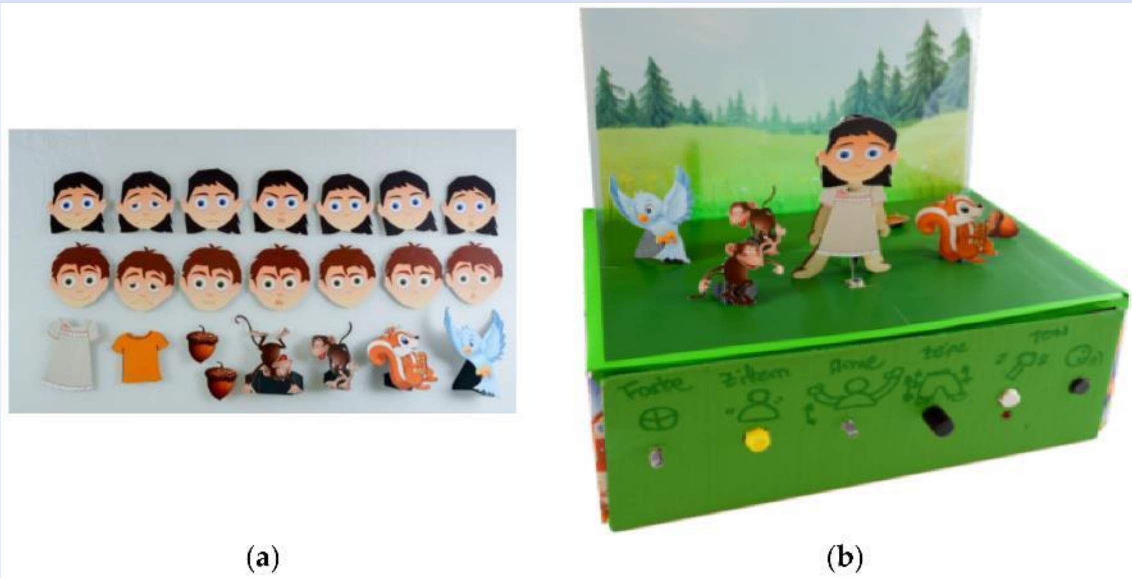

Figure 15. Storytelling kit, *Wallbaum et al. (2017)*

Song et al. (2020) from Shandong University proposed a TUI system for story creation by natural interaction. The technical concept consists of a desktop as an operating platform, while a PC allows hand data acquisition and gesture recognition by connecting the LM (Leap Motion) controller, with HoloLens glasses for coordinate mapping hand gesture positions and implementing them to the virtual scene to achieve tangible interaction. The Leap Motion is attached to the kickstand and detects the hand positions and gestures on the desktop. Through the HoloLens, the users see folding paper and learn to make origami. Then the user sees the virtual model of the origami. This is an effortless way to create animation. The user can create the story, story viewing, recording the story, and storytelling to other users with HoloLens (Figure 16). The function is switched by virtual buttons on the desktop and by the hand position recognition function. The system effectively supports children's language skills and creativity and parent-child interaction.

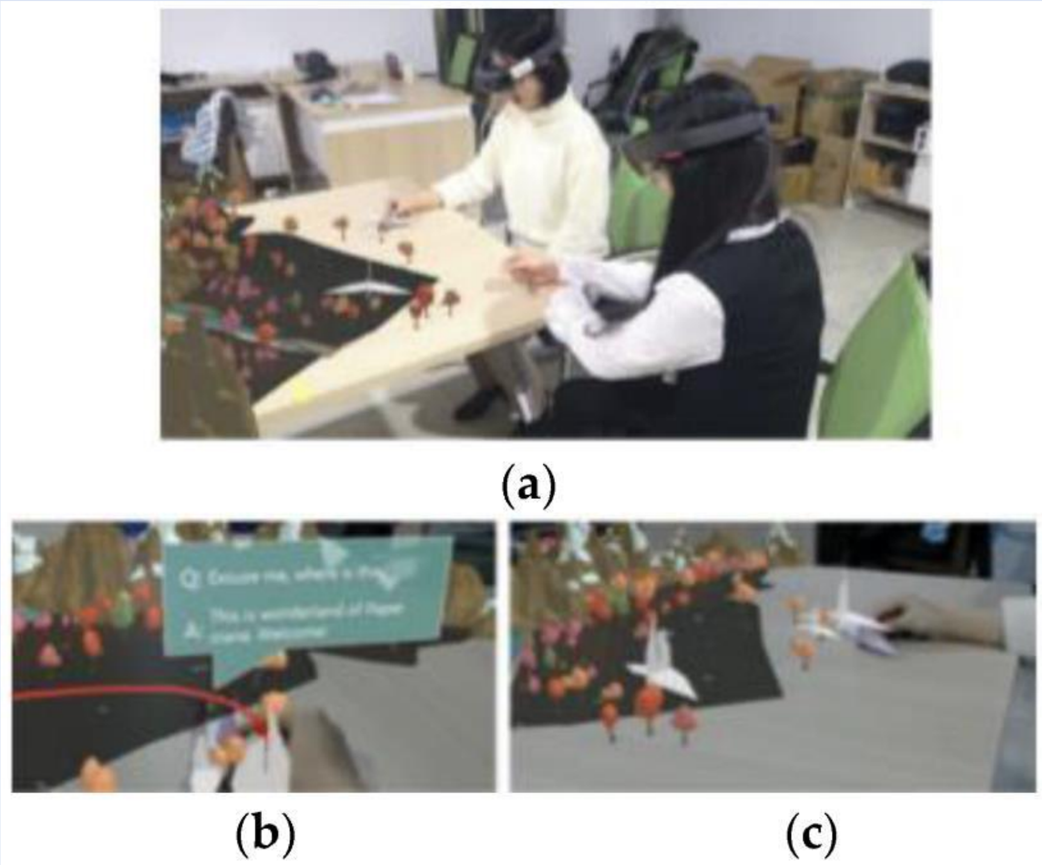

Figure 16. TUI system for story creation, *Song et al. (2020)*

Virtual manipulatives, such as WOLFRAM Demonstrations Project, Shodor Interactive Activities and Geogebra, completely substitute the physical elements. Empirical studies show that virtual manipulatives encourage creativity and increase the variety of solutions that students encounter (Moyer-Packenham & Westenskow, 2013), which is in line with the constructivist theory.

Cubelets and RoboWunderkind enable young children to design and construct robots through manipulatives – mountable blocks that contain the functions of a robot (a switch, a motor, a sensor, etc.). These tools demonstrated to positively change students' attitudes towards STEM and computer science (Correll, Wailes, & Slaby, 2014), as well as to foster critical thinking skills (Gross & Veitch, 2013).

5- Inclusion aspects in the application of TUIs

The inclusion aspect is a strength point of the project because the technology implemented in it supports multi-sensorial and different modalities of interaction (touch, voice, smell, taste, manipulative objects) that could address specific basic needs both cognitive, physical, and socio-cultural terms.

Technical progress has made it possible to develop several innovative assistive technologies to support educational, rehabilitative, and playful activities. Some technologies are primarily digital, others, such as Tangible User Interfaces (TUIs), allow interaction with the digital world using physical artifacts, making use of touch and manipulation, providing new possibilities to build innovative technology-enhanced learning environments.

This approach could benefit a larger group of users in the field of special needs, from children with visual disabilities to the intellectual disabilities (ID). TUIs allow interaction with the digital world through the use of physical objects. These physical artifacts represent both the input to the digital event and the output as they provide users with feedback on the action and manipulation they are doing, through digital information (audio or visual) from the associated device. Touching and manipulating objects is an important, if not primary, aspect in interacting with TUIs. In this way, it allows to children to use their residual senses using haptic approach, or involving senses like olfactory or gustative, bringing all the students of the classroom to the same level. If a storytelling involves the sense of smell, both the children with a typical development, both the children with sensorial disabilities (blind, deaf) are able to interact with the interface in the same manner. This highly supports a collaborative learning and the inclusion of all the students.

TUIs technology designed and developed to be used by children with visual impairments is suitable for developing spatial skills or learning spatial concepts, maps, diagrams: the results of using it are promising to think at TUIs as a support for activities, such as storytelling, accessible to people with low vision, to enhance their cognitive, social and emotional development.

TUIs for sighted people have been extensively studied in the field of human-computer interaction (HCI), however, although visually impaired people demonstrate very efficient manual exploration strategies, there is little work and study on TUIs designed for visual impairments.

TUIs are suited also in the case of intellectual disabilities. Traditional exercises are supported by physical artifacts and now most of them see a virtualization. Nowadays, typically, most rehabilitation practices for children with ID embrace this approach involves GUI (Graphical User Interface)-based tools. Less conventional paradigms of interaction such as TUIs – Tangible User Interfaces – have been explored in research but have a much more limited adoption in interventions for children with ID. Existing practices to assess or train memory skills among children often use physical objects, being physicality an essential feature to engage these subjects, especially at a young age. Such approaches provide a number of insights that can be inspirational for the design of TUIs in this domain. (Beccaluva et al., 2021)

Following that, we point out some solutions in this field. (Krestanova, 2021).

- De La Guía et al. (2015) from the University of Castilla-La Mancha proposed a TUI technology for strengthening and stimulating learning in children with ADHD. Children with Attention Deficit Hyperactivity Disorder (ADHD) suffer from behavioral disorders, self-control, and learning difficulties. Teachers and therapists can monitor children's progress using a software system. The user communicates with the system via cards (or other physical objects) that have built-in RFID tags. This is the principle of this technology. The user selects a card with the appropriate image and zooms in on the mobile device that contains the RFID reader. The loaded electromagnetic signal is processed by the server and sends information back to the device whether the card is selected correctly or incorrectly. Sounds, praise, and motivational messages support the children's interest in the next game. Games that run on a PC are also displayed on the projector. From the results, it follows that TUI games have a motivational effect and noticeable improvement in children with ADHD.
- Jadan-Guerrero et al. (2015) from Technological University Indoamerica proposed the TUI method called Kiteracy. Kiteracy enables children with Down Syndrome to develop literary and reading skills. The technical concept consists of plasticized cards grouped into categories (animals, fruit, homes, landscapes), physical letter objects, RFID readers, a computer, and a tablet. The physical letter can also play sound. The RFID reader is attached to the laptop and it reads the marker from each card and object. The results show that the technology could strengthen speech, language, and communication skills in the literacy process.
- Haro et al. (2012) from the University of Colima proposed a book with a tangible interface for improving the reading and writing skills of

children with Down Syndrome. The system is composed of a tabletop, projector projected educational materials, webcam scanned tags from tangibles objects, and a multitouch screen in a tabletop, PC with software interface recognized and processed data from a web camera. The user manipulates word and image cards and puts them on the tabletop according to the task. Each card has unique tags for image recognition. The proposed system is good for analysis by teachers and experts. Children like the system and they were motivated to read and write .

- Rivera et al. (2016) from the University of Alcala proposed smart toys for detecting developmental delays in children. In this research, they focus on the analysis of children's interactions with appropriately-selected objects. They represent the design of an intelligent toy with built-in sensors. Children perform various tasks and experts are provided with feedback in the form of measured data. One of the first tasks addressed in the article is the construction of a tower. The collector contains information about the activity such as date, time, the person that is performing the activity, child identifier, etc. After finishing the activity, the collector saves the received data. A tablet was used to control the activity. The obtained data allows the detection of possible developmental motor difficulties or disorders.
- Lee et al. (2018) from Case Western Reserve University proposed TAG-Game technology for cognitive assessment in young children. The children used SIG blocks for playing TAG-Games. SIG blocks are a set of sensor-integrated cubic blocks, and a graphical user interface for real-time test management. The system allows the recording of the total number of manipulation steps, correctness, and the time for each. Based on the results from testing TAG-Games, it shows potential use for assessing children's cognitive skills autonomously.
- Al Mahmud et al. (2020) from Swinburne University of Technology proposed POMA. POMA (Picture to Object Mapping Activities) is a TUI system for supporting the social and cognitive skills of children (3–10 years old) with autism spectrum disorders in Sri Lanka. The technical concept of the TUI system consists of tangibles, objects (animals, vegetables, fruit, shapes), and a tablet with the software application. Each plastic toy was pasted with conductive foam sewn with conductive threads on Acryl Felt sheets. Each toy has a specific pattern of conductive foam on the bottom layer of the toy; therefore, each toy has a specific touch pattern. The software application runs on an iPad. There were four activities (shapes, fruit, vegetables, animals) and six levels. The user sees the task in an application and puts the object on the iPad. The software evaluates the correctness of the choice based

on multi-touchpoint pattern recognition. The children can play together on a split-screen or alone on a full screen. This system shows that children with mild ASD can play alone to the second level, but children with moderate ASD need more help and time in the initial levels.

6- Co-creation and co-design tools and procedures

Co-creation and co-design "are two approaches to innovation" (Durall et al., 2019: 202). The terms of co-creation and co-design include a participation of multiple stakeholders in a teaching ecosystem. The ecosystem can be defined as "an environment in which the individual agents (innovation entities) exist and interact" (Engler and Kusiak, 2011: 55). In the context characterized by technology, the co-creation approach was seen as the coproduction of knowledge through a collaborative way in using files and media creation (Dede and Barab S., 2009; Lewis et al., 2010; García-Peñalvo et al., 2013). Co-design is focused int eh collaboration between designer, end-users and stakeholders (Durall et al., 2019). This allows to share a sense making through which ideas can be designed with a perspective of producing positive change in the specific situation (Mattelmäki et al., 2011).

In recent literature the terms of co-creation and co-design has been differentiate as described in the following table.

Conceptual differences between co-creation and co-design

	Co-creation	**Co-design**
Stakeholder's role	Creators	Information providers, creative thinkers, evaluators of new ideas
Designer's role	Coordinators, developers and providers of co-creation tools	Facilitators, mediators.
Opportunities	Collective creativity, knowledge exchange, and social capital	Design creativity, engagement, reflection and reflexivity, collective dialogue and negotiation
Challenges	Risk of non-reciprocal relations in which stakeholders feel instrumentalized.	Balancing tensions and creating relationships of trust

Source: adapted from Durall et al., 2019

As result of their research, Voorberget al. (2015) provide a classification of different categories of stakeholders involved in the co-creation process: co-implementers, co-designers and initiators.

From the side of the co-design, Mattelmäki et al. (2011) define stakeholders co-designers "who can act as information providers, creative thinkers, and evaluators of new ideas." (p. 219)

For the purpose of this BLUE ARROW project and following the extant literature early described we refer to both concept of value co-creation and co-design.

In relation to the co-design and according to Durall et al. (2019) and Mattelmäki et al, (2011), the stakeholders involved in an innovative teaching ecosystem (such as teacher, educators, lecturers and professionals in their specific sector) are co-designers and they can contribute to the value co-creation process (value co-created for itself and for another) as creative thinkers, information providers and evaluators of innovative ideas. In doing so, and more concretely for the context of the teaching ecosystem, they can define template with the main aim to simplify the collection of ideas and will help the sharing of OERs.

The process of design constitutes a frame of reference that supports the processes of change and methodological innovation and helps to overcome the gap in learning situations mediated by technologically rich contexts. According to Beetham and Sharpe (2007:7), the design process involves:

1. *Research*: who are my users and what do they need? What principles and reference theories are relevant?
2. *Application*: How should these principles be applied in a specific case?
3. *Representation and modeling*: Which solution best fits the needs of the users? How to communicate this solution to the developers or to the users themselves?
4. *Iteration*: How does the design withstand the demands of the development process? How useful is the design in practice? What changes are needed?

Procedure

In BLUE ARROW, we will follow these principles, and use a co-creation process which will consist on the following steps:

Definition

In the first step, all entities and actors are clearly presented each with the respectively Knowledge, Skills and Attitude (KSA). This with the main aim to build and improve a map and be aware that: firstly, projects require transdisciplinary competences; secondly, having a map of the KSA of each stakeholder involved, it will make the problem solving and decision making more effective and, for this reason, each problem will be faced with a higher probability to be fixed in the short; thirdly, a clear map of KSA will create more opportunity to interact and cooperate inside the project context and also outside and for this reason, it enhance the stakeholder engagement for the benefit of the project. I.e. the interaction between teachers and technicians or professional can facilitate the definition of a teaching kit of a specific subject that respect the contextual needs.

Also, the boundary of the context situation (both for the institutional and geographical aspects) needs to be defined. At the same time general goals and the available technology needs to be defined by involving all actors. The contribution in terms of value of the multiple actors involved is part of the co-creation process.

Build trust

Positive leadership is needed to build trust. Leaders have to facilitate the building of trust both from the side of the co-designer involved in the definition of the process and between these figures and the end users. Higher trust will stimulate creativity and active approach in the problem-solving process (Hennessey, 1998; Forester, 2013; Reilly, 2017; Ruijter, 2019) necessary to have the right approach for the next steps. The contribution of each actor involved to build the trust is a value co-created along the process.

Exploration

Exploration is the step in which the general and specific needs have to be represented, classified and analyzed in relation to the specific context. Leader stimulates the co-designers to share all the information and data available so that they can be collected by using appropriate technological tools or software. In order to achieve this objective, social research techniques will be used. I.e. the qualitative method of focus groups (by involving the co-designers and the end user to realize the co-creation process) can be organized and inside this method, the brainstorming can be applied to stimulate debates without barriers from which valuable information or valuable insights can be noted. The quality of this step can influence the next step of building ideas. Trust between the all the multiple actors involved is particularly important to make this step more effective.

Ideation

While the previous step can be considered as an outward opening to co-create a knowledge-based that can be used to define possible solutions to response to specific needs, the ideation is a step that starts with an initial closure because all the information and insights emerged (thanks to the leadership and trust), needs to be analyzed and systematized. In this step, the leader has to provide a correct direction of the discussions that have to be focused on each specific problems previously defined that requires a solution (defined in the previous steps). Once the needs have been clarified and the information and data has been collected (i.e. technology, budget, intellectual or relational capital, the necessary KSA, innovation level, etc…), the creativity and rationality can be stimulated to build a number of ideas (as possible solutions) thanks to which specific problems can be faced and solved. For each idea, a scenario analysis approach by using a "what if analysis" have to be considered as techniques to better understand all the possible relapses and happenings under the lens of action-reaction. In this step, brainstorming can be useful to collect all the possible negative effects necessary to evaluate the better solution to face a specific problem in a specific context, in a specific time. The leadership and the trust, represents the way to explore all the needs and collect all the available and possible information and data necessary to define the effective solutions for the end users. The degree of participation of each actor involved define the degree of the co-creation process. At the end of this step, all the solutions (ideas) for a single or multiple problems are formalized also defining all the material and immaterial resources necessary for their development. The ideation is the most representative example of the co-creation process since the multiple actors involved, depending on the degree of trust created and engagement, contribute to define the value proposition (ideas and solutions to face problems).

Development

The step of development is the operationalization of the previous step. In other words, ideas as visionary solutions are, in this step, concretely developed in concrete solutions (i.e. teaching kit) to face and solved specific problems. All the actors are involved in this process and each of them co-product the solutions for the specific needs detected in the previous steps. The development step has to be oriented to the feasibility in terms of economic and technological aspects and of social and pedagogical relapses. Leader involves all the actors that have contributed in the previous steps (i.e. exploration and ideation) to guarantee that the better knowledge is used to define a better solution. Jointly with the previous step, also this activity represents the higher degree of the co-creation process in which each actors provide value to the benefit of another.

Monitoring

This step is necessary to monitor the effectiveness of the ideas or solutions defined in the previous steps through which problems are defined, faced and, possible, solved. Time dynamically changes the factors used to define a problem and the related ideas/solutions. For this reason, all the problems require a monitoring and at the same time also the solutions. A twofold reason can be used to explain the monitoring utility: 1) problem does not change overtime, but new technology can require a review of the solution to be more effective on the problem; 2) problem change and the previous ideas/solutions is no longer suitable to solve the need/problem. A third and extreme way is that problem change, and technology is obsolete. All the contribution provided by the multiple actors are solutions to fix new problems, and it represents new evidence of the importance of the co-creation process.

7- BLUE ARROW's co-creation strategy for the design of learning activities with TUI.

Co-creation can be defined as "the joint, collaborative, concurrent, peer-like process of producing new value, both materially and symbolically" (Galvagno, Dalli, 2014, p. 644). Co-creation of value allows organizations and customers (in this case lecturers) to create value through interaction.

We propose the integration of the theoretical framework of the BLUE ARROW project with the specific topic of value co-creation approach. The Value Co-creation (VCc) "is the process of creating something together in a process of direct interactions between two or more actors, where the actors' processes merge into one collaborative, dialogical process" (Grönroos et al., 2014). The VCc concept has captured ever-growing attention of scholars who have worked on the issue from different perspectives in literature concerning marketing and post-modern marketing (Prahalad and Ramaswam, 2004).

The domain of the Blue Arrow project is the education and training, and its main aim is "the improvement of the teacher education of pre-primary and primary in higher education institutions Initial Teacher Education (ITE) and Continuous Professional Development (CPD) by providing new tools and new methodologies" (Blue Arrow project, 2020). The way used for this improvement is the innovation, or more in detail the development of a MOOC for teacher education. The scope can be seen in the improvement of the effectiveness of the teaching actions and so the improvement of the teaching services quality.

The teaching activities refer to the service area and they are provided in a specific environment in which multiple actors with distinct roles and resources can be detected. Here, the concept of "ecosystems" can be used to frame actors, institutions that at different level and with different role are involved in the teaching activities (Figure 17). Also, the ecosystem approach helps to detect, define, and explains the interactions among multiple actors involved in these activities.

The boundaries of the teaching ecosystem provide a clear frame in which it is more readable detect the opportunities to enhance the value potentially creatable in the teaching activities. More in detail, by using the value co-creation approach, it is possible to have a new lens or perspective through which observing social phenomenon in the teaching domain and in which from the interactions between actors involved value can be co-created.

An explanation of the teaching ecosystems is below, in which the interaction between multiple actors can be detected.

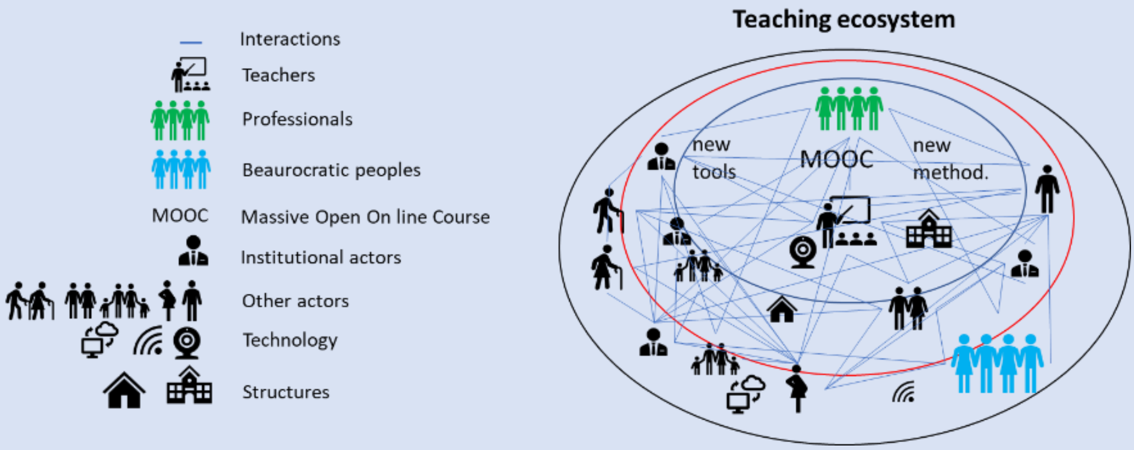

Figure 17. The teaching ecosystem

O1.A3
Tangible exercises and learning/teaching scenarios

1- Introduction

Action 3 section deals with the application of Tangible User Interfaces (TUI) for distance teaching in formal education. This Activity focuses on the definition of a case-study defining four main scenarios (home without parents, home with the parents' support, classroom with small groups, typical classroom) as well other scenarios as e.g. for external activities, etc.

The learning/teaching scenarios and the exercises with Tangible User Interfaces are here sketched with the aim to promote learning also in distance, with laboratorial activities based on widely used pyscho-pedagogical practices applied by the teachers, e.g. Montessori activities, Piaget games, or Munari applications stressing the playful dimension of tangible objects adapted to digital education.

The Activity selects the set of TUI addressed for this peculiar learning, defining the concrete object to be implemented for this application.

Below we present 5 model scenarios adapted to different modalities of learning, which can be currently implemented either in the classroom or at home, or in both. Of particular importance is the role of families, acknowledging the importance of the family environment at that time and the difficulties children had during isolation, but also as a window for the future of digital education.

2- Scenario 1: Home without parents

Learning environments	Home, a dedicated area as a desktop or a little table. On the table will be placed all the materials, like wood toys, little dolls, olfactory jars, manipulative objects. The object could be contained in a box. The learning environment will be built with a PC or a tablet, the objects described tagged with NFC technology and the software and an active board.
Materials	All tangible materials, like: • wood toys, • Cards • little dolls, • olfactory jars, • manipulative objects. The materials could be contained in a box. The materials could be used in conjunction with the hybrid interface but could be used also a traditional object for other activities.
Description	The children will be able to open the box and use all the materials. The exercise will be ready in a form of an app. The children will use the app as simple user and without the support of a teacher they could be enabled to create or connect new objects. Opening the Blue Arrow App the students will have the possibility to use an object as a trigger of the story. When the story starts, they could freely use all the other objects. Every object will be placed on the board and will produce a multimedia effect (a video or an audio will be outputted by the PC/tablet)
Scaffolding	The software should support the proposal of the next object with aureal feedback (i.e. “Great! Now place on the board the next object in order to hear the next step of the story” “Fantastic! Now please place an olfactory object” “Great now found the next card representing the king”, etc.). In this case the play and the learning are totally autonomous.

Distance learning	If an activity of distance learning is on, a learning platform is active (i.e., Google Classroom, Teams, Zoom, etc.) and the teacher will support the learning exercises and the storytelling.
Technology involved	Blue Arrow App, NFC Board and NFC tags already placed on the objects and already tagged.

Table 1 – Scenario 1

3- Scenario 2: home with the parents' support

Learning environments	Home, a dedicated area as a desktop or a little table. The parents will set the learning environment, placing on the table will be placed all the materials, like wood toys, little dolls, olfactory jars, manipulative objects. The object could be contained in a box. The parent will be the role of the distribution of all the objects, including the mobile devices (tablets or smartphones) and the active board. The learning environment will be built with a PC or a tablet, the objects described tagged with NFC technology and the software and an active board.
Materials	All tangible materials, like: • wood toys, • cards • little dolls, • olfactory jars, • manipulative objects. The materials could be contained in a box. The materials could be used in conjunction with an hybrid interface but could be used also a traditional object for other activities.
Description	The parents will set the environment opening with the children the box and allowing the use of all the materials. The exercises will be ready in a form of an app inside the digital component of the learning environment. The children will use the app as both interacting with the board and object and with the support of the parents could create or connect new objects. Opening the **Blue Arrow App** the students will have the possibility to use an object as a trigger of a single story. When the story starts, they will freely use all the other objects.

	Every object will be placed on the board and will produce a multimedia effect (a video or an audio will be outputted by the PC/tablet)
Scaffolding	The parents will represent the main support for the activities, facilitating the learning process, however the software will output the aureal feedback giving a good degree of autonomy for the children.
Distance learning	If an activity of distance learning is on, a learning platform is active (i.e. Google Classroom, Teams, Zoom, etc.) and the teacher will support the learning exercises and the storytelling. The parents will have the role to set the learning environment
Technology involved	Blue Arrow App , NFC Board and NFC tags already placed on the objects and already tagged.

Table 2 – Scenario 2

4- Scenario 3: classroom with small groups

Learning environments	School, in this case the classroom is the real environment. The classroom will be equipped with PC or tablet, with an active NFC table involving small groups. The small groups are considered maximum 5 children. The teacher will set the learning environment, placing on the desk will be placed all the materials, like wood toys, little dolls, olfactory jars, manipulative objects. The object could be contained in a box. The teacher will be the role of the distribution of all the objects, including the mobile devices (tablets or smartphones) and the active board and distribute the groups. The learning environment will be build with a PC or a tablet, the objects described tagged with NFC technology and the software and an active board.
Materials	All tangible materials, like: • wood toys, • cards • little dolls, • olfactory jars, • manipulative objects. The materials could be contained in a box. The materials could be used in conjunction with the hybrid interface but could be used also a traditional object for other activities.
Description	The teacher will set the environment opening with the children the box and allowing the use of all the materials. Another important task of the teacher will be to creating the group and support them. The exercises will be ready in a form of an app inside the digital component of the learning

	environment (i.e. the PC/tablet). The children will use the app in small group as both interacting with the board and object and with the support of the teacher could create or connect new objects. In this case will be elicited the peer learning. Opening the app the students will have the possibility to use an object as a trigger of a single story based on the teachers' proposals. Every object will be placed on the board and will produce a multimedia effect (a video or an audio will be outputted by the PC/tablet)
Scaffolding	The teacher will represent the main support for the activities, facilitating the learning process, however the software will output the aureal feedback giving a good degree of autonomy for the children.
Distance learning	The activity is in presence
Technology involved	NFC Board and NFC tags already placed on the objects and already tagged.

Table 3 – Scenario 3

5- Scenario 4: face-to-face classroom

Learning environments	School, in this case the learning environment could be the classroom or a PC lab. The classroom will be equipped with PC or tablet, with an active NFC table involving small groups. For face-to-face classroom we consider a full system for each student (a tablet/PC, an active NFC table for each user, the manipulative materials). The teacher will set the learning environment: on the desk there will be placed all the materials, like wood toys, little dolls, olfactory jars, manipulative objects. The object could be contained in a box. The teacher will distribute of all the objects, including the mobile devices (tablets or smartphones) and the active board and distribute the groups. Each child could obtain audio feedback with headsets. The learning environment will be built around a PC or a tablet, the objects described tagged with NFC technology and the software and an active board.
Materials	All tangible materials, like: • wood toys, • cards • little dolls, • olfactory jars, • manipulative objects. The materials could be contained in a box. The materials could be used in conjunction with the hybrid interface but could be used also a traditional object for other activities.
Description	The teacher will set the environment opening with the children the box and allowing the use of all the materials. Another important task of the teacher is

	to assign the exercise or story to live using a screen for the presenting the exercise. The exercises will be ready in a form of an Blue Arrow App inside the digital component of the learning environment (i.e. the PC/tablet). The children will use the app one-to-one, with a single scenario, interacting with the intelligent board and object for, with the support of the teacher, create or connect new objects. Teacher will ask to all the class to perform some defined action (i.e. "Now place the Queen doll on the board", etc.) In this case will be elicited the peer learning, the children could support each other in the case of problem. When opening the app, the students will have the possibility to use an object as a trigger of a single story based on the teachers' proposals. Every object will be placed on the board and will produce a multimedia effect (a video or an audio will be outputted by the PC/tablet)
Scaffolding	The teacher will represent the main support for the activities, facilitating the learning process, however the software will output the aureal feedback giving a good degree of autonomy for the children.
Distance learning	The activity is face-to-face
Technology involved	NFC Board and NFC tags already placed on the objects and already tagged.

Table 4 – Scenario 4

6- Scenario 5: external activities

Learning environments	The environment can be placed in museums, game rooms, kids' clubs, associations, etc. A typical scenario could be a learning exercise by storytelling in a science museum or a section of a museum addressed to children, i.e the presence of little dolls for representing the story of a certain castle. In the case the activity is open and could be placed in a closed room. The room will be equipped with PC or tablet, with an active NFC table involving children. They could be involved in a single scenario, or in social scenario, depending on the materials provided. Each group or user will use a tablet/PC, an active NFC table for each user, and the manipulative materials. We propose the presence of teacher or a facilitator who will check the presence of the objects and will support the children during the activities. The learning environment is expected to be with non-movable stations. The role of the teacher will be to check the functionality of the platform. Each child will receive audio feedback wearing headsets. The technological infrastructure of the learning environment contains a PC or a tablet, the TUI objects described tagged with NFC technology, the Blue Arrow software, and an active board.
Materials	All tangible materials, like: wood toys, cards little dolls, olfactory jars, manipulative objects.

	The materials could be placed in a certain space of the room. The materials could be used in conjunction with the hybrid interface but could be used also a traditional object for other activities.
Description	The teacher/facilitator will set the environment opening with the children the box and allowing the use of all the materials. Another important task of the teacher will be assigned the exercise or story to live using a screen for the presenting the exercise. The exercises will be ready in a form of a Blue Arrow app inside the digital component of the learning environment (i.e. the PC/tablet). The facilitators could create sessions for the creation of new stories. Teacher/facilitators will ask to all the class to perform some defined actions (i.e. "Now place the Queen doll on the board", etc.) In this case, peer learning will be elicited, then the children could support each other in case of problem. By opening the app the facilitators will ask the students to use an object as a trigger of a single story based on the teachers' suggestions. Every object will be placed on the board and will produce a multimedia effect (a video or an audio will be outputted by the PC/tablet)
Scaffolding	The facilitators/teacher will be the main support for the activities, facilitating the learning process, however the software will output the aureal feedback giving a good degree of autonomy for the children.
Distance learning	The activity is face-to-face
Technology involved	Blue Arrow NFC Board and NFC tags already placed on the objects and already tagged.

Table 5 – Scenario 5

O1.A4

Elaboration of evaluation tools

The task is oriented towards the definition of a set of qualitative and quantitative methods to assess the learning results about this innovative application of Tangible User Interfaces with MOOCs. This set will be drafted in a generic sense, for a future re-applicability in other sectors.

1- Introduction

To evaluate the BLUE ARROW teaching kit, two different target groups must be considered: On the one hand, the teaching kit should develop the creative, logical, mathematical, linguistic, strategic and social skills of children. A special emphasis is made on children with special needs.

The BLUE ARROW teaching kit aims at using innovative TUIs, so the children are motivated to engage in playful learning. The teaching kit is a teaching tool that consists of a set of manipulatives that are enhanced with different digital technologies (NFC, apps, etc). By having different scenarios and repeated tasks, we ensure a more motivating children learning experience, and an appropriate mixture of presentations and practical tasks adapted to children's specificities.

In O2, selected lecturers and specialists in teacher education will design a collection of learning exercises using the BLUE ARROW KIT. This process will be undertaken using co-creation processes. Sine one of the steps of cocreation is product evaluation, this aspect will be covered in this phase. Appendix I includes a tentative description of the learning activities.

Additionally, one of the key aspects of BLUE ARROW is to create a training course in the cloud, particularly as a Moodle course. The primary target group is teacher trainers in charge of teacher education (preservice teachers), ad secondarily, in-service teachers. This implies that the effectiveness of the online training course should also be evaluated.

To do so, a pilot training course will be conducted with potential users of the tools. The pilot study aimed at identifying issues with the TUIs for the MOOC and with technical shortcomings of the chosen platform, since these problems could potentially reduce the effectiveness of the learning experience, hence the ability and disposition to apply the system in real situations.

2- Partners involved

As with respect to the learning activities embedding TUIs, each partner will evaluate the activities in a trial experiment involving expert lecturers and in-service teachers (not participating in the design)

Evaluation will be done at the following institutions: University of Foggia, University of Barcelona, and Reald University College.

3- Actors

The design of the learning activities will be undertaking by university lecturers in collaboration with their students (future pre-primary schoolteachers, although first stage of primary education teachers can be part of). Then, the evaluation actors are:

- university lecturers (learning activities and MOOC)
- preservice teachers (MOOC)
- inservice teachers (trialing the learning activities)
- Expert practitioners

4- Evaluation dimensions and methods

The basic objects of the evaluation are:

- Learning activities embedding TUIs
- MOODLE training course

In terms of the learning activities embedding TUIs, a draft rubric (See Annex 2) will be prepared for experts in the field of pre-primary education and ICT to analyses each learning activity, the product of the co-creation workshops (O3.A3, M13). The rubric is linked to the competence framework created to BLUE ARROW. The areas covered in the rubric are:

- Originality/creativity (according to competence framework)
- Identification / selection /use of suitable TUI to achieve the pedagogical objectives pedagogical objectives

- Coherence between learning goals, methods and scenario suggested (at home, in class, hybrid, external, etc)
- Planning a learning environment that promotes playfulness, exploration, invention
- Linkage of curricular concepts with real Childrens' life and between different topics or themes
- Planning activities that foster inclusion, personalization, and active engagement

Among the participants in the co-design learning activities, partners will identify a total of 3 people for doing the evaluation task.

On the other hand, the Moodle training course will be trialed in the participating institutions with preservice teachers (IO4) psychology students and Inservice primary school teachers. We will measure the training effectiveness of the MOOC and the usability of the platform, including the pedagogical effectiveness of the technologies involved (TUIs, videos, contents, etc). Quantitative data will be gathered from three categories of participants:

a) participants that complete the MOOC,
b) participants that complete MOOC with the support of BLUE ARROW Kit,
c) participants that leave the course (dropout and its relationship with other courses).

From a qualitative point of view, the categories are:

- Usability of the MOODLE course: To consider usability issues identified in the evaluation during the design process, an iterative process is common. Therefore, a sequence of usability tests will be done to accompany the development process during cocreation. In all cases, data will be collected by focus interviews
- Training effectiveness of both contents and BLUE ARROW tools: each lesson will have an achievement test embedded, which includes closes questions (3 per lesson)

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ANNEXES

ANNEX 1: CO-CREATION WORKSHOP "TANGIBLE TOOLS FOR CREATIVE EDUCATION" – BLUE ARROW PROJECT

Learning scenario format (example)

SCENARIO TITLE:

AUTHOR(S) - NAME AND SURNAME:

1. WHAT DO I WANT TO TEACH?

- Subject – *E.g. educational technologies, didactics of science*

  Educational level - *E.g. Undergraduate (Bachelor's degree), Graduate (Master's degree)*

- Pedagogical objectives for the students – *E.g. understand the main concepts about inquiry-based learning and its application in the teaching of mathematics, develop basic concepts, stimulate collaboration among students.*

EXAMPLE

- *Know the basic principles of ….*
- *Integration of digital creativity with the help of tangibles (XXXXX) for the development of YYYY skills in students.*
- *Etc*

- Type of psycho-pedagogical practice: *Montessori activity, Piaget game, Munari application, etc.*
- Pedagogical methodologies – *E.g. manipulative, robotics, game design, cooperative work, etc.*

2. HOW DO I INTEND TO INTEGRATE CREATIVITY TUIs IN MY CONTEXT?

- Free description - *Also describe how this scenario would be different from your usual classes*
- TUIs used: *The TUIs used are the following (EXAMPLE):*
  - ***Bee-Bots:*** *one for each group of students. It is the tool that students must program with the objective that they*

move along the mat depending on the tasks given by the teacher.

Other Materials:

3. WHICH TYPE OF IMPLEMENTATION SCENARIO IS INTENDED TO: (PLEASE MARK ONE OR MORE)

- home without parents
- home with the parents' support
- classroom with small groups
- face-to-face classroom
- external activities

4. HOW WILL THE EDUCATIONAL ACTIVITIES IN THE CLASSROOM BE SEQUENCED? (decide on the number of activities necessary for the application of your scenario)

The proposal consists of four sessions of one hour each.

- Activity 1 - Description (place, time required, student role, teacher role) (EXAMPLE)

Session 1	
Duration: 1 h	*Place: YOUR PLACE*
Throughout the first session, the teacher will introduce the key principles and elements of YOUR-ACTIVITY (e.g. healthy nutrition). You can use any audiovisual medium: videos, Power Point, Prezi, infographics, graphics … During the explanation, it is important to create debates, launch open questions, generate active participation … with the objective that students reflect and participate in the classroom (1 h).	

- Activity 2 - Description (place, time required, student role, teacher role) (EXAMPLE)

Session 2

Duration: 1 h	*Place: YOUR PLACE*
During the second session, students will become familiar with the Blue-Bots. With the help of the teacher, they will explore each of their keys discovering their function. For this you can help with the "sequence cards" (20 min). *Students will be grouped, according to their preferences, into small groups of 3 or 4 participants and will start the design of their teaching guide. Students must design the guide with the content they deem appropriate and that most interests them. (40 min).*	

- Activity 3 - Description (place, time required, student role, teacher role) (EXAMPLE)

Session 3	
Duration: 1 h	*Place: YOUR PLACE*
Throughout the third session, students will continue to prepare their teaching guide and prepare the mat where infants will move their Blue-Bot. For their preparation, they must have previously searched and printed images or materials that will be useful for their composition and will have brought them to the classroom. *The teacher will supervise and accompany the entire creation process, both for the teaching guide and the Blue-Bot mat (45 min).* *Students will do pilot tests to check the operation of the Blue-Bots in relation to their mat design (15 min).*	

- Activity 4 - Description (place, time required, student role, teacher role) (EXAMPLE)

Session 4	
Duration: 1 h	*Place: YOUR PLACE*
The groups will briefly present their projects to the rest of their classmates and explain the contents that will be worked on, what questions they will address in the ***hypothetical*** *implementation with the children, etc. During the presentations, each group will evaluate the rest through a rubric (1 h).*	

4. HOW WILL I EVALUATE THE KNOWLEDGE / COMPETENCES DEVELOPED BY STUDENTS?

- Evaluation methods – *E.g., questionnaire, Peer evaluation, rubrics, digital portfolios,*

5. WHAT DIGITAL CREATIVE COMPETENCES WILL BE DEVELOPED THROUGH THE SCENARIO?

- AREA A: PROFESSIONAL ENGAGEMENT - *Use digital technologies for collaboration and professional development*

  ☐ A1. Community building
  ☐ A2. Reflective teaching practice and digital Continuous Professional Development (CPD) ÁREA URSOS CREATIVOS DIGITALES
- **AREA B: DIGITAL CREATIVE RESOURCES -** *Source, create and share digital creative tools and resources.*

  ☐ B1. Identify and select digital resources to generate creative pedagogical ideas
  ☐ B2. Create, modify and share digital resources
- AREA C: DIGITAL CREATIVE PEDAGOGIES - *Use digital technologies to support creative teaching & learning.*

  ☐ C1. Build a creative learning environment supported by digital technologies
  ☐ C2. Apply creative teaching strategies mediated by digital technologies
  ☐ C3. Facilitate classroom interactions that foster students' creativity
  ☐ C4. Facilitate synergies
- AREA D: CREATIVE ASSESSMENT - *Use digital technologies and strategies to assess and foster children's creativity.*

  ☐ D1. Actively engage trainees in assessment processes which foster metacognition and critical thinking
  ☐ D2. Use technologies to evaluate trainees' creativity
- AREA E: EMPOWERING LEARNERS - *Use digital technologies to enhance inclusion, personalization and learners' active engagement.*

  ☐ E1. Call for students' engagement
  ☐ E2. Encourage self-learning
  ☐ E3. Personalize the learning process
  ☐ E4. Promote creativity for all learners
- AREA F: LEARNERS' DIGITAL CREATIVITY - *Foster children's digital creative competences.*

  ☐ F1. Divergent & convergent thinking
  ☐ F2. Digital creation & expression

 F3. Information literacy & digital citizenship
 F4. Creative dispositions
 F5. Computational thinking and design thinking

5. ADDITIONAL COMMENTS (difficulties, requirements, reflections on the competences developed during the co-creation process)

ANNEX 2: RUBRIC FOR THE EVALUATION OF THE LEARNING SCENARIOS PRODUCED IN THE CO-CREATION WORKSHOP "TANGIBLE TOOLS FOR CREATIVE EDUCATION"

Draft evaluation rubric

	EXCELLENT	GOOD	AVERAGE	INCOMPLETE
Originality/creativity (according to competence framework)				
Identification / selection /use of suitable TUI to achieve the pedagogical objectives pedagogical objectives				
Coherence between learning goals, methods and scenario suggested (at home, in class, hybrid, external, etc)				
Planning a learning environment that promotes playfulness, exploration, invention				
Linkage of curricular concepts with real Childrens' life and between different topics or themes				
Planning activities that foster inclusion, personalization, and active engagement				