UNIVERSIDAD POLITÉCNICA DE MADRID

ESCUELA TÉCNICA SUPERIOR DE INGENIEROS DE TELECOMUNICACIÓN

Towards a new paradigm to empower students and enable their social-emotional well-being: a strategic model for evolving digital learning environments.

TESIS DOCTORAL

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Ingeniera en Sistemas de Información
MBA, Msc. International Health Management

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Departamento de Tecnología Fotónica y Bioingeniería
Grupo Life Supporting Technologies
E.T.S.I de Telecomunicación

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Madrid, 2019

“Learning constitutes the heartbeat of society, while ‘learning to know’, ‘learning to do’, learning to live together’ and ‘learning to be’ constitute four pillars of education.”

The Delors Report (1996) – Jacques Delors

‘Learning – The Treasure Within ‘

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ABSTRACT

Digital transformation is impacting almost every area of the digital age (manufacturing, government, health, etc), disrupting its value-chain and integrating actionable intelligence as the bases for decision making in all core areas; the educational domain will not be different. The education domain is by default the domain where knowledge is the core service provided to the individuals. Data and information needs are core assets and critical enablers in the 21st century schools and information age. Thus, either called education 3.0, 4.0 or x.0, the technological advances, changes and transformations are affecting, and will affect, education; in both in its structure and the learning environments.

Based on the processes established in No One Left Behind (NOLB) project, the main objective of this research is to create a holistic model that will be scalable and support the journey toward the digital transformation in education. This will be done is dependent on a broader vision and a structured framework for implementation of selected priorities to enhance the quality and innovation in teaching, learning, and research while improving operational efficiency of administration and management.

The framework will be evaluated through the different phases of the NOLB project as well as will be evaluated through qualitative and quantitative means.

The results achieved showed that the research questions were answered with validated results, through the No One Left Behind pilot, focus groups and questionnaire: The model provides the bases to generate actions to change and transform classes, curriculum and school structure by introducing digital transformation-oriented actions and/or integrating digital tools in these educational environments.

RESUMEN

La transformación digital afecta a casi todas las áreas de la era digital (fabricación, gobierno, salud, etc.), cambiando su cadena de valor e integrando inteligencia procesable como bases para la toma de decisiones en todas las áreas centrales. El dominio educativo no es, ni será diferente. La educación es, por defecto, el dominio donde el conocimiento es el servicio central que se brinda a las personas. Las necesidades de datos e información son activos centrales y facilitadores críticos en las escuelas y la era de la información del siglo XXI. Por lo tanto, ya sea llamado educación 3.0, 4.0 o x.0, los avances tecnológicos, los cambios y las transformaciones están afectando y afectarán a la educación; tanto en su estructura como en los entornos de aprendizaje.

Basado en los procesos establecidos en el proyecto No One Left Behind (NOLB), el objetivo principal de esta investigación es crear un modelo holístico que pueda ser escalable y que apoye el viaje hacia la transformación digital en la educación. Esto se hará depende de una visión más amplia y un marco estructurado para la implementación de prioridades seleccionadas para mejorar la calidad y la innovación en la enseñanza, el aprendizaje y la investigación, al tiempo que mejora la eficiencia operativa de la administración y la gestión.

El marco se evaluará a través de las diferentes fases del proyecto NOLB y se evaluará a través de medios cualitativos y cuantitativos.

Los resultados obtenidos mostraron que las preguntas de investigación fueron respondidas y validadas; a través del piloto, focus group y encuesta. El modelo proporciona las bases para generar acciones para cambiar y transformar las clases, el plan de estudios y la estructura escolar mediante la introducción de acciones orientadas a la transformación digital y / o la integración de herramientas digitales en estos entornos educativos.

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1 INTRODUCTION

1.1 Introduction to the challenges posed to the digital transformation in education

Digital transformation is characterised “by a fusion of advanced technologies and the integration of physical and digital systems, the predominance of innovative business models and new processes, and the creation of smart products and services (European Commission, 2017).” Digital transformation is about embracing digital technologies into processes and services to generate improved value (e.g. from efficiency or efficacy to engagement or emotions).

“Creating a digitally connected Europe” is the vision of the European Commission (EC). During last decade the EC has enabled a set of policies and large financing budget to create a common digital space that allows digital sharing, exchanging and transacting of goods and services in Europe, as a Digital Single Market (DSM). One of the goals of the DSM vision, has been to stimulate the generation of the needed infrastructure, standardization and policy environment to set the preconditions for the uptake of digital innovation and transformation. By enabling access to digital communications infrastructures to a large number of European Union (EU) population, and supporting availability of new digital technologies to people and organisations through the EU space, the people (EU consumers)’s expectations on how organisations shall deliver high-value real-time digital products and/or services, in all contexts, are changing.

The adoption of digital technologies (e.g. usage of mobiles, sensors, cloud, artificial intelligence, etc) has already changed the way we spend our time with friends (e.g. digital social networks), play (e.g. digital games), interests (e.g. interest in electronics), how we select and decide the places we travel (e.g. decided through low cost trips instead of a dreamed inspirational place), how we work (e.g. with laptops, in remote locations and using content in the cloud), the way we produce goods (e.g. collaborating with robots and based on predictive algorithms of the potential demand), the speed to get a response (e.g. we expect instant communication and/or wait for real time or immediate answers from emails or WhatsApp request), how we purchase goods and services (e.g. through internet, based on recommendations or listening influencers) or how we learn (e.g.

researching in internet or using digital boards), amongst other things. Just by looking these examples we see that digital transformation is becoming pervasive and impacts on how we interact with all our contexts in life (i.e. personal, professional, economic, leisure, etc.). In a few words, the digital transformation is disrupting not only the way operate, live and enjoy our context, but also our behaviours; it goes beyond a mere digitalization of processes, business and economy, it really goes across all levels of society transforming the society itself.

Digital transformation is not only about digitizing replicating a physical process using digital means; once this is done, it is also about changing, using or integrating new digital technologies to remake a process to become more efficient, effective or providing value-based services or products. So digital transformation is not a one-time project; it is a continuous and dynamic process for state of being; a continuous remaking of the context for providing people-centric value-based services.

In the educational domain, it is not different. Over the last decade, we have seen that mobile devices, laptops, tablets and other technologies are carried around pockets and backpacks to be used in technology-based lessons in classrooms; embracing a new journey toward digital transformation in education. The digital and tech-centric behaviours have expanded inside and outside school; not only for students, but also to teachers and parents. Current students have been raised and exposed from earliest youth to the internet, social media networks and digital technologies, being native users and in many cases having greater knowledge of digital technologies than their own teacher.

New methods of learning, such as adaptive learning, flipped classroom models or generating your own content based on coding apps, can be seen in classes. Evidence of digital transformation in classes is being created with many pilots being performed, however pilots are still island of digital transformation implantation with different ranges of success.

The No One Left Behind (NOLB) project is an example of a successful digital transformation approach, aiming at unlocking “the inclusive gaming creation experiences of students in formal learning situations from primary to secondary school levels”. The NOLB project integrated game mechanics, dynamics, and data measurement and modelling, transferred from traditional leisure oriented digital games companies into the

Pocket Code media-rich programming environment (an application that allows children and adults with no programming skills to code). For this purpose, the NOLB project, developed the Create@School application; which an enhanced version of Pocket Code, specifically customised for education environments. The NOLB project provided a user-centred and participatory design where students, teachers and pedagogical staff from the schools, worked together with project partners and digital games designers from the leisure domain. This created a powerful game-making environment which was successfully integrated in the educational curricula, while empowering children with games that not only supported the learning process, but could be customised to the students special needs through the Global Public Inclusive Infrastructure (GPII) framework integrated in the application, as well as to the personal likes and preferences (e.g. colours, characters, type of game, etc); allowing a highly inclusive approach.

Evidence of successful adoption and lessons learnt from NOLB were created, based on the successful results, experiences and adoption of the technology by the NOLB experimental pilots. The NOLB pilots comprised more than 25 teachers, 22 classes and 600 students from three different EU countries (Spain, Germany and UK).

It cannot be said that the NOLB piloting schools had a fully traditional or classic approach in classes. All of them worked with digital teaching resources (e.g. presentations, internet homework delivery system, some classes had digital boards or used of some gamified content, etc). However, at the beginning of the project each class and teacher had their own digital approach (mostly based also in their digital skills and capacities). The content was shared among teachers on demand bases, so there were no standardized practices or harmonized repositories to serve with digital tools and resources to the teachers.

The NOLB project provided a game development-oriented methodology which was integrated in the class and pedagogic curriculum development process. This approach generated a standardized way to work and share digital resources/tools. The methodologies, training of teachers, integration of gaming in pedagogical curriculums and template-based standardization approaches were highly successful and increased the efficiency of working. Moreover, the developed tools (Create@School and the Project Management Dashboard) were positively evaluated. However, these tools did not achieve the maximum evaluation ranking, which was the desired level. The main reasons reported for this positive, but still lower than expected, evaluation, focused on the

problems in connection and authentication processes. The students were through out of the Wi-Fi network which caused continuous authentication processes, and in turn caused frustration. These negative issues were not linked to the project scope but to the infrastructure which needed to support the usage of this digital tool and consumption of digital resources in classes. Also, other issues such as the need of several hours on both sides (teachers and students) to prepare needed coding to present the project that supported the homework of the subject being studied (e.g. physics, maths, science, etc).

Addressing the need of having a holistic view of the digital transformation processes and actions (new digital tools and approaches) in schools, could considerable benefit from the existence of a framework model that could provide valuable guidance for structuring actions that need to be approached to reach the ultimate goal of enabling digital wellbeing during digital transformation paths.

1.2 Motivation

The previous chapter describes at general level, the current pressures and situation that pose challenges to digital transformation. The acknowledgement of these challenges, coupled with the author's experience based on the failures and successes of NOLB project and the author's experience in the area of innovation and digital transformation, triggered the motivation to develop a multidisciplinary research work. The educational organisations (i.e. schools) need to be ready for the coming digital transformation waves and evolutions, driven by maturity of new technologies (such as artificial intelligence or 3D and computing vision); as well as for the accelerated adoption of digital transformation happening in both, the education domain, as well as in other related areas, which results also impact the educational context (e.g. new services delivery through platforms for e-education or e-commerce). The impact of adopting digital transformation, calls for an increase technologies in classes and schools, as well as for new multidisciplinary (e.g. pedagogical behavioural, infrastructures, etc) organisational effectiveness and agility of innovative digital-based teaching-learning value-based services; driven by the new role of all forms of data and information, and the exploitation of increased connectivity capabilities that the digital transformation brings with it.

The teachers and educational organisations need to understand the way learning occurs in digital contexts, and how technologies can better support both learning processes and

the analysis of behavioural constructs¹; in order to provide to teachers, digital tools that help to improve and manage both: academic and digital behavioural results; as well as to support students of this generation that succeed in the digital future.

Motivation of this research work relies in the fact of providing a framework model that supports the harnessing, deployment and exploitation of digital transformation in the education sector; supporting the organizational activities and operations that could track and regulate the online space within the framework of digital wellbeing, values and ethical behaviours of the schools. While also, schools can succeed adopting the continuous waves and investments on digital transformation, stimulated by the national and EU advancements towards the overall digital vision.

For this research work, the aim of digital transformation is not only to integrate digital technologies and services for enabling digitalization of processes in education, but to increase the life expectancy of the digital implementations and guarantee that new process where effort and resources are allocated create or improve the capacities for students and teachers, when also the physical and digital spaces are framed towards digital wellbeing.

The pervasiveness of digital transformation, rapid evolution of digitalization trends in many processes of related contexts (e.g. communications) and importance of other domains (political, economic, social, technological) on education, set a road with plenty of challenges to manage digital transformation.

1.3 The Context of Digital Transformation in Education

This section presents a deeper view of the context of digital transformation for the domain of education; providing a better understanding of the current situation and problem or challenges posed for digital transformation driving motivation of research questions. As any transformation, **the impact of digital transformation is radically changing our society, creating both opportunities and challenges.**

¹ A construct derives its name from the fact that it is a mental construction, derived from the general scientific process: observing natural phenomena, inferring the common features of those observations, and constructing a label for the observed commonality or the underlying cause of the commonality (<https://www.britannica.com/science/construct>)

1.3.1 High level policies driving a digitally connected Europe

Research by the Joint Research Centre (JRC) on Learning and Skills for the Digital Era started in 2005 with the aim of providing evidence-based policy support to the European Commission. Before 2008 digital education policies tended to focus on infrastructure (Del Rio and Dondi, 2008); there were various EU-wide policy initiatives for digitalisation of education and technology systems (e.g. eLearning Action Plan, e-Europe) mostly aiming at reaching objectives under a student to computer ratio of broadband access approaches.

After 2008 an innovation, competitiveness and inclusion approach became patent in ICT for learning in general (Punie and Cabrera, 2005). Most of the EU countries formulated national policies for ICT in education, either as standalone policies or as part of a wider national ICT strategy (European Commission, 2011; fostering students' digital competence, justified by future economic benefits.

After 2011, main policies on digital transformation have highly focussed in the infrastructure provision; but participants have not systematically translated many of these policies into the integration and routine use of digital technologies across European schools. For example, the Organisation for Economic Co-operation and Development (OECD) New Millennium Learners survey (2010c) found a significant difference between learners' use of ICT at home and in school.

In May 2015, the European Commission adopted the Digital Single Market (DSM) strategy (EUR-LEX, 2015) as one of its top 10 political priorities. In this context Information and Communication Technologies (ICT) infrastructures and broadband technologies continue to be considered be very important; the access and use of the internet as well as ICT in general offer to users (individuals and organisations), and stimulate the possibility to digitally connect, rapidly transfer large volumes of data and provide new services and products through digital means.

Tangible results regarding adoption of infrastructure due to focused policies have been reported. By 2018 in the EU-28, 86 % of the households used broadband internet access and more than three quarters (76%) of the people aged 16 to 74 accessed the internet daily. Also, in this population cohort (from 16 years old to 74) more than half (56 %) of individuals used the internet for social networking (e.g. Facebook, Twitter, Instagram,

Snapchat, etc), 60% of this population had ordered or bought goods or services over the internet for private use, 70% of the users provided some kind of personal information, 46 % refused to allow the use of personal information for advertising and two fifths (40 %) limited access to their profile or content on social networking sites. In addition, more than one third (37 %) (Eurostat, 2019).

In parallel, but still with lower adoption rates, the digital technologies are being uptaken at work and production environments. The increasing uptake and usage of digital technologies in business (business digitalization and e-commerce) is generating impact in the economy and on the labour market. In this context, the Digital Economy and Society Index (DESI) is an index that summarises relevant indicators on Europe's digital performance and tracks the evolution of EU member states in digital competitiveness. According to the DESI index 2019 report, the e-commerce turnover surpasses 10%. The DESI also reports that only slightly more than a third (34%) of EU organisations share information electronically (European Commission, 2019). The Digital Intensity Index (DII) is a micro-based index that measures the availability of 12 different digital technologies at business or industry level. The 2019 DII reported that almost a fifth of companies in the EU-28 are highly digitised (European Commission, 2018). In addition, the Digital Innovation Scoreboard reports that the four most popular technologies and technological solutions in 2017 have been cybersecurity, blockchain, big data analytics and artificial intelligence.

Still new large new technological deployments are to come in this area; 5G technologies are expected to hit the market in 2020 in a reliable and disruptive manner. The proliferation of these technology is expected to accelerate the advancement and uptake of other technologies (e.g. cloud, robotics, AI, etc) as well as areas such as Smart cities, industry 4.0 or intensive usage of sensors in Internet of Things (IoT).

Advancement in technologies and areas related to the education domain (e.g. telecommunications, uptake of technologies at personal and business level), create an increasing pressure over the education sector.

In the Rome Declaration (March 2017) the EU Member States committed to “providing young people with the best education and training”. The education sector not only will be pressured to digital transformation, but also to provide the new generation of human

resources, with needed digital skills and capacities, to cope and manage the future digitally enabled society. In this regard, in October 2017 the European Council called for training and education systems to be “fit for the digital age” (European Council, 2017), and in November 2017, with the communication ‘Strengthening European Identity through Education and Culture (European Commission, 2017), the new “Digital Education Action Plan” was announced.

The EC hosted the first European Education Summit in January 2018 with a broad theme of “Laying the foundations of the European Education Area: for an innovative, inclusive and values based education”, as an initiative to deliver the New Skills Agenda for Europe (European Commission, 2016), this Digital Education Action Plan, sets out the European Reference Framework of Key Competences for Lifelong Learning (European Commission, 2018), generating the bases enabling the knowledge, skills and attitudes that people need for life, including digital competences. Overall, this plan covers schools among other education levels, and sets out a plan to make better use digital technologies and support the development of relevant digital competences needed for life and work in the digital age.

The main challenges for schools will be to the pressure coming; on one hand from policy makers (top-down), will be called for efficiently provide valuable educational services (e.g. continuous preparation in digital skills) and continuously adopt digital transformation, ensuring education as the backbone of growth for preparing a digitally enabled and inclusive society and citizens for the future. Moreover, from a bottom-up approach, digitally enabled citizens and people experiencing high speed telecommunications (e.g. WiFi6 and 5G technologies) will increase their demand of digital services and knowledge since very early ages. Like commented above, all these major disruptions caused by digital transformation affects how people live, interact, study and work (e.g. industries will be digitally transformed and new activities will emerge (European Commission, 2017)), which in turn will change the way education is taught, delivered as well as learnt and consumed.

In addition, greater challenges will be generated by the current lack of structured programs; that organise or track digital connections or generation of content at school and work. Issues such as establishing appropriate mechanisms and guidelines for regulating the development homework, extension of homework, and use of electronic

content, or enabling teachers to use open educational resources, create electronic content, and share knowledge experiences and practices using technology are still not harmonized.

1.3.2 A digital society with new educational needs

*“We increasingly live in a digital society –
without knowing precisely what that means.”* *Rathenau Instituut*

Digital technologies are changing the way teachers teach, how doctors and patients talk to each other, what politicians’ debate, and how people share news. Behind the scenes, algorithms and artificial intelligence work in ways we often don’t even recognise

Sally Wyatt, scientist at Maastricht University: ‘The impact of digitalisation is radically changing our society, creating both opportunities and risks. A rich country like the Netherlands is no exception regarding the fact that people can become excluded due to the constant technological developments.’ The data and algorithms used in artificial intelligence were also widely discussed. ‘The way in which artificial intelligence influences society depends on our ability to invest it with human values and diversity’, (Sennay Ghebreab, Digital Society Conference at Media Plaza Utrecht, 2019).

The public sector, the private sector and civil society organisations must steer digital society in such a way that greater focus is placed on people and values. The aim is a digital society in which no one is excluded. This report identifies five actions aimed at values-driven innovation.

1.3.3 Current schoolers belong Generation Z, hard work to motivate

Today’s generation of children and teens going to schools, is a generation of digital natives, which is well trained in using internet, apps, phones or laptops. From messages to memes, this generation easily adopt new technological trends, knows the benefits and drawback of technological innovations and are usually knowledgeable of how technology is changing their world. According to McKinsey *“people born between 1995 to 2010— are true digital natives: from earliest youth, they have been exposed to the internet, to social networks, and to mobile systems;”* also *“coupled with technological advances, this generational shift is transforming the consumer landscape in a way that cuts across all socioeconomic brackets and extends beyond Generation Z* Businesses must rethink how they deliver value to the consumer, rebalance scale and mass production against

personalization, and—more than ever—practice what they preach when they address marketing issues and work ethics.” (McKinsey 2018)

The challenges at this point are several. While the education systems are looking for integrating better technological tools and digital content formats to support digital transformation and engage with students; students from this Gen Z are characterized for being digitally dependant and digitally native students that sit in classes, with millions of very attractive digital contents at their service and within a click of distance.

According to Compuware research “Gen Z has grown up in a world where rapidly evolving smartphones, laptops, tablets and other high-tech gadgets have become the norm” ; also, often it is said that this generation suffer of short attention spans. According to the Marketing Institute (Instituto Empresa, 2018) *“This generation expects to be able to communicate quickly and easily through instant messaging, social networks and email, rather than the means of communications of the past.”* *“This generation has a need for speed and expect technology to work at the click of a button or the tap of a screen”*. This research reported that Generation Z does not like waiting; 80% of these consumers expect a mobile application to transact in three seconds or less; also, they can switch between devices and platforms 27 times per hour (Ben Rossi, 2014). This generation consumes information from many screens very quickly; under a large quantity of options, where the only limit is time.

Although motivation is an individual issue, the demand for creating a motivating environment is placed on teachers; so, it becomes a challenge and time-consuming activity to prepare classes (with tools) and environment that motivates students in all these several ways. It is a demanding work to create and maintain relationships and to know each student (Marie Barse, 2015). Additionally, and at the same time, the teacher needs also to earn the authority of the class.

In this regard, the traditional schools are in trouble when they see themselves competing with so big and fashioned digital transformation opponent, as they need to deal with techy-fashioned users which also are receiving personalized services from many sectors and marketing practices.

To capture the Gen Z attention and motivation is usually difficult; as the digital content needs then to have not only attractive formats (such as the multimedia learning materials;

e.g. videos, apps, websites, and/or games) but to allow personalization of content. The consumption of content has also changed the speed and way to get informed. The speed is achieved by collecting information from peers' trusted sources or pages that collect most popular content (e.g. use Moments from Twitter which provides curated latest news from around the world or use known influencers to locate relevant information and entertainment).

Several schools/teachers are using serious games within to motivate students; especially in the Science, Technology, Engineering, and Mathematics (STEM) classes. Also, programming robots are becoming popular among students, as they learn through a ludic activity that really is complex, where a student must apply cognitive skills, such as abstraction, to solve the task (Or-Batch *et al.*, 2004). However, the activity of programming or building the robot is not usually part of the classes, which becomes a drawback to some of the teachers.

Moreover, the time dedicated by this generation to the large screens has highly increased, to the point that it is difficult to balance between screen time (mobiles and tablets) and in-person time. In the Z generation, nearly 100% of the individuals own a smartphone and spend over 4 hours per day online (Jaquelin Dooley, 2019). To the point, that Gen Z's parents and older adults are often confused and uncertain about what exactly their kids are doing on their phones.

1.3.4 Early school leaving (ESL) and lack of behavioural data

The EC indicates that early school leaving is linked to further unemployment, poverty, social exclusion and poor health; as the early leavers may face considerable difficulties in the labour market; for example, they can find it difficult to obtain a secure foothold as employers may be more reluctant to take them on with their limited education. Main reasons for early leaving comprise learning difficulties, social problems or a lack of motivation, guidance or support (ESHA Magazine/Children 2017).

An average of 11% of students (12.2 % of young men and 8.9 % of young women) drop out of school or training in 2018 in Europe. Early leavers in Europe ranged from 3.3 % in Croatia to 17.9 % in Spain; failing to reach their academic potential (Deloitte 2016). Europe 2020 target to reduce the rate of early school leaving below 10% by 2020.

In addition, data shows that in most countries boys are more likely to early school leaving than girls; also, students from migrant background or disadvantaged minorities have a higher average rate of dropping out school. The ESL is often seen as a result of loss of interest and cumulative disengagement, and generated by problems related to structural characteristics of the education system (e.g. inflexible education pathways), the school, emotional difficulties, the socioeconomic or family background of pupils, limited access to quality education, poor relationships between pupils and teachers, unhealthy school climate, bullying, not feeling ownership of their education, etc. (European Commission, 2013).

The common thread for early school leaving, losing interest or experiencing unhealthy schools' climate in many cases is driven by internal and external factors that drive to intrinsic and extrinsic motivation. The challenge here comes with the deployment of inclusive initiatives and support to students, both socio-emotional and cognitive. For this purpose, usually there is no recent and historical data that enables the possibility to create a patron or foresee further reactions. In these cases, the application of big data is expected to be beneficial in order to provide feedback to teaches and enable positive actions over motivation or behaviours. For example, although, Birgit Ohlin (2016) consider that external motivation produce pressure which reduces engagement with the task, Tranquillo (2016) supports that both types are important, researchers have found that intrinsic motivation and extrinsic motivation can have different effects on behaviours and how people pursue goal. Maria Barse (2015) identifies five types of motivation, all of which can be crucial for the individual student's level of motivation (i.e. knowledge motivation, mastering motivation, performance motivation, relationship motivation and involvement motivation). Potentially, if behavioural data is gathered on students, this will be differentiated actions to target a specific type of motivation could be approached.

1.3.5 New digital skills and capacities for social and professional development, and social inclusion

Chimombo pointed out education's role as a policy instrument, capable of driving social change and economic advancement in developing countries by giving communities the opportunity to take control of their destinies. The theme "Laying the foundations of the European Education Area: for an innovative, inclusive and values based education" (Effie Law *et al.*), is the initiation of the 2017 Digital Education Action Plan; which also links with

the 2030 Agenda for Sustainable Development, adopted by the United Nations (UN) General Assembly in September 2015; this UN agenda calls for a new vision to address 17 Sustainable Development Goals (SDGs), including SDG 4 on education. In this context the education has the challenge to prepare the current, and following, generations of citizens with the right digital skills and capacities to cope with the next generation of jobs, which are currently characterized to integrate a high increased technology use, extensive problem solving, in a global context and complex communication environment.

Education planning is required to oversee education needs over the future perspectives; this generates the challenge and pressure on how we can best prepare students, not only for the coming schools' years, but also well beyond the school. For example, schools are required to produce outcomes to support social innovation, potentially integrating digital education as a tool for inclusion. The social inclusion is, and has been, at the heart of European policies, being one of the targets of the Europe 2020, aiming at ensuring that every citizen or individual develops the necessary skills to remain active and included in an increasingly digital society.

The European platform against poverty and social exclusion, aims at supporting this challenge, as one of the seven flagship initiatives of the Europe 2020 strategy for smart, sustainable and inclusive growth. This platform aims at boosting work at all levels, aiming at reaching the agreed EU target of lifting at least 20 million people out of poverty and exclusion by 2020; several standardisation efforts are focussed on supporting accessibility and inclusion of ICT products and services, such as the recent standard ETSI EN 301 549.

Also, this challenge is related with the integration of migrants and refugees as an important point in the European agenda, education is the best channel to facilitate the settlement of the migrants and refugees received in Europe.

In this context, the principles of designing accessible user interfaces are well-known today, with guidelines and standards to test needed criteria for their development (e.g. ISO 9241-171). However, different users (with different disabilities) usually require different accessible oriented approaches. For this purpose, the NOLB project integrated tools such as the Global Public Inclusive Infrastructure (GPII) (Vanderheiden, G. and

Treviranus, J., 2011), which is a world-wide initiative on the support of personal user interfaces (i.e. one-size-fits-one), based on ISO/IEC 24751.

In addition, this issue also opens the challenge to integrate in schools, innovative digital transformation tools; such as gaming, which can support social inclusion, including women, children in risk of social exclusion or with disabilities; according to the JRC (Stewart James *et al.*, 2013) the use of digital games has a huge potential for empowerment and supporting inclusion.

1.3.6 Need to build up teachers' competences and sharing practices for evidence

In many cases teachers' lack of digital competences, and confidence for using digital technologies, which poses a challenge to digital transformation. Supporting teachers and strengthening their capacity to meaningfully integrate digital technologies into education is a key priority in current digital education policies. This includes better linking of systemic and operational policy levels and combining pedagogical competence development with the provision of digital devices or resources. The crucial role of educators in supporting the integration of digital technologies into education is acknowledged (Schleicher, 2015) but the confidence in using digital technologies in a pedagogically meaningful way is not high. Approximately, 50% of students in the EU are taught by a teacher who has a positive attitude about his or her ability to integrate digital technologies in a pedagogically manner into the teaching activities (European Commission, 2013a). Moreover, also digital skill gaps are reported in the context of Science, Technology, Engineering and Mathematics (STEM), in 2015 UK employers did not fill 43% of the STEM vacancies; which are essential for digital transformation.

Whilst students should be at the heart of the digital transformation journey, the empowerment of teachers and educators enables building a capital asset; as empowering educators to design and support the learning experience using technology, remains as a very important goal.

In this context, a challenge is to deal with the negative feeling of many teachers given by the fact of having been born as a millennial or in a pre-digital world. Many teachers still feel not confident enough to apply technologies. Many teachers also tend not to step outside of their comfort zone; and fear failure and seem reluctant to acquire the new set

of digital skills or capacities. To prevent this, also it is important to understand and communicate the benefits and value of digital transformation in education. In this context there is a challenge to create a stronger corpus of evidence, good practices and experience; facilitating lesson learnt to overcome the challenges of digital transformation in the schools. More experimental cases and evidences need to be provided to examine both the failures and successes of the past; and to recommend best practice so that school leaders and educators are inspired to embrace digital transformation. Moreover, generating information driven evidence enables better knowledge and experiences to provide insights based on behaviours or activities that children perform in classes; for example, by analysing with big data applications use in classes, teachers can be empowered to take positive actions that help students to reach their goals.

1.3.7 Cultural backlash towards continuously measuring the student's academic progress with valid and reliable data.

Instead of using data to personalize instruction, most educators adopt a one-size-fits-all strategy, supporting some special cases; this approach usually supports the most “average” child and the special needs cases, but failing providing support to the rest of the students. As teacher usually relies on intuition and observation. The lack of time and the implementation of a usually classical observation approach does not allow to implement a fully evidenced-based education planning, policy and teaching.

In general, many parents, educators and policymakers have an instinctual aversion to create a more data-driven education system; driven by the assumption that increased reliance on data will drive educators to focus on helping students succeed at testing rather than at learning. Achieving this type of transformation will require schools to integrate new technologies, processes and training. For this purpose, schools need to adopt digital management systems to facilitate student instruction and assessment; backend databases to store the massive volume of data; and the front-end systems to provide students, teachers, parents and administrators access to the relevant information. However, also many teachers and schools use different apps to facilitate the learning process through projects; for example, using Minecraft , Decoder, etc. Most of this apps collect information which also could be shared with the school. So, data could be re-used.

1.3.8 Need to integrate and promote new digital transformation as part of the academic curricula: digital games

Digital games can provide an opportunity for play through simulated environments and shall become an integral part of learning and intellectual development. We think and understand best when we can imagine a situation and that prepares us for action. In this context the use of Digital Games (Kerr, 2006) can be integrated as part of the formal academic curricula for delivering innovative teaching and learning practices, and to support development of cognitive, psychomotor and affective learning, is a natural response.

Cuban (1986) cited in Squire (2005,p8) wrote that *“However, the history of educational technology also suggests that educators will abandon media that do not fit the social organization of schooling”* and *“yet, as challenging as it is to design a good educational game, it may be more challenging to design a good educational system for an educational game to flourish in.”* The main aspect of this barrier to be considered, is the beliefs teachers and parents hold about the value of computer games in education. Teachers are decision makers for the use of games at school. Their attitudes, and the culture of the school, are crucial elements to consider in the adoption of games into education.

Games also are built with clear goals and provide immediate feedback. This allows game-makers to provide different paths or solutions to reach the goals. The idea of immediate feedback is also prominent in good formative assessment processes for teachers and empowers them as mediators to support cognitive work through constructive feedback and social empowerment. Placing game-making as a tool, linked to the educational curricula, enable children empowerment and access to the opportunities, experiences, skills, and knowledge for children`s full participation. Some game design platforms provide a "Lego-style" platform on which the users (e.g. children) can build simple games based on pre-defined building blocks that are visualized on the screen. This context has provided a positive approach to motivate students, capturing their interest. The usage of games, video-games design and gaming elements in learning environments aims at simplifying the understanding of complex topics, through an interesting and entertaining learning path for studying different fields and subjects.

Moreover, the opportunities to apply digital games to non-leisure sectors are expected to increase, as there is an increasing demand for quality education using modern and

interactive technologies. The potential to use Augmented Reality (AR) and Virtual Reality (VR) in this field also increases the attractive interactive and immersive approaches of game-based learning. According to Gartner Report worldwide spending of game-based learning market reached \$2.4 billion in 2018; driven by the increasing adoption of tablets, game-based learning and e-learning methodologies the market is forecasted to almost double by 2024 (Laura Wood, 2019).

However different challenges pose digital transformation; the low awareness and negative stereotype of games, knowledge gaps for new ways of using games, improve their benefits` evaluation, address the lack of impact through assessment tools, empowerment of teachers for inclusion mediation, improve weaknesses in the capacity to develop digital games adapted to the grade curricula (in terms of academic and emotional growth) and formalise best practices to approach this problem, and improving the distribution channels further than teachers or community networks.

In this context, also a wide problem is the lack of continuous measuring tools for game-based approaches in education that provide evidence of efficiency and value to support teachers` mediation process for empowerment and inclusion. Standen and Brown (in Press) have described how the lack of robust evaluation has been a barrier to the adoption of serious games. In 2010 Ulicsak and Williamson wrote: “As yet there are no definitive studies on the effectiveness of games, nor how they can be used for formal assessment purposes, or for learning in the home” (p6). Any evaluations reported are often on small, heterogeneous samples and lack a comparison or control group. Lack of robust evaluations may go some way to explaining why few of the developments reviewed are commercially available. In order to reassure commercial distributors and practitioners that these interventions are worth investing in, evaluations are necessary. Measures in special education settings should include the more qualitative goals of motivation and engagement, since without engagement there will be no deep learning or meaningful outcome in this cohort (see <http://www.ssatrust.org.uk>).

1.3.9 Structure of the research work

This guide brings together best practice from decades of experience working in countries across the globe, using contemporary education research to provide a practical resource for educational leaders. Each section chapter deals with an essential and specific aspects

of digital transformation processes in education and how we can navigate the change affecting our overall approach, schools and classrooms.

This document has been structured in nine chapters that follow a pyramidal schema (see figure 1), which represents how knowledge for this thesis has been developed.

The thesis is originated from the experience and own knowledge developed through European R&D and innovation projects in regarding digital transformation, as well as the experience acquired from the No One Left Behind project in the educational domain. This supports the motivation of the research. The Knowledge has been enriched taking in account trends and state of the art literature on the domain and challenges affecting the digital transformation on the education domain and the students, allowing the bases for the thesis (Chapter 1).

Figure 1: Research Work pyramidal structure

Over the pyramid base, two supporting pillars (comprising Chapters 2,3 and 4) have been developed, to provide the bases (research questions, objectives, literature research and a description of the No One Left Behind project) and framework for the performed activities of this research work. These pillars hold a central block (Chapter 5,6, 7 and 8) that enables the research work's core activities, comprising the generation of the model

and results from validation and evaluation. All these blocks enable to build the top of the pyramid block (chapters 9 and 10) which provides the conclusions and recommendations of the research work. These chapters are organised as follows:

- Chapter 1 Introduction: introduces the main challenges that drive digital transformation, the motivation of the thesis, and the context of Digital Transformation in Education.
- Chapter 2: Concepts and multidisciplinary scientific foundations: this chapter discusses the concepts and multidisciplinary scientific foundations; providing a comprehensive review of scientific literature and contextual factors that support the research work scope.
- Chapter 3: Research questions and objectives: presents the Research Questions (RQ) and proposed main objective, as well as specific objectives for the research work.
- Chapter 4 Materials and Methods: this chapter describes the overall materials and methods used for the research work, as well as for the Stage 0. It presents the methodological approach for designing the framework, as well as for its validation. Also presents the H2020 No One Left Behind (NOLB) as the pilot framework that supports the development of the model. Also, it needs to be taken in account that due to the nature of the model (sequential) being proposed, specific materials methods used in each of the model step (modelling approach) to allow the flow of this document.
- Chapter 5, Stage 1- Selection of the DT model and customisation to education: this chapter provides the selection and adaptation/customisation of the selected model as a generic approach, to be further customised/adapted to the education domain.
- Chapter 6, Stage 2 – Development of the EDILE framework model: this chapter presents the customisation for education domain, by mapping the development of the processes and structure to the No One Left Behind project activities, goals and developed processes. It is the development of the EDILE framework model

- Chapter 7, Stage 3 – Validation of the behavioural based model: this chapter validates the behavioural -based model by integrating the DT processes in the EDILE model
- Chapter 8 , Stage 4 - Validation of the value-driven proposal integrated in the model: this chapter presents the validation of the main model's main components.
- Finally, Chapter 9 presents the conclusion and discussions that link to the results achieved, verification of presented hypothesis, description of original contributions and a reflexion of the research direction for further steps. Chapter 10 provides the references; and an Annex.

2 CONCEPTS AND MULTIDISCIPLINARY SCIENTIFIC FOUNDATIONS

The literature review explored definitions, concepts and other elements relating to the integration and effective use of digital technologies in education. This literature review aimed to synthesise existing knowledge on this area as well as the Project No One Left behind as the foundation for the digital transformation framework.

2.1 Digital Transformation

Digital transformation is described as "the total and overall societal effect of digitalization" (Khan S., 2017). According to literature digitalization refers to "the adoption or increase in use of digital or computer technology by an organization, industry, country, etc." (Brennen S. and Kreiss D., 2014). Also, digitalization is considered as "the changes associated with the application of digital technology in all aspects of human society". In the context of business, we can define digital transformation as the "integration of digital technology into all areas of a business, fundamentally changing how business operate and deliver value to customers. It's also a cultural change that requires organizations to continually challenge the status quo, experiment, and get comfortable with failure." (The Enterprise Project) The EC characterizes digital transformation as the "fusion of advanced technologies and the integration of physical and digital systems, the predominance of innovative business models and new processes, and the creation of smart products and services."

Based on these concepts, we can say that digital transformation can be defined as the changes generated to the spaces we interact with (home, work, school, leisure, etc) and to our behaviours, as the result of adopting digital technologies. Digital transformation is considered a continuous and dynamic process.

2.2 Digital transformation as systematic innovation in education

Education institutions need to evolve and bring innovative forms to deliver knowledge to students in digital environments and support the socio-emotional behaviour resilience to reach digital wellbeing. Digital transformation is not a differentiator, it is the path towards

a more digitalised society where digital systems are becoming a large part of our everyday lives.

Nowadays, the schools' core mission aims to educate students to be successful in a complex and interconnected world that faces rapid technological, cultural, economic and demographic change (European Commission). Traditional education systems are not best equipped to cope with the changing nature of learning, the changing demands on learners and their competences, and the need for new ways of teaching and managing complexities.

A study conducted by the UNESCO International Institute for Educational Planning indicated that stronger capacities in digital educational planning and management may have an important spill-over effect on the system as a whole. Sustainable capacity development requires complex interventions at the institutional, organizational and individual levels Kirkland and Sutch (2009) said: "... the core of successful innovation in schools is the relationship between the innovation: the capacity and disposition of the innovator, and the environment in which the innovation occurs... The relationship between each of these areas is unique to each school and each innovation." Then the identification of the barriers that limit the innovation is critical to the success of any initiative; and a model that allows identify those barriers will be useful to reach the objectives.

The lack of progress in integrating digital transformation in schools partly might stem from a lack of clarity or common understanding of the school as learning organisation for establishing a the direction that the organization needs and/or wants to take (vision) for supporting most of the knowledge as digital services in a systematic manner. One of the main barriers to overcome is the need of the schools to acquire the knowledge to implement and take advantage of the digital tools in a systematic manner. This might mean to reconceptualise schools as "learning organisations" including to support new needed structures and resources required for the digital innovation that can help to react more quickly to changing external environments, embrace innovations (European Commission, 2016).

To establish a model framework for innovation to plan digital transformation and take schools towards the 21st digital century could be seen as a first step towards a shared

understanding of a thoughtful strategy for digital transformation; instead of a practice raised by silos in classes and teachers on their own.

Successful innovation and digital transformation require an integrated design process, which should be supported by efficient knowledge management techniques and tools. In education, as well as in any domain, the importance and challenge rely in connecting and developing the strategic vision of how and under which resources the organisation and classes should develop. Otherwise ideas will come "come out of the blue" and through different small areas or parcels (e.g. each teacher with different approaches, technologies or ways to introduce the academic curricula).

It is not easy and time consuming. The magnitude of positive effects of implementation of both, digital technologies and policies in many cases depend on contextual factors (European Commission, 2017). Digital transformation and innovation need to proactively take in account socio-economic and legal market trends, the competitive landscape, new technology availability, and changes in the needs of the stakeholders (students, teachers, school, etc), as well as in their preferences. The lack of a systematic and holistic models that supports digital transformation in education, also impacts the lack of creation of evidence for supporting positive effects and successes from embedding digital technologies in education, as well as for the creation and implementation of digital education policies.

2.3 The European Digital Single Market

The European Commission (EC) develops the overall strategy and political direction of the European Union (EU) which is designed to bring benefits to citizens, businesses and other stakeholders in the EU. Every five years the European Commission starts a new Commission term where each president of the EC determines the socio-economic and political priorities that support the strategical and political direction that will be implemented during that presidency. Coupled with these priorities set of policies and an annual work programs with concrete actions are developed and deployed, aiming at reaching the goals set in the established and planned strategy.

In May 2015, the European Commission, under Juncker Commission (European Commission in office since 1/11/2014 to 1/12/ 2019 with Jean-Claude Juncker as president), adopted the Digital Single Market (DSM) strategy (European Commission,

2015) as one of its top 10 political priorities. The DSM was built in three main pillars: promoting better online access to goods and services across Europe; designing an optimal environment for digital networks and services to develop; ensuring that the European economy and industry takes full advantage of the digital economy as a potential driver for growth. In this context Information and Communication Technologies (ICT) infrastructures and broadband technologies are considered to be very important; the access and use of the internet as well as ICT in general offer to users (individuals and organisations), the possibility to digitally connect, rapidly transfer large volumes of data and provide new services and products through digital means.

Besides regulation, the EU policies are also highly focused in stimulating development and growth. For example, the 2014-2020 budget for competitiveness for growth and jobs, education, energy, industry and Small and Medium-sized Enterprises (SMEs), networks and technology research and innovation transport was approximately of €142 billion; focusing on stimulating and increasing EU as an “information society” that works under a common digital cooperative EU market (DSM). Impact and adoption have been observed in many areas.

The increasing incentives (policy and budget investment) for moving EU towards a more digitized and connected society and economy, coupled with the proliferation of internet and digital devices, are bringing a digital age with a new scope, dimension, scale and speed to solve problems and manage the working operational processes, personal context, culture and the day to day living experiences at all levels (i.e. home, work, leisure places, etc); resulting in an increasing pressure for the digital transformation of process in all aspects of society at large.

2.4 Gamification as a strategy for digital transformation and supporting pedagogic capacities

2.4.1 Constructivism, computational thinking and socio-emotional learning

Learning is a complex activity that requires several gradual steps, and in general must be guided (Razak, 2008). To attain to the scope of this research work, this section focus on three learning processes that have been considered as pillars: constructivism, computational thinking and socio-emotional learning.

Constructivism, computational thinking and socioemotional learning are three learning processes that have been considered as pillars in this research work.

The constructivist approach (Rheinfrank and Evenson, 1996) is one of the most suggests that students learn best by the design and sharing of artefacts (Parmaxi and Zaphiris, 2014). The Constructivism links to educational psychology theories (Piaget and Innholder, 1967). This theory encourages students to build knowledge through active engagement, ideas and from their experiences in the real world. Designing sharable artefacts on their own reflects students' different styles of thinking and learning (Papert, 1993).

Constructivism can be perceived as something we do together, in interaction with each other, rather than an abstract concept (Dewey, 1938), thus teaching and learning can be conceived as a matter of sharing constituted knowledge, and the teaching may result in different learning by each student, as their subjective interpretations differ. Thus, the characteristics of constructivism drives towards empowerment, community building, and educational change.

Computational Thinking (CT) is a problem-solving process which involves expressing problems and the way a computer will execute. Seymour Papert has promoted the need to think computationally in his book *Mindstorms* (Papert, 1980). Papert connected computational thinking and constructivist digital pedagogy initiated by J. Piaget. Papert's enhanced thinking, specifically with a problem-solving approach integrating processes such as abstraction, data representation, and logically organizing data. J. M. Wing brought a modified approach and new attention to computational thinking (Wing, 2006) considering computational thinking as a fundamental skill for everyone's analytical ability; along with reading, writing and arithmetic. Wing's paper was welcomed by the community in all levels, especially in K-12. So, computational thinking is a 21st century skill for an increasingly technological world; which not only is considered important for development of computer applications, but to use for problem solving across other disciplines such as math, and science.

This project-based learning approach follows a certain sequence. First, students decide how to approach the problem and look for a solution based on their prior knowledge. Second, the team develops roles for each member that relate well with their knowledge

and complement each other in search of a common goal (OECD, 2014). Tasks and responsibilities must be shared among all members of the group to switch from individual work to teamwork. Third, they gather information from a variety of sources, analyse, and derive knowledge from it. Project work is always student-centred and task oriented. The teacher adopts a coaching role and students can consult with them for guidance, input, and feedback. The final artefacts of this project work can be shared with a community, thus fostering ownership. Other studies have found differences in problem solving abilities by gender (Resta and Laferrière, 2007) and in collaborative learning by the gender, status and culture of the groups (Masuch and Rueger, 2005).

Socio-Emotional Learning (SEL) provides a student-centred learning by taking the point of view that value in education is created with the student whose needs, interests and perspectives should be considered in the design of a learning experience (Padley, 2017).

Social and emotional learning (SEL) enhances students' capacity to integrate skills, attitudes, and behaviours to deal effectively and ethically with daily tasks and challenges. Like many similar frameworks, CASEL's integrated framework promotes intrapersonal, interpersonal, and cognitive competence (CASEL, 2019).

Research interventions support that SEL is central to development in terms of physical and mental health, moral judgment, citizenship, academics, and achievement motivation (Durlak, Weissberg, Dymnicki, Taylor, & Schellinger, 2008). SEL theory builds on self-awareness, self-control, and interpersonal skills, and supports that learning takes place in the context of relationships and that risk factors are responsible for maladaptive outcomes (Payton et al., 2000). SEL (Gardner, 1999) identifies two intelligences: a) intrapersonal for understanding and managing the self, and b) interpersonal for establishing and maintaining positive relationships. In this context, the Committee for Children (Committee for Children, 2019) SEL supports decreasing between 5 and 12% school dropout while increases by almost 13% the academic achievement. Moreover, gamemaking and games facilitate and develop SEL. Games are a powerful way of developing social and emotional learning in young people; as the interactional nature of playing a game together provide the potential for transformative learning through social interaction, social connectedness, cooperation and collaboration, and possess many of the features that encourage student well-being and resilience (Hromek, Roffey, 2009).

2.4.2 Games in Education

Games might be used in pursuit of engaging, effective learning experiences and can provide fun and learning scenarios designed to illustrate their pedagogical potential. The following learning paths support integration of games in the learning process.

Problem-solving and learning from failure are the natural ways in which children initially learn through play; this is the basis of most games; and of most of the more satisfying kinds of work.

Game-Based Learning (GBL) is an activity to engage and hold learners' focus by encouraging them to participate during the lesson through game creation and play thus allows a multidimensional construct of learning process, development of skills and reproduction of learning outputs (Domínguez et.al., 2013). Therefore, it is an innovative learning approach and possesses educational value. Engaging activities are overall well received by students and contribute to improving their overall motivation and productivity. Game-based learning is fun and motivating, fosters collaboration and teamwork, encourages a problem-solving approach, organises students' learning experiences, encourages self-reflection and provides learning support (Sanchez and Olivares, 2011). Within a game-based learning environment student can unleash their own creativity, express themselves, connect with their classmates, all of which promotes their social inclusion (Chandrasekaran et.al., 2012). In groups students can solve challenging problems that are open-ended, curriculum-based, and often interdisciplinary.

Li and Watson (2011) divided game-based learning computer courses into three main categories: 1) The authoring-based approaches, which refer to game themed assignments (O`G Kelly *et al.*, 2006)) constructing, completing, or modifying existing games; the use of graphical and simplified learning tools (Cooper S, 2010; Meerbaum-Salant *et al.*, 2010); or providing frameworks. The visual programming environments allow novice users to keep the focus on the semantics of programming and problem-solving aspects and eliminate the need to deal with syntactical problems. 2) The play-based approach, which allows learning to program through game playing. The students can develop code while playing tutorial games (Paliokas *et al.*, 2011) debug a game (Barns *et al.*, 2007), or use multi-player real time strategy games (Jiau *et al.*, 2009). 3) The visualization-based approaches: use micro-worlds and demonstrates code execution in a visual context (Xinogalos, 2006)).

Recently, Standen and Brown have described the barriers to the adoption of games as an intervention for students with special education needs. As far as these students are concerned, games have not been widely adopted in educational or therapeutic settings. Discussing mainstream education, Pivec (2008) points out that: 'Although video games have been around for nearly 40 years, and GBL (games-based learning) has been researched for over 20 years, the uptake of this technology in the classroom has been slow.' (p2). However, currently the GBL grows at a compound annual rate of 10% (2019-2024), expecting to reach a global market of €3854 million by 2024 (Imarc, 2019).

Gamification (Detridink et al., 2011), attempts to keep users motivated to perform certain tasks (Glower, 2013) via integration of elements, such as adding points, badges, and leader boards (Deterlink et al., 2012). Gamification involves using game-based mechanics, aesthetics, and dynamics to engage people, motivate them, promote learning, and help them in problem solving (Seaboron *et al.*, 2015). The goal is to improve the user experience (UX) and user engagement, which requires a deep understanding of the users' needs. In such settings, the players perform tasks and are rewarded for them, which should increase their engagement. However, not reaching their learning goals can lead to stressful situations, which discourages the users from continuing to play.

Serious Games (SG) are games which primary purpose entertainment. SG are a subgenre of serious storytelling used by industries like defence, education, scientific exploration, health care, etc; where the of high value. SG are mainly used for pedagogical, fun and competition purposes; especially considering the changes to educational practices and infrastructure faced by educationalists and instructors over the coming years (de Freitas, 2011).

Learning through game making is a constructivist approach (Alesandrini and Larson, 2002) that allows students to develop their own games. The approach includes enhanced problem-solving skills, fostering of creativity, and the ability to learn programming skills (Zaibon *et al.*, 2010). The constructivism approach provides game challenges that help players solve problems in the game environment. These challenges can be solved through player's experiences in previous game levels (Zaibon and Shiratuddin, 2010). This means that purposeful play experiences can be constructed to create deeper learning experiences that a child shall remember and internalize.

The intention of using games within education involving programming is to motivate students; especially in the Science, Technology, Engineering, and Mathematics (STEM) classes. Programming is not a single skill but more a complex activity, where a student must apply cognitive skills (such as abstraction) to solve a single task (Or-Bach et al., 2004)). Gamemaking follows the constructivism and social constructivism philosophies, embracing the concepts of active learning, hands-on instruction, and cooperative learning. Using gamemaking for teaching children to create inclusive digital games is a way to let them stretch their creativity, computer thinking skills, intelligence and empowerment. There are no bounds for digital games, they can be as complex as the creator wants, and can be linked to many curriculum-areas (maths, physics, art, etc.). Creating digital games under a “teaching framework” allows the children to acquire different levels of “sequential thinking” (think abstractly and deconstruct a problem into smaller pieces - decomposition and composition) at different educational levels (primary and secondary levels), in order to progressively use it to reproduce, through games, knowledge about reality, and thus avoid frustration.

Games, in contrast to playing, are characterized by explicit rule systems towards discrete goals or outcomes. Therefore, they are an innovative learning approach and possess educational value (Stiven *et al*, 2018). Engaging activities are in general, well received by students and contribute to improved overall motivation and productivity. Within a game-based learning environment, students can unleash their own creativity, express themselves, and connect with their classmates, all of which promotes their social inclusion (Chandrasekartan *et al.*, 2012). Learning is an active process based on the learners' interests, curiosity, and experience. Establishing such an educational practice requires an understanding of new learning principles and content-based curriculum issues, students' collaborative learning processes, and the development of new concepts of projects based on learning knowledge. In groups, students can solve challenging problems that are open-ended, curriculum-based, and often interdisciplinary (Citi Nurul *et al.*). Teachers must consider how to support collaboration and communication during the whole game production process (Clapper, 2009). The teacher must ensure that the ideas for games are simple and have clarity and reduce the size and complexity of the game projects.

Many concepts in programming are difficult to understand for students in computer science education. This may be due to the degree of complexity and the level of abstraction of such concepts or limited experience.

Blocky Coding and Pocket Code: Several block-based visual oriented programming tools such as Blockly library (Blockly) or Scratch Blocks (MIT Media Lab, 2019) have been introduced to help students and people to have an easier time when first practicing programming. The visual programming blocky approach focus on younger learners, support people in their first programming steps; it can be used in informal learning situations and provide a visual oriented programming as interlocking blocks which allows students to have syntactically correct outputs; instead of using syntax²³.

The Pocket Code Framework (Pocket Code, 2018) follows the constructivism approach allowing users to creatively develop games and animations without previous programming knowledge. It is an Integrated Development Environment (IDE) that interpreters the Catrobat language. Pocket Code is an open-source framework for mobile devices that allows children to create their own games, animations, music, videos, and many types of apps, directly on their phones or tablets. Pocket Code provides follows the blocky approach and provides pre-coded modules (so called bricks), that enable connection with mobile devices sensors, as well as links with other sensor-based approaches and developments, such as LEGO Mindstorms®. Pocket Code programs are created by snapping together command bricks which are arranged in scripts that can run in parallel, allowing concurrent execution. For this purpose, Pocket Code uses widely used or standardized concepts such as variables or lists, and allow communication among objects, trigger execution of scripts, or scripts beyond objects, by using broadcast messages. Pocket Code is the basis of the Create@School App and was used as a pre-designed version of this App to train both students and teachers, in coding skills.

Pocket Code was initiated in 2010 for Android devices and extended in 2011 and 2012 to Microsoft Windows Phones, iPhones and iPads, as well as the HTML5 platform that is used in Firefox Phone OS. The Android version of Pocket Code is the most advanced and already publicly available now. It is also part of Google Play for Education that makes the Android version of Pocket Code most suited for its use in schools (e.g., Apple prohibits in its terms of use for iTunes the sharing of apps made by children through a third party service such as Catrobat's – in the past, interpreters for Scratch projects were rejected

by Apple, so it is not sure that the iOS version of Pocket Code will actually be allowed in the market once it leaves its beta status). All versions of Pocket Code are divided into two main parts: an IDE that allows children to visually create their Catrobat programs in a “Lego”-block style and a Player that allows children to run their own programs as well as the programs of other children

3 RESEARCH QUESTIONS AND OBJECTIVES

Based in conclusions from chapter 2, this chapter poses the research questions and subsequent objectives of the research work.

3.1 Research questions

The following questions have been depicted:

- Question #1 (RQ1): is it feasible to generate a model that assist the development of digital tools and infrastructure that support the digital transformation in schools? Will this model allow evolving digital transformation?
- Question #2 (RQ2): would it be possible to incorporate parameters that allow measuring and analysing behavioural constructs within DT tools designed for learning?
- Question #3 (RQ3): if school organisations maintain their classical organisation structure, would it be possible to reach the DT objectives?
- Question #4 (RQ4): what are the components and/or concepts needed in an evolving DT model that supports digital wellbeing of the main schools' stakeholders?

3.2 Objectives

The overall objective of this research is to develop a flexible and scalable framework model that allows to any school, independently of the level of Digital Transformation (DT), to plan and develop the DT actions needed for reaching digital wellbeing.

The specific objectives to reach the main objective comprise:

- O1: To select, adapt and/or develop a visual, flexible and scalable model that will provide a holistic view that enables to move from a current situation to a desired situation in an evolving DT environment.

- O2: To integrate behavioural constructs in the selected/developed model and asses additional needed actions or parameters to be measured, when adopting the behavioural based model.
- O3: To validate the DT model being developed can be adopted by schools with a classical organisation structure.
- O4: To identify and integrate the value-based components that must be integrated into a DT evolving model that reaches digital wellbeing for students and professors.

4 MATERIALS AND METHODS

4.1 Overview of materials and methods

This chapter presents the research work structure and describes how the materials and methods used for accomplishing the aims from this research work (presented in Chapter 3) have been managed and are presented in this document.

This research work is structured in four stages, which are the following:

- Stage 0: Concepts and multidisciplinary scientific foundations
- Stage 1: Selection of the DT model and customisation to education
- Stage 2: DEVELOPMENT OF THE EDILE FRAMEWORK MODEL
- Stage 3: Validation of the behavioural-based model
- Stage 4: Validation of the value driven proposals to being integrated in the model

RESEARCH QUESTIONS	OBJECTIVES	STAGE	Structure & Outcomes
		0	Materials, Methodologies, Results & Discussion Output: Concepts and multidisciplinary scientific foundations
Question #1 (RQ1): is it feasible to generate a model that assist the development of digital tools and infrastructure that support the digital transformation in schools? Will this model allow evolving digital transformation?	O1: To select, adapt and/or develop a visual, flexible and scalable model that will provide a holistic view that enables to move from a current situation to a desired situation in an evolving DT environment.	1	Materials, Methodologies, Results & Discussion Output: Selection of the DT model and customisation to education
Question #2 (RQ2): would it be possible to incorporate parameters that allow measuring and analysing behavioural constructs within DT tools designed for learning?	O2: To integrate behavioural constructs in the selected/developed model and asses additional needed actions or parameters to be measured, when adopting the behavioural based model.	2	Materials, Methodologies, Results & Discussion Output: Development of the EDILE Framework Model
Question #3 (RQ3): if school organisations maintain their classical organisation structure, would it be possible to reach the DT objectives?	O3: To validate the DT model being developed can be adopted by schools with a classical organisation structure.	3	Materials, Methodologies, Results & Discussion Output: Validation of the behavioural -based model
Question #4 (RQ4): what are the components and/or concepts needed in an evolving DT model that supports digital wellbeing of the main schools' stakeholders?	O4: To identify and integrate the value-based components that must be integrated into a DT evolving model that reaches digital wellbeing for students and professors.	4	Materials, Methodologies, Results & Discussion Output: Validation of the value driven proposals integrated in the model

Figure 2: Research Work: structure, objectives and research questions

Figure 2 presents and summarizes the overall methodological approach that drives this research work, and shows how the objectives, research questions and methodological stages have been interlinked

The methodological approach for this research work comprises a sequential approach that highly interlinks four procedural stages, going from the foundations to the validation of the main proposals recommended to be integrated in the digital wellbeing-oriented DT model. Under this context, the overall vision of materials and methods of the research work is presented in this section and described in the section 4.1.2 as part of the overall vision of the No One Left Behind project (NOLB), which is used as a pilot framework for the model development. The specific materials and methods for each process are presented in each research work stage, as follows: the literature research (Stage 0) is presented in this chapter (section 4.1.1). As for the other stages (stages 1 to 4) the materials and methods are presented in the respective chapters to provide a flow that links with the development of the model.

4.1.1 Materials and models for Stage 0: Concepts and multidisciplinary scientific foundations.

This is the initial phase and provides the scientific bases of the research work, including concepts and a multidisciplinary background analysis; which aims at the foundations of the research work. The materials, methods are presented as follows.

4.1.1.1 Materials

Materials for this stage comprise: scientific literature peer reviewed papers, market research reports, facts and news related to digital transformation, education including teaching and learning, policy reports and digital wellbeing.

4.1.1.2 Methods

Methods for this stage comprised:

- Literature review and in-depth analysis of online scientific literature: This methodological approach comprised conceptual review of published multidisciplinary literature over the tackled domain of the research work; which included digital transformation, education (including teaching and learning) and technologies for education. A state of the art and conceptual review was used for digital transformation and dynamic processes models have been performed,

followed by an in-dept assessment of digital transformation trends, game-based educational technologies, behavioural constructs, motivation, digital wellbeing and socio-emotional learning. Scoping review was used for challenges and trends analysis, in order to provide a picture of current situation.

- All review processes comprised the following steps:
 - Search and selection processes: these processes were performed online using mainly the following sources: Science Direct, Web of Knowledge, Scopus, Google Scholar, Research Gate, IEEEExplorer. For this research work English and Spanish peer reviewed journal articles were considered using a time span that comprised mostly the last 20 years (from Y2000 to Y2019); for some specific topics such as education or specific theories (e.g. constructivism theories), the search comprised articles from 1920. Search terms comprised a single-word or composed version of words (using and/or) of the following words: education, wellbeing, teaching, learning, behavioural constructs, social behavioural, social innovation, digital innovation, digital transformation, digital society, amongst cognitive education response, pedagogic response, motivation; amongst others. As for technology main words combined, the search was focus
 - Complementary search: search over the internet using topic or domain related key words was performed to review other type of sources such as magazines, newspapers, reports, large companies reviews or technical information. For this purpose, also the European Commission and United Nations` portals were accessed and reviewed, to research on policies, programs and/or reports.
 - Literature organisation: a selection of xxx articles was included in the research work. This procedure allowed to categorize by domain and or concept (in some cases taking in account publication date) the selected literature.

The results from the research work and multidisciplinary analysis that has been carried out in Stage 0 is depicted in Section 2.

4.2 No One Left Behind (NOLB) as a pilot framework to develop the methodology

The “No One Left Behind” (NOLB) project was a project co-funded under the European Union’s Horizon 2020 research and innovation programme (grant agreement No 645215; from 2015 to 2017). The project was created under the vision of building on the potential of the leisure oriented digital games to achieve “social innovation” in the education sector.

Under this context the NOLB project selected Pocket Code (a mobile media-rich programming environment for children) to develop a new optimized version (of high usability) for developing serious games in the education sector; and thus, increasing the students’ empowerment.

The overall project goal was to unlock inclusive gaming creation and experiences in formal and informal learning situations, underpin meaningful learning and support children to realise their full potential.

For this purpose, NOLB used a user-centered and participatory design, where teachers and students worked in collaboration with well-known designers of digital leisure oriented games, to create a powerful game-making environment to be used in schools, integrated as part of the educational curricula; empowering teachers and students under a co-creation of games that mix gaming and academic content under an inclusive design.

To reach these goals, the NOLB project integrated the traditional characteristics and properties of digital leisure-oriented games (i.e. game mechanics, dynamics and aesthetics, as well as game assets and in-game analytics) into Pocket Code. In addition, Pocket Code was adapted to academic curricula; and the academic curricula was adapted for supporting Game Based Learning (GBL).

Real evidence of the efficacy of this approach was provided through the experimental pilots. These pilots validated the developments with the participation of over six-hundred students (from 8 to 17 years old) from primary and secondary education of eight different schools; which were in Austria, Spain and the United Kingdom. In these pilots, we aimed at experimentally demonstrate how targeted children were able to empower their learning process by using a New Generation of Pocket Code (later in the project branded as Create@School). The children worked to effectively develop and adapt their learning material, by programming, coding and designing games for their academic subjects, such

as science, maths, history and languages. Through this playful experimental process, we expected to support the children's self-empowerment by learning the building blocks of knowledge and the related rational thinking of the themes approached in their academic subjects.

These pilots effectively developed and adapted the classes' learning material, by programming, coding and designing games for their academic subjects (including subjects such as science, maths, history, music, languages, physics, maths, and some others) with the goal of enhancing their classes' abilities across the academic subjects as well as their computational proficiency, creativity, and social skills. Through this playful experimental process, the students used the building blocks of knowledge and rational thinking for the themes approached in their academic subjects.

To tackle the social innovation, the pilots validated its outputs in three different social scenarios: students with disabilities (in UK), gender imbalance (in Austria), and differentiated collectives (in Spain). Moreover, students had the opportunity to share, socialize and collaborate with their peers during the game-making process by working in team.

As for the scope of this research work, we will use the Spanish use case of NOLB, which was deployed in two schools located in Andalucía.

4.3 NOLB Project development stages and results

NOLB started with a 9-month preparation phase, followed by two iterative (cycles) experimental pilots, that validated and evaluated the NOLB tools and resources developed for education during two consecutive school years (academic years); each year corresponds to an iteration or project cycle. During the first iteration Pocket Code was used in classes to gather all the changes, suggestions and conditions needed to be changed for adopting it. During the second iteration, the enhanced version of Pocket Code (branded as Create@School) was launched integrating the new suggested features and functionalities. The following figure summarizes and illustrates the three NOLB stages.

Figure 3: Main phases/iterations of the NOLB project

4.3.1 Foundational Stage

During this phase the foundational activities of the project were performed in order to integrate a functional conceptual framework for the NOLB project; all major operational work was performed during these periods. Activities from this phase included:

- Training for teachers and students in coding skills, Pocket Code and capacities.
- Technological needs assessment in the pilot sites, as well as acquisition of mobile devices (tablets) for students and teachers were gathered
- Revision and integration of teaching approaches in order to fully integrate the constructivist teaching approach. The teaching guide framework and academic

curriculum template were developed. Academic curricula were adapted, and problems solved in the different subjects, for using the Pocket Code app as a supporting gaming tool in the subject (e.g. in physics, computing, arts, music, history, language, etc).

- Identification of key challenges and assessment of didactical, social and gaming methodologies to be matched with academic content and academic curricula, and thus ensure the Pocket Code customisation for educational domain. Templates to adapt the subject with serious gaming was developed. The bases for game-making framework and game templates were developed Pilot deployment planning was developed
- Gathering and approaching classrooms and teaching processes` needs and requirements for transference of gaming technologies in classes
- Revise requirements students` academic, social and inclusion needs, requirements and/or capabilities
- ViPi framework was applied
- Coordinate the adaptation of GPII and revise the planning of experimental pilots; and design the accessibility framework.
- Parental consents for participation in the project were collected
- Infrastructure requirements, including cybersecurity processes and framework were defined. All tablets needed for classes were acquired, inventoried and distributed to schools in all countries

Results from the foundational stage comprised:

- Academic curriculum was adapted, and problems solved in the different subjects, for using the Pocket Code app as a supporting gaming tool in the subject (e.g. in physics, computing, arts, music, history, language, etc).
- A template to adapt the subject with serious gaming was developed.
- The bases for game-making framework and game templates were developed
- Pilot deployment planning was developed
- Teacher and students' requirements for coding were defined to provide training.
- Infrastructure requirements, including cybersecurity processes and framework were defined. All tablets needed for classes were acquired, inventoried and distributed to schools in all countries.

4.3.2 NOLB project - Iteration 1

The first iteration (i.e., first year of the project) took place during the year 2015-2016 academic year (Sept. 2015 to July 2016). During this iteration the Pocket Code mobile application (Spieler *et al.*, 2016) used in classes, to integrate coding in the curriculum and provide training in the schools for teachers and students while gathering requirements for the enhanced version of Pocket Code. During this first year we could consider that Pocket Code as a pre-design stage version of Create @School. The PDM, lessons and game templates and behavioural measures were designed in this cycle. Results from this iteration comprised: Teachers were trained for gamified teaching and Pocket Code usage, in order to integrate it as the gaming creation tool in classes

- The teaching framework game-based teaching-learning process was finalized
- Game templates were developed, and 38 different games were developed in Spain, as a testing collaborative approach in classes
- New functionalities and features were proposed for easing usability and decreasing the complexity of Pocket Code programming, such as: revise the use conditional bricks and variable bricks in large scripts, allowing to create user-defined bricks which would allow to increase the readability of long scripts by allowing to shorten them and give a name to important sub-tasks performed in the script, allow easier navigation in the script area, as well as redefining, creating and grouping objects and components or introduction of “scenes” in Pocket Code should ease the creation of large programs by abstraction of semantically coupled objects.
- The accessibility features started to be implemented on manual bases on the tablets.
- Teachers were guided and students were assisted in their learning processes by using a game-based development approach through making games to topics from their subject areas
- Students had the opportunity to share, socialize and collaborate with their peers during the game-making process by working in teams; more than 38 shareable programs were developed in Spain;
- Observations and insights were gathered from teachers and students during the pilot studies to provide feedback to the processes to be adopted in classes and to develop Create@School based on Pocket Code.

- NOLB partners created new modules to enhance Pocket Code and adapt it for use in schools
- Game-Projects (Pocket Code) repository was created for the Project

Results from iteration 1 comprised:

- The teaching framework game-based teaching-learning process was developed
- The bases for game-making framework and game templates were developed
- 38 different games were developed in Spain, as a testing collaborative approach in classes
- Teachers and students were trained in blocky coding using Pocket Code
- Game-Projects (Pocket Code) repository was created for the Project
- New functionalities and features were proposed and started to be developed/integrated (under agile approach) for easing usability and decreasing the complexity of Pocket Code programming, such as: revise the use conditional bricks and variable bricks in large scripts, allowing to create user-defined bricks which would allow to increase the readability of long scripts by allowing to shorten them and give a name to important sub-tasks performed in the script, allow easier navigation in the script area, as well as redefining, creating and grouping objects and components or introduction of “scenes” in Pocket Code should ease the creation of large programs by abstraction of semantically coupled objects.

4.3.3 NOLB project - Iteration 2

This lasted the academic year 2017-2018 (Sept. 2017 to July 2018). During this phase Create@School with new modules and templates integrated was used in classes as part of the approach to manage classes by projects, integrating projects in the academic curricula. Needs for new tools and modules for Create@School were assessed. The app was released in October 2016 as an open Beta version on Google.

During this period the SDK for the Big Data measurement was integrated, behavioural construct was re-aligned with the big data measurements, and a socio-behavioural measurement was provided on real-time by analysing the blocks and time spent by students in Create@School. The main activities during this period comprised:

- Projects were integrated in the academic curricula programs using Create@School and pre-coded templates were used as digital resources to be customized.
- Needs for new features and modules for Create@School were assessed. The app was released in October 2016 as an open Beta version on Google.
- During this period the SDK for the Big Data measurement was integrated,
- The behavioural constructs were re-aligned with the big data measurements, and a socio-behavioural measurement was provided on real-time by analysing the blocks and time spent by students in Create@School.
- Create@School was validated including the bigdata based behavioural analytics; 249 games for classes were developed and uploaded to the platform to be evaluated.

4.3.3.1 NOLB tools

4.3.3.1.1 Pocket Code

Pocket Code is a coding environment, which empowers the learning through play and creativity. It provides a newly developed game-like environment adapted to be used in school environments and the resources and guidelines to integrate game-based methodologies. Pocket Code allows a) developing games: within the 'playful learning', Pocket Code allows children to develop their own games within their curricula lessons, using their perspective, rational and logic, as well as their preferred assets (thematic images, sounds, etc.). Thus, students create their own learning material under Pocket Code game projects; b) playing games already developed in Pocket Code that approach knowledge of the theme in the subject to be instructed could be used to understand the rational of problems or issues approached. These games embed school-like exercises in a computer game environment, with images and themes that relate to the students' preferences or likes, allowing children to see how solutions or knowledge relate to the academic subject being instructed.

4.3.3.1.2 The Create@School App

Create@School is a Pocket Code based integrated development environment (IDE) for smartphones and tablets designed for children that provides a media-rich programming environment customised to the education environment, with ludic enhanced coding possibilities. Create@School was created specifically for the educational environments;

which embeds the MDA concepts. The game mechanics and dynamics from leisure-oriented video-game companies were transferred to ready-to-use (pre-coded) game templates, as well as the GPII inclusive and accessibility framework. The students used the Create@School App in class, to integrate playful activities into regular classroom education settings, and to perform class projects that respond to work to be done in themes integrated in the lesson plans.

Figure 4: Pocket Code vs Create@School enhancements (Spieler *et al.*, 2017)

4.3.3.1.3 The Project Management Dashboard (PMD)

The Project Management Dashboard (PMD) is a web tool interfaces that integrated information from all students in class, including the list of students per class, the projects assigned, and evaluation of the projects about the academic or curricular objectives. PMD allowed teachers to plan, assign, and manage the delivery of game projects and evaluate students for game projects. The PMD tool was developed within the project in order to have an integrated environment where educators could review and evaluate the games and apps developed by the students for each class context

Figure 5: PDM functionalities in NOLB (Spieler *et al.*, 2017)

4.3.3.1.4 The analytical tool

It is a big-data-based tool embedded into the PMD for monitoring and assessing through the tablets, the way the students' work and code on a class project. This tool measures socio-behavioural constructs designed in the socio-behavioural methodology (see below); including confidence, self-efficacy, performance, interest, creativity, persistence, effort/dedicated time, and concentration amongst others. This tool generates feedback data on each student's progress, socio-behavioural constructs, coding, and use of elements of the Create@School App, streamlining the process of the assessment of student work.

The NOLB game-making framework has three pillars, that represent to teachers, three important processes during the teaching practices: curriculum adaptation/planning, the teaching-learning process and the assessment and feedback process. Universal Design for Learning (UDL) principles rational (UDL Center, 2018). ‘what’, ‘how’ and ‘why’ of education, are three fundamental questions that provide a simple scaffolding structure that easily links to the NOLB game-making framework. Through the game-based methods the game mechanics (used by game-makers in the entertainment and leisure domain) were transferred into the academic curriculum, objectives and expectations.

Game-making Templates were developed to support the instructional approach promoting a creative inclusive learning environment. The goal of these templates was to integrate the concepts of game mechanics and dynamics and provide a ready-to-use or

pre-coded game giving the students an opportunity to start with an almost finished game; while in parallel applying game-making to any kind of curriculum subject. The templates used the Mechanics Dynamics Aesthetics (MDA) framework (Hunicke *et al.*, 2004) as game design process. The MDA structure comprises different roles: developing the core idea, writing a game concept, producing the artwork, programming the game engine, producing the game content, testing, balancing, and fixing the bugs. Thus, this approach also enables team collaboration and communication during the whole game creation process, as students can take the role that likes better. Three out of 13 templates were developed in Spain.

4.3.3.2 Frameworks and methodologies

NOLB standardized as many processes as possible both the academic curriculum and the game-making process. During the first year the templates were developed for: the lesson plans (developing academic curriculums; see lesson plan templates in materials) and for developing games (see game templates in materials). To enable this standardization procedure and link between game-making and its integration in the procedure.

4.3.3.2.1 Teaching Framework

The teaching framework is a three steps framework motivated under the continuous improvement framework, thus comprises three cycle oriented steps: Plan, Teach and Improve, to ease implementation, transfer in a 'fun' but pedagogic manner into the academic content, understand the rationale of the template and the Pocket Code guide and to ease operational purposes. Each of these steps comprised the activities planned by teachers to prepare classes in a full year.

Lesson plan templates were developed as a tool for the teaching framework to structure the instructional approach promoting a creative inclusive learning environment (see Figure 28). The template incorporates learning objectives for both the transference of game mechanics and dynamics through Pocket Code in lessons and the development of the pedagogic subject and knowledge using a hierarchy of learning, which is discussed in more detail below. The template also allows for planning and summarising the class strategies for the academic knowledge (topic) to be instructed. Thus, this component allows processes to be considered for the Plan and Teach phases, to be included in the template. The NOLB lesson plan template is structured in four (4) areas (boxes in the template) which support the Plan (first three boxes: Profile, Learning and Organisation)

and Teach (last box summarizes the class strategy in three areas: To start with..., Main learning and Extension).

4.3.3.2.2 *The NOLB Game making framework*

The NOLB game-making framework is the methodological approach that comprises the concepts, content and games to transfer into practice the processes (curriculum adaptation/planning, teaching-learning processes, and assessment and feedback) to assist teachers in integrating game-making activities into the academic curriculum. The game-making framework aims at supporting constructivist and inclusive teaching practices as well as deep learning processes, in order to empower students' learning processes via the use of Create@School.

This framework provides a practical tool to work under a common framework of understanding for integrating and applying game Mechanics Dynamics Aesthetics (MDA) to the Create@School games created for the subjects of the academic curricula.

Game-making Templates are the tools developed to support the instructional approach promoting a creative inclusive learning environment. The goal of these templates was to integrate the concepts of game mechanics and dynamics and provide a ready-to-use or pre-coded games for different game genres coming from a leisure gaming environment (e.g. adventure, action, puzzle, fighting, etc); giving the students an opportunity to start with an almost finished game; while in parallel applying game-making to any kind of curriculum subject. The templates used the Mechanics Dynamics Aesthetics (MDA) framework (Hunicke *et al.*, 2004) as game design process, integrating or preparing the mechanics and dynamics in the templates to be reused as generic genre oriented semi-finished games. The aesthetics of the games were left for the student to personalize the game; so students will select and integrate a look and feel that match with their personal interests, age, etc (e.g. students were allowed to personalize backgrounds, landscapes, and characters, create new challenging levels, as well as changing the difficulty of a game). This also was used as an inclusion tool for stimulating girls' participation and create inclusive games for also other students in risk of exclusion or with special needs. The academic content will be linked to the game dynamics and aesthetics selected by pupils. In addition, Create@School App allowed the editing of an existing game design. Three out of 13 templates were developed in Spain; below an example of one of the three templates.

Figure 6: Template structure developed in in NOLB (Gaeta, Cea & Beltrán, 2017)

Figure 7: Example of predefined template developed in NOLB (Gaeta, Cea & Beltrán, 2017)

4.3.3.2.3 Accessibility Framework

Framework for accessibility developed in NOLB based using the Global Public Inclusive Infrastructure (GPII) framework, which provided accessibility preferences to be set (e.g., text with bigger font sizes, appropriate colours, etc.) for children and people with special educational needs, making the Create@School App a more accessible IDE. Accessibility preferences are part of a profile changing option has been embedded within the

Create@School menu and made profiles selectable under “a name” (to make them more distinctive and attractive for the user). The profiles use names of gods to make profiles unique, attractive and to avoid discrimination. Each profile is linked to a special need usage. Therefore, Argus is a profile for visual (colour) impairment, Odin for general visual impairment, Fenrir for motoric impairments and Tiro for a beginner mode (see Figure 8).

Figure 8: GPII accessibility features in NOLB (Gaeta, Cea & Beltrán, 2017)

4.3.3.2.4 ViPi Framework

This framework was developed in response to the need to recognise and respect people’s diversity and provide an effective educational environment that works for a wide range of abilities (Standen and Burton, 2014). The ViPi framework four dimensions to the educational (Standen and Burton, 2014) and pedagogical framework taken from Minocha (2009): Educational, social, organisational and technical. These dimensions can generate directives and questions. Standen and Burton (2014) provide some context here – “a directive is like an instruction, i.e. telling someone what they should do, for example *“the organisation must be supportive of the introduction of ViPi and possess an appropriate pedagogic culture. Directives are made on the basis of evidence that suggests this advice is good for a range of trainees and learning environments”*. This is in contrast to situations where actually the trainer has to make up their own mind because only they know the situation in which they are using a new educational technology and for these situations

Standen and Burton use questions such as “*What are realistic training goals for this trainee?*” . In this way it is easy to see how the results from the characterisation of the educational domain could be converted into directives and questions to neatly summarise the implications for the transfer of Pocket Code to the educational domain in terms of what is known so far about the context of the transfer, functions, surrounding conditions, academic and didactical needs.

4.3.3.2.5 Socio-Behavioural constructs framework

Major cognitive and socio-behavioural constructs were selected and defined in NOLB, to relate to a group of socio-cognitive behaviours with game-making activities. For this purpose, we used the experience and knowledge from psycho-pedagogical departments, teachers and specialized partners in education psychology and gaming. Also, the teachers provided their related perception of externalized and internalized behavioural and emotional problems.

The following behavioural constructs were selected and customised (defined) to evaluate the teaching-learning process in the NOLB; which were categorized in four types: didactical/cognitive, socio-behavioural, Self-regulatory and Engagement. Each construct has been defined with the Spanish schools through a set of factors (categories) that build or link to a set of behaviours that support learning.

The following table shows the schema of the constructs and its related behavioural factors. These behavioural constructs were defined as a top-down approach; while a bottom up approach was done trying to match these constructs with the type and frequency of usage of the coding blocks.

Table 1: behavioural constructs & related behavioural factors (Collazos, Pérez, Beltran & Ursa, 2017)

Didactical/Cognitive	Socio Behavioural
<ul style="list-style-type: none"> Academic Readiness Usage of Create@School Coding 	<ul style="list-style-type: none"> Confidence Creativity Interest Performance Positive Affect Self-efficacy
Self-Regulatory	Engagement
<ul style="list-style-type: none"> Concentration Effort/dedicated time High Thinking Persistence 	<ul style="list-style-type: none"> Action-Engagement Self-engagement (over average in positive affect) Social Engagement

Didactical/cognitive construct

According to Collazos , Pérez, Beltran & Ursa (2017), this construct measures aligns of the learning objectives and the developed game; comprises two factors:

“The academic readiness and achievement of learning goals (learning achievement): progressive increment of knowledge of the student over its initial baseline (when the academic theme was started to be delivered). The rational of this category is to balance the goal of the game vs the achievement of the academic oriented goal. Overall, the teacher looks for answering to the question: Does the game responds/integrates to the academic challenge/question/goal to be gamified?

Use of Create@School coding: this category evaluates the program design; its evaluation comprises the assessment over the usage of different coding concepts: sequence, event handling, conditional statements, threads, variables, coordination and synchronisation, iteration, x/y coordinate, usage of formulas or keyboard inputs (interaction). This information is automatically gathered by the Create@School SDK”.

Socio behavioural constructs

The social and behavioural defines categories is conceptualized through three categories (Collazos , Pérez, Beltran & Ursa, 2017):

- Confidence: meaning to have the control over the outputs to be provided in the project (academic and gaming).
- Interest: links with self-interest, meaning eliciting personal benefit or advantages for yourself when making decisions (Mills and Allen, in press).
- Creativity: links with self-expression, and representativeness of the academic theme, linking with the narrative, type of game, use of backgrounds, characters and other assets.
- Performance: meaning self-efficacy of the gamified experience; for example, using blocks that are not common, objects, scenes, groups, formulas, etc.
- Positive Affect: links with the excitement, enjoyment within reaching goals
- Academic self-efficacy: this is taken as academic readiness and having the academic capability to reach the goals of the academic theme that supports the gamified experience.

Self-regulatory construct

Self-regulatory is defined in NOLB as self-effort needed to reach the goals, thus measure impact in academic performance and learning process. These factors were considered to link with self-regulatory behaviours:

- Concentration: capacity of being working on the app vs the time logged in.
- Effort/ dedicated time: time spent in Create@School
- High thinking: it relates with synthesis of ideas high order thinking and representativeness of the academic theme, such as the flow of the program to reach the goals.
- Persistence: is the effort to reach the challenge of matching the academic goal and game goal. It will link with time spent on Create@School, dropped relatedness, to interact positively.

Learning goal orientation: learning new knowledge and skills, new challenges, like new worlds or levels, rewards, etc.

Engagement and collaborative construct

The engagement and collaborative are considered as important social behaviours specially from inclusion perspective; these construct aim at measuring the connection between the learner and the learning activity or the school environment/class; mainly is measured by the intensity or frequency of interaction with social (e.g., peers), and academic environments. Collazos , Pérez, Beltran & Ursa, (2017) mainly considered three types of engagement:

- Social engagement comprises behaviours such as sense of collaboration with other, face to face interaction and social relatedness, improving or expanding social network or decision-making process (exchange of opinions).
- Self-engagement: it comprises positive affect and enthusiasm, as well as high self-regulated learning, working with individual responsibility.
- Action-engagement manages the affects for gaming the assets/resources and game coding in Create@School; this links with the number/intensity of interactions, total time using the system.”

4.3.4 The Spanish pilot: sample, evaluation and validation activities

4.3.4.1 NOLB Spanish pilot sample

The Spanish pilot was deployed in Andalusia, in two different cities. A total of 303 students (45% were girls and 54% were boys) participated in the pilot and technically validated the tools during the two cycles (each cycle developed during an academic year). The students' age ranged from 8 to 17 years, studying courses from 6th to 11th grades. In addition, sixteen educators participated in the evaluation of both the Create@School App (six of them used the preliminary version in Pocket Code, six used the Create@School App, and four used both versions) and the PMD.

Create@School was implemented in the following academic subjects: Science, enrichment, mathematics, and the program for children with attention deficit disorders (PEMAR; a special program for children with attention deficit disorders), computing, science, programming basics, biology, geology, language and social sciences.

Figure 9 illustrates the sample through the two project iterations.

Figure 9: Total sample Spanish Pilots (schools) NOLB (Gaeta, Cea & Beltrán, 2017)

The pilots adhered to the national guidelines in terms of ethical considerations and principles, using and providing amongst others: a) Parental informed consent; b) provision of information specifying the alternatives, minimal risks (i.e., not to be exposed to minimal risks), participation conditions and benefits for those involved before consent was sought; c) anonymity; d) confidentiality; and d) in-detail information to stakeholders (e.g., the European Commission - EC) regarding ethical aspects of research and evaluation/validation in reporting activities.

4.3.5 Evaluation and validation in NOLB

The validation of the Create@School App was performed by students and teachers, while the PMD was validated by teachers alone. The PMD tool was developed within the project in order to have an integrated environment where educators could review and evaluate the games and apps developed by the students for each class context. The Create@School App integrated the results from the teachers' observations, which were used to better inform the use of the Create@School App in educational environments. The following evaluation and validation activities were performed:

Table 2: Evaluation and Validation Summary activities in NOLB

Evaluation/Validation Activity	
1	Goal: Usability of Pocket Code; looking for new functionalities and requirements` assessment for Create@School Methodology: Co-Creation Focus Group Target: Teachers (N=8) and Students (N=151)
2	Goal: Evaluation of the PMD Methodology: quantitative assessment using AttrakDiff survey & Hassenzahl model Target: Teachers (N=14)
3	Goal: (validation) Acceptance & Attractiveness of Create@School Methodology: qualitative assessment; and quantitative (using AttrakDiff survey & Hassenzahl model) Target: Students (146), Teachers (14)
4	Goal: (validation) Interoperability and integration with other tools & sensors Methodology: integration with LEGO® technologies and participation in the LEGO® League Open European Championship Target: Students (N=6)
5	Goal: Demand and usage of game templates Methodology (validation): qualitative and quantitative (through PMD) Target: students (N146)
6	Goal: Demand and usage of game templates and Pocket Code or Create@School apps Methodology (validation): Jams organised during the project (Alice Jam 2015 and Galaxy Jam 2016) Target: Children through EU (N=3000)
7	Goal: (validation) Learning Achievements Methodology: quantitative (through PMD/analytics) Target: students (N146)
8	Goal: (validation) Analysis of Socio-Behavioural constructs using big-data. Methodology: quantitative (through analytics tool) Target: students (N=146)

5 STAGE 1: SELECTION OF THE DT MODEL AND CUSTOMISATION TO EDUCATION

As commented in previous chapters, DT is pervasive and impacting all around our contextual environment; changing not only this context, but also the behaviour, culture and values of people. DT offers technological opportunities, but also challenges and policy impact.

To monitor DT, fosters the DT knowledge on the state of play and the evolution of it in the schools (and organisations in general). By looking and analysing to the DT deployments, as well as to what to do or where to improve, schools can improve, create and/or acquire in a planned manner digital resources and tools that empower and strengthens teachers and provides them with a sense of ownership. In turn this shall empower students.

The fact of having a DT model provides a driver for transformation and having documented this process in a structured form together with practical evidences, enable further study areas for DT.

In this context, **the objective of this stage** is to analyse the literature resulting from Stage 0 regarding digital transformation models, which has been integrated in Chapter 2; in order to select a model that provides the bases to design a DT oriented framework model, with an ultimate aim of developing one in Stage 3 that enables or supports the vision of digital wellbeing for the students.

5.1 Materials

Materials to be used comprise results from Stage 0; having for this purpose the three candidate models for the customisation assessment.

5.2 Methodology

The methodological approach derived the following steps:

5.2.1 Selection of the model to be customised in the education domain

Customisation of the model: this is to select from the model the different modules or types of iteration needed. For this purpose, Cognitive Walkthrough (CW) (Wharton, Rieman, Lewis and Polson, 1994) will be used.

Wharton, Rieman, Lewis & Polson propose cognitive walkthrough as a method inspired in the organisational introductory “walkthroughs” used for many years in the software engineering community. The methodological approach supports theory-based evaluations of early interfaces evaluations, “in detail, is based on a theory of learning by exploration”. Wharton *et al.* (1994) define CW more in depth as a “usability inspection method that focuses on evaluating a design for ease of learning, particularly by exploration. “The cognitive walkthrough (CW) is a method for evaluating user interfaces by analysing the mental processes required of users. To perform a CW an analyst chooses a specific task from the suite of tasks that the interface is intended to support and determines one or more correct sequences of actions for that task. The cognitive walkthrough is used to identify problems with a user interface and to suggest reasons for these problems”. (Lewis and Wharton, 1997)

5.2.2 Selection of the model to be customised in the education domain

For this purpose, the FutureOxford multi-criteria assessment (MCA) was used. This tool provides a means of judging the functional characteristics of various alternatives; and weights different functional aspects. The criteria to select the model was fixed following the conceptual idea of this research work; this a model that is:

- DT, process, research or service oriented, so the model can be used to model the objectives of the DT.
- Modular: a modular model is needed to allow customisation to the educational domain by exchanging, customising and selecting/deleting modules.
- Generic: a conventional model that defines standardized general relation types that will be generic enough to transfer the model to another domain (education)
- Flexible: meaning flexibility in a twofold sense:
 - Modelling can start from any digital transformation stage or situation; so, any initial state (current situation) can be the starting point.
 - Different organisational situations can be modelled.

- Scalable: this means to:
 - allow continuous improvement, thus it provides continuous iterative development (iterations or phases)
 - Extend to new objectives
- Visual: allow to visualization in order to easy explanation to users regarding objectives, processes, take away action points, critical points, initiatives or provide visibility to innovative people.
- Show actions: easy to detect what is needed to do and where to generate changes

5.2.3 Adaptation and development of the new model

In this section the selected model is customised by adapting the different iteration/ phases and/or components. For this purpose, model is analysed according functionalities and optimized by adapting the model to the domain.

5.3 Results

One of the contributions of this research is the generation of a model that allows schools to establish the necessary changes to implement a system that facilitates the implementation of new technologies as an integral part of the courses and that allows continuous improvement, adapting each case to the reality of the group.

Overall, no practical models were found in the literature for specific digital transformation and/or educational oriented frameworks that enable holistic view, high flexibility and positive feedback for integrating, evaluating and scaling digital transformation processes.

Performed research included several research mixings in several ways words that could refine the search; these are: digital transformation, cycle, modular, module oriented, iterative, phases, engineering and non-linear models, research-based model, entity models, agent-oriented models, requirements models, amongst others. At the beginning 12 models came out from the hybrid composition of words search; from a quick read of the abstract and overall methodology 4 framework models or methodologies matched overall, several of the needed criteria. Thus these 4 methods were pre-selected to be reviewed in depth and see the potential to be adapted to this research work objectives. Among those the Design Research

Methodology (DRM) developed by Blessing and Chakrabarti (2009) was the one that was considered to have more potential.

The pre-selected and assessed models were:

Table 3: Pre-selected models from research search process, reviewed to select the one to be adapted

<p>Model/approach: An approach to understand and elicit requirements using systemic models. Ensuring a connect from problem context to requirements.</p> <p>Author(s): PadmalataNistalaSupriyaKummamuruM.G.P.L.Narayana</p> <p>Year: 2013</p> <p>Takeaway: The approach aims at connecting from the business context to the elicited requirements providing solution development with a case illustration. At the beginning aimed as a potential methodology as its systemic approach drove this method under a nonlinear behaviour and systemically ensures traceability from an initial context understanding to the requirements phase. It is a software development methodology, but it was thought to fit because it was thought that environment which influences or is influenced by the proposed solution for the system could be easily represented. However, the fact of not having an iterative approach has been a negative issue over the decision.</p>
<p>Model/approach: A Requirements-Driven Development Methodology</p> <p>Author(s): Jaelson Castro, Manuel Kolp, and John Mylopoulos</p> <p>Year: 2001</p> <p>Takeaway: These authors propose the Tropos methodology, which was pre-selected as to a first read showed to be very oriented to the organizational environments, founded in the concepts used to model early requirements. The method integrates the notions of actor, goal and (actor) dependency, and uses these as a foundation to model early and late requirements, architectural and detailed design. Besides allowing an agent-oriented approach and having the potential of scalability of knowledge engineering methodologies, this methodology relies on formal analysis techniques and the development of tools which support different phases of the methodology. The methodology fitted well with this thesis concept, but not real use cases that showed its usability were found.</p>
<p>Model/approach: An effective and efficient method to design services: empirical study for services by an investment-machine manufacturer.</p> <p>Author(s): Sakao, Tomohiko; Birkhofer, Herbert; Panshef, Veselin; Dörsam, Edgar</p> <p>Year: 2009</p> <p>Takeaway: This case was pre-selected during as in its abstract and first pages the research reported to be a method that solves a methodological demand for the case of designing a combination of services and products, methodical support may be demanded (Sakao et al., 2009^a; cited in Castro et al 2009). The methodical was focused to provide design procedures and design-object models and to describe activities. The method was scalable and flexible. However, it fails at the integration of products and service, show a more integrated view; also, the first steps of the methodology (gathering data) is highly oriented to products from marketing perspective.</p>
<p>Model/approach: Design Research Methodology (DRM)</p> <p>Author(s): Blessing, Lucienne T.M., Chakrabarti, Amaresh</p> <p>Year: 2009</p>

Takeaway: The Design Research Methodology (DRM) developed by Blessing and Chakrabarti (2009) was analysed. The DRM was specifically created to help design research engineers. Its objective is to make available to the design engineer an open methodology, valid for this complex activity, which allows them to formulate, develop and validate knowledge, methods, processes and tools based on the models and theories that drive to improve the design including, modifying and / or eliminating factors that influence in it and that with its use will allow them to improve the chances of producing a successful product.

DRM has been selected as the supporting framework for this research project since its methods are intended to support not only rigorous research approach allows while being flexible, to integrate new information, provides a holistic view of processes, guidelines for systematic planning, visual representation enabling interaction and providing measurable criteria. Four adaptations and applications in use cases were found.

Amongst other methodologies or models, the following agent oriented models were reviewed: Web Applications with UML(Conallen *et al.*, 2007), Software Requirements: Objects, Functions and States (Davis,1993) and (Odell *et al.*, 2000) Extending UML for Agents, the Gaia Methodology for Agent-Oriented Analysis and Design (Wooldridge et al., 2000). In depth review was not developed as these methodologies found to be very design oriented.

5.3.1 .Blessing & Chakrabarti Design Research Methodology – DRM, analysis summary

The Design Research Methodology (DRM) developed by Blessing and Chakrabarti (2009) was created to help design research engineers. Its objective is to make available to the design engineer an open methodology, valid for this complex activity, which allows them to formulate, develop and validate knowledge, methods, processes and tools based on the models and theories that drive to improve the design including, modifying and / or eliminating factors that influence in it and that with its use will allow them to improve the chances of producing a successful product.

DRM has been selected as the supporting framework for this research project since its methods are intended to support not only rigorous research approach allows the following advantages:

- High flexibility, as the model evolves as new information and/or new results are being incorporated and analysed.

- To integrate the formulating success and measurable criterion, which is natural in the model (criterion definition phase).
- To provide a holistic view and increasing understanding of the digital transformation phenomena design or implementation (descriptive phase)
- To integrate the importance of developing an impact model (or theory) as the basis for systematic development given in the design support (prescriptive phase).
- To support flexible and efficient planning and implementation processes of high complexity, as the ones used in design engineering.
- To allow a variety of research approaches and methods while providing guidelines for the systematic planning under rigorous research approach.
- To help select suitable key factors to maintain a list of important areas and process that need to be monitors that can influence the formulated measurable processes or criteria.
- Reflect the iterative nature of digital transformation

In addition, four previous customisations and adaptations of the DRM have been found; thus it was deeply analysed how these four cases have re-used or transformed DRM to be taken from a quite generic level to the different domains; more over one of the domains where already has been used is education. Below the list of domain, cases and context is summarized.

Table 4: Adaptation of DRM models to different domains

Domain	Reference & Definition
Operational Engineering	Reference: (Lli, 2014) Research work: Context: the model was used to represent the insourcing and outsourcing processes
Education	Reference: Calderon, ML. (2015) Research work: Context: Application of reverse engineering activities in the teaching of engineering design.
Manufacturing	Reference: (Paulson, 2018) Research work: Inclusion of sustainability aspects in product development at manufacturing companies. Context: the model was used to represent the inclusion of sustainability aspects in product development at manufacturing companies.
Design	Reference: (Dwyer, 2017) Research work: Model for engineering design research

Domain	Reference & Definition
	Context: process to develop a model that combines agile process elements with mechatronic products.

As for this research work, an adapted and customised version of this model is proposed taking as the foundation base the work of Blessing & Chakrabarti (2009) and Lli (2014). The model developed by Blessing & Chakrabarti (2009) is designed to be used in a research environment, not to be used in the operations and continuous improvement. However, the framework is visual, intuitive, structured, iterative and facilitate the understanding of the impact of the relations between different factors then it's a good base to define a new Model, more simple, that help not only, but also, in both stages: Research and continuous improvement in operations.

The Blessing & Chakrabarti (2009) DRS model is iterative, looking for a final design of the product in study. The DRM potential exceeds the area for which it was developed and can be used in any other field that requires evolving from a non-existent or current model to a new evolved model (Lli,2014).

Blessing & Chakrabarti (2009) model focus on two overall objectives of design research: “formulating and validating models and theories about the phenomenon of design as well as developing and validating knowledge, methods and tools founded on these models and theories with the aim to improve design, that is, to improve the chances of producing a successful product.” The DRM model provides four phases:

Figure 10: DRM phases (Fig. 2.1 from DRM framework)- (Blessing & Chakrabati, 2009)

Figure 10 shows the links between these stages, the basic means used in each stage and the main outcomes. The bold arrows between the stages illustrate the main process flow, the light arrows the many iterations. Blessing & Chakrabarti (2009) describe each of the model stages as follows:

- “In the Research Clarification (RC) stage the researchers try to find some evidence or at least indications that support their assumptions in order to formulate a realistic and worthwhile research goal. In the Descriptive Study I (DS-I) stage, the researchers, now having a clear goal and focus, review the literature for more influencing factors to elaborate the initial description of the existing situation.
- In the Prescriptive Study (PS) stage, the researchers use their increased understanding of the existing situation to correct and elaborate on their initial description of the desired situation.
- Any Comprehensive DS-I should be followed by an Initial PS to at least suggest how the findings could be used to improve design. The comprehensive development of support (Comprehensive PS) should at least be based on a review of descriptive literature (Review-based DS-I) and be followed by an Initial DS-II to evaluate the resulting support.
- A Comprehensive DS-II (evaluation) should be based on a Comprehensive PS or a Review-based PS to identify the background of the support to be evaluated, and at least be followed by an indication of how the support is to be improved (Initial PS).”

This set of stages complete a cycle or iteration; several cycles and/or iteration can be performed to enable continuous changes in the design.

5.3.1.1 DRM features and models

The main features integrated in the stages, and which were considered as advantages for the goals of this research work are the following:

Representing Existing and Desired Situations: DRM concept is based on going from the existing to the desired situation, representing them in opposite areas, and Blessing & Chakrabarti (2009) recommend to use the “*networks of influencing factors*” to describe the situations; which are the intended to represent interlinked steps to reach the desired situation and shows the assumed impact of the support to be developed. The models developed in

the RC stage describe the initial image of these situations and hence are called Initial Reference Model and Initial Impact Model. All the DRM models represent mainly statements in a rather qualitative situation.

Visualization through Graphical Representation: DRM provides visualization through nodes representation, which represent the influencing factors; where an influencing factor is an aspect of the existing situation or desired situation (in Impact Model) that influences other aspects of this situation. The following figures illustrate the visualization approach.

Figure 11: Graphic representation form DRM model - (Blessing & Chakrabarti, 2009)

Blessing & Chakrabarti (2009) use what they call Key Factors, which are “those influencing factors that seem to be the most useful factors to address in order to improve an existing situation. These are considered the core factors or the root causes. The Key Factors are addressed directly by the support.

Every link is labelled with the source(s) of the statement(s) it represents, using the following abbreviations: [X]: the statement was published in the reference numbered X; • [A]: the statement is an assumption; • [E]: the statement is based on experience of the stakeholders; • [O]: the statement is based on own investigations; • [?] : it is not known whether a link exists.”

From Reference Model to Impact Model: The Reference Model and the Impact Model are very alike; however the Impact Model includes the support and the desired, expected, effects, which may require new nodes and links; and sometimes require the introduction of assumptions, because there may be no available evidence of their validity. It is important to

make these assumptions explicit, so that the reasoning behind the Impact Model can be traced and judged. The following figure illustrates factors. The labels are used as support e.g., 'support problem definition'.

An Impact Model, representing the – partly assumed – desired situation after the introduction of the support (represented as an hexagonal element) (Figure 2.6 Blessing & Chakrabarti 2009)

Figure 12: Impact Model representation from DRM framework- (Blessing & Chakrabati, 2009)

Success Criteria and Measurable Success Criteria: the criteria for success can be added to determine whether the results help achieve the aim or objective targeted; which can be relative or absolute, qualitative or quantitative. According to Blessing & Chakrabarti (2009) the “*Success Criteria relate to the goal to which the research project or programme intends to contribute*” and the “*The factors whose desired values are taken as Measurable Success Criteria are the Measurable Success Factors.*” It is important to take in account that “*measurable refers to the possibility of measuring the criteria during the project.*” The following figures illustrate success factors and measurable ones.

Figure 13: Examples of measurable success in DRM impact model (Blessing & Chakrabati, 2009)

In many cases, the Measurable Success Criteria are redefined as understanding increases and specific support is developed

Overall, the DRM stages integrate the goals, success criteria and factors over what it is call referential, descriptive, prescriptive and impact models, depending on the stage as follows:

Research Clarification (RC) stage: this phase aims at:

- Identifying the goals that the research is expected to realise; the focus of the research project.
- Developing the Initial Reference and Impact Models;
- Identifying preliminary Success Criteria and Measurable Success Criteria;
- Providing a focus for the DS-I stage and helping focus the PS stage; addressing those factors that are likely to have the strongest influence on success;
- Providing focus for the DS-II stage for evaluating the effects of the developed support against the goals of the research.

Descriptive Study I (DS-I): The DS-I provides explicit links between success and the influencing factors investigated. According to Blessing & Chakrabarti (2009) the objectives of the DS-I stage are: “a) to obtain a better understanding of the existing situation by identifying and clarifying in more detail the factors that influence the preliminary Criteria and the way in which these factors influence the Criteria; b) to complete the Reference Model including the Success Criteria and Measurable Success Criteria; c) to suggest the factors

(possible Key Factors) that might be suitable to address in the PS stage; d) to provide a basis for the PS stage for the effective development of support that addresses those factors that have the strongest influence on success, and can be assessed against the Criteria; e) to provide detail that can be used to evaluate the effects of the developed support in the DS-II stage.”

The output of this phase DS-I is a **completed Reference Model**, Success Criteria, Measurable Success Criteria and Key Factors, that describes the existing situation and highlight the problems.

Prescriptive Study (PS): According to Blessing & Chakrabarti (2009) the objectives of the PS stage are: “a) to use the understanding obtained in DS-I or DS-II to determine the most suitable factors to be addressed in PS (the Key Factors) in order to improve the existing situation; b) to develop an Impact Model, based on the Reference Model and the Initial Impact Model, describing the desired, improved situation that is expected as a consequence of addressing the selected Key Factors; c) to select the part of the Impact Model to address and to determine the related Success and Measurable Success Criteria; d) to develop the Intended Support; e) to evaluate the Actual Support with respect to its in-built functionality, consistency, etc.; f) to develop an Outline Evaluation Plan to be used as a starting point for the evaluation in DS-II.”

The output of this phase is **Intended Support Description showing** the organisational, technical, infrastructural pre-requisites.

Descriptive Study II (DS-II): According to Blessing & Chakrabarti (2009) the objectives of the DS-II stage are: “a) to identify whether the support can be used for the task for which it is intended and has the expected effect on the Key Factors (Application Evaluation); b) to identify whether the support indeed contributes to success (Success Evaluation); c) to identify necessary improvements to the concept, elaboration, realisation, introduction and context of the support; d) to evaluate the assumptions behind the current situation represented in the Reference Model, and the desired situation **represented in the Impact Model.**”

The output of this stage comprises comments and results of the actual support; the intended support, its concept, elaboration and underlying assumptions, customisation, use and maintenance issues, amongst other comments.

5.3.2 EDILE: DRM inspired model to manage DT under a wellbeing goal

The different features and overall cycle philosophy of the DRM fit very well with the requirements of the model being pursuit. However, the design stages and combinations needed for the design research areas make the model quite complex for DT evolution.

If it is true that there is no finish line for DT (as you adopt technology, the need to change and go either to a new, more efficient and/or policy compliant technology one waiting there.

The idea of developing a model is to have a tool that helps organisations to systematically develop the capacity of continuously adapt and implement DT when looking at the new possibilities. Thus, to provide a set continuous envisioned goals, and continuously set, build and validate digital processes and resources that support the DT transition.

DT is not only about changing and adopting new technology, it is also about adapting the organisation culturally, socially and its governance to digital processes and resources to provide enhanced valuable digital based services.

Different from DRM this model is not used for design, but it has been developed against real DT process and resources being deployed and adopted by two schools in Spain, during its participation in the NOLB project. Thus, the model has been used under an operational (may could be called “production”) approach.

This resulting model has been named EDILE (model for Evolving in Digital Environments).

The EDILE model, has been inspired in DRM, and builds on the experience of the four adaptations done to four different domains (including education). EDILE not only is more simplified approach but has been optimized and customised to a new framework model adapted to DT in schools and under the goal of digital wellness.

Figure 14: EDILE model. Cyclic and evolving approach by phases

The EDILE model is defined as an iterative model, which allows schools to have a holistic vision of the situation for the current adopted, and further to be adopted digital DT situation; to be implemented in a dynamic and iterative manner. In this context EDILE:

- Provides alignment among teaching, learning, socio-emotional and behavioural constructs, and digital resources and process, under a common DT vision and goal.
- As recommended by Blessing & Chakrabarti (2009), it uses “networks of influencing factors” (comprising external factors, key factors, factors (general)) enable on-going move from a key objective to a success criterion.
- Integrates action points and measurable success factors to monitor actions and initiatives progress against goals.
- Works directly with the reference and impact models (no stages but models), creating a sequence of models that evolve by integrating, over the current situation,

the key factors, the actions needed to be taken (action taken) and solutions/gaps over actions taken.

- Visualization is enabled by graphical representation of the interlinked or networked factors, the objectives, actions, success criteria and measurable success factors. The graphical terminology allows to represent how an existing or desired situation can be modelled, the relationship between two factors or nodes is done through a connecting line (causal link) pointing at the effect. The link is labelled or annotated with the source of the statement (who or what enabled the relationship) this allows to know the support (reason) and/or responsible. The following nomenclature (figure 15) is used to model the digital initiatives resources and processes in DT.

Figure 15: Graphic representation of features in EDILE model

In addition, the EDILE framework model, the representation of factors has been enhanced, in comparison with the DRM model. To ease the reading and understanding of the models, the factors have been enriched providing an element (the subject; e.g. student), an attribute (skill, capacity or characteristic; e.g. empowerment). The figure 16 shows the modelling terminology used for the graphical representation.

Figure 16: representation for the model terminology

As example, the relationship between “The level of student empowerment” and its impact on “social Emotional Learning (SEL) Success”. (2014),

Definition of the sequential models in EDILE:

- 1) ***The initial referential model:*** this model represents the current initial situation (starting situation); the model integrates and illustrate:
 - The current situation, setting also in the model the key objective, the different DT processes as external factor, key factor or as a factor.
 - The success criteria at current or starting situation (not the vision). The success criteria represent the overall goal of the school and it is set by the school direction or management. This allows a consistent and common starting point and goal for all stakeholders; although at this stage the information for the model might not be complete or fuzzy.
- 2) ***The Descriptive Model*** is developed over the initial reference model and provides the desired or envisioned situation (strategic vision) where the school wants to move. The model starts by setting the new success criteria as the envisioned goal. Following then the concepts, key factors and factors are introduced in the model, representing the new digitally based initiatives that needed or want to be adopted (digital processes or resources), and that at the same time help to reach the new envisioned success criteria. Links among factors are “prescript” (annotated) with models, systems, theories from the literature and / or the experience and knowledge of the participants. Also, measurable criteria and the success factors should be integrated to support measuring the proposed initiatives .
- 3) ***The initial impact model,*** this model starts over the described a set of actions to be taken (action taken blocks) are added to the model (it is the launching of the operational phase and maintains and illustrates the operational strategy). This means to integrate in the model the action points in which quality actions/resources and or changes should be implemented to reach the both the critical objectives and success criteria. The aim of this model is to integrate the action taken boxes, together with measurable success factors, so this model ensures not only that taken actions implemented in a systematic manner but measured; so, all actions provide a measurable value in the implemented area.

During the development of this model, the pilot initiatives driven by the actions being taken, need to be tracked and provide the empirical implementation and respective data, to be analysed and check against objectives and factors. The aim is to validate if the changes

implemented allows to reach the success the factors (criteria) mapped or integrated in this model; this means also not only to reach success, but to detect the failures to improve the model. New actions, updates in factors or key factors, and through the different entities. The result of this stage (last updated model) is the *Final Impact Model*; which in turn becomes *initial reference model* for the next phase or iteration. Allowing a continuous cycle of DT transformation.

For each DT plan or projects, two or three cycles are a good option. For example each cycle or iteration can respond to an annual plan, where at the end of the year the technologies, aims and new needs are revised; thus a new descriptive model can be built over the Final Impact Model of the closing year (new reference model for the incoming year).

As is indicated by Blessing (2004), It cannot be expected that each of the stages of the methodology will be executed in depth in every single project. Resources might be limited, or it might not be necessary to do so.

In summary, the EDILE framework model flow can be represented as follows:

Figure 17: EDILE framework model (phases/cycles and modelling approaches/activities) by cycle

5.4 Discussion

This section addresses the Stage 1 of the overall research work methodology. The Stage 1 focus on the evaluation of existing framework models, in order to select one that could be adapted to the DT implementation in schools; in order to design the design a DT oriented model in this phase and develop the model in the Stage 3 towards the overall success criteria of reaching digital wellbeing; which has been the ultimate need driven goal proposed by the NOLB pilots when the project finished.

In this regard, the first issue during the development of the goals of this section has been the mismatch for not really being easy to find a framework model that could match several of the criteria specified in the methodology. These are: being flexible, scalable, representative of key and generic factors, visual oriented and capable of integrate measurable KPIs to be measured in the validation or projects implemented. One of the issues observed is that many of the methodologies seemed to be inspired by the programming paradigm when looking for iterative methodologies. Nicely presented methodologies, usually integrating concepts, methods or tools in the different phases of development. However, mostly multiagent, design and/or requirement and object-oriented, the model framework algorithms get really linked to the implementation phases.

The issue is that either looking for iterative, requirement or multiagent oriented generic models had sense, as the main idea or continuous cycles and getting aligned of concepts between technical implementations and “business areas” (multidepartment or multidomain) made sense at a high-level concept.

One of the main findings during the work performed in this chapter, is that in many methodologies, under the author of this research work perception, are well balanced to answer and support fundamental research questions, but these models are unbalanced when approaching technical developments against social and organizational holistic perspectives.

Among pre-selected models or methodologies, the DRM was selected to provide the foundations for EDILE. The DRM presented characteristics that matched the DT needs, such as having iterative flexibility, scalability for continuous improvement (continuous DT), service

orientation, modularity (by models or modules), visual approach and action-oriented profile. Also, DRM is generic enough and has been previously adapted to various domains.

In this context, EDILE is designed in Stage 1 as an iterative framework model that responds to the idea of DT as a never-ending journey. DT is focused in this research work as continuous transformation; implying more than only transformation of technology, but of the organisation, its teachers/employees or students/customers.

Each iteration has a set of four models that are developed while the DT project lasts or during a fixed lapse of time (e.g. annual plans). These four models were design as the “four high-level moves” needed for DT: a) the current and starting situation (initial referential model; b) the strategic vision and approach supported by the description model; c) the operational vision where actions and measurements are included in the initial impact model and d) the final impact model which has the comments (good and bad) of actions taken. Referential and descriptive model take to the operative initial impact model, which provides the opportunity of self-adapting and updating while different actions progress; this approach allows to support weekly or monthly updates (as done during NOLB). This fact was the main point taken in account during this stage by this research work; it has been important for this research that EDILE, engrains adaptability from the design of the model to enable successful transformations. Successful transformation is aimed at being reported in the final impact model when closing the DT project or DT period. The final impact model is considered the starting point for the current situation of the next DT phase or iteration.

6 STAGE 2: DEVELOPMENT OF THE EDILE FRAMEWORK MODEL

This stage aims at developing the EDILE model under the goal of envisioning digital wellbeing as the critical success. The NOLB is used as a piloting experience over which the model is layout. This stage captures and analyses the EDILE model and uses the NOLB project approaches, activities and experience to enrich the EDILE model.

Each iteration in EDILE is matched with each iteration in NOLB; and each model of each EDILE iteration aligns and enriches with information from the different digital services, initiatives, resources or actions being implemented or developed in NOLB; as this information is integrated as element or properties of the different factors in the EDILE model.

The EDILE models in each iteration are considered as a set of four interlinked models that comprise a) initial situation (setting where the model starts) and b) an end point (set the goal that want to be reached; in this case digital wellbeing); showing in the middle a descriptive and impact model with the critical points and areas that require change. The following paragraphs describe the materials, models, results and discussion for Stage 2.

6.1 Materials

Materials in this phase main comprise the infrastructure, tools, methodologies and behavioural measures that were used originally at the NOLB piloting schools, and brought, by the NOLB project to the piloting schools, which mostly has been described in Section 4.2.2 of this research work. More specifically this comprises:

An overall idea of the type of materials used in Stage 2 is summarized below:

- outputs from Stage 1: Design Research Methodology (DRM)
- NOLB project context and materials, comprising activities, apps, developments, tools, initiatives and results from the iterations designs, evaluation and validation activities.

- LEGO MINDSTORMS® educational tool provides a set of LEGO Technic pieces or elements (e.g. one EV3 Brick, motors, infrared sensors, etc) for building, programming, and commanding of LEGO robots.
- Arduino (Arduino, 2018): is a cross platform Integrated Development Environment (IDE) used to write and upload programs to Arduino compatible and third party boards (e.g. to build robots) but also, with the help of 3rd party cores, other vendor development boards. The user-written code only requires two basic areas: starting the sketch and the main program loop, that are compiled and linked with a program.
- Tablets and mobile phones: 338 Android based tablets and mobile devices with a set of embedded physical and virtual sensors to derive their data directly by measuring particular environmental characteristics (e.g., accelerometer, gyroscope, and proximity, etc.), were used in the Spanish Schools for the NOLB project.
- NOLB Teaching Framework and related lesson plan templates
- Game making framework and game templates
- Set of pedagogical methodological resources (Academic readiness, didactical/cognitive approach, academic success) , Socio-Behavioural constructs and Analytic tools
- Framework for accessibility and ViPi framework
- Pocket Code and Create @School

6.2 Methodology

6.2.1 Transformative interplay between digital and non-digital boundary (spanning tool)

The transformative interplay between digital and non-digital boundary-spanning tools (Pershina, Soppe & Thuna, 2019) is the overall methodology used to interrelate in the research work the DRM (Blessing & Chakrabarti, 2009) selected methodology with the different iterations of the NOLB project.

Raissa Pershina, Birthe Soppe, and Taran Mari Thune (2009) propose the Transformative interplay between digital and non-digital boundary (spanning tool); this methodology fits perfectly with the intention of mapping the different activities, approaches, materials,

initiatives, etc; from the NOLB non-digital boundary (pilot) that supports the development of the different steps of DT (digital boundary) that are captured by the EDILE model. This methodology uses the concept of “knowledge bridges”, which according to the authors “emphasize the importance of synthesis of digital and analogy expertise” or environments; this means that “the ability to bridge digital and analogy knowledge, seems to become increasingly important to leverage innovation in the digital era.”

Overall, Pershina, Soppe & Thuna (2019) propose that innovation happen under an iterative approach between the analogic and digital environments. These iterations integrate the appropriate information through a collaborative and co-creative approach, to the next element in the next interaction. The following figure adapts the spanning tool to illustrate the approach followed in the Stage 2, in this research work.

Findings of their research report that “analogue tools were mobilized to enable more open-ended innovation activities among the educators and digital experts, such as brain-storming and creative sessions, alternated with digital tools as tools of convergence, supporting the unfolding transformation of an emerging game idea towards a final digital output.”

In summary, this methodology links the iterations of NOLB with the Iterations/phases of the EDILE methodology as shown in figure 18.

Figure 18: Representation of the Transformative interplay methodology in EDILE

To perform this match and generate the knowledge bridges in the transformative interplay, two approaches were performed:

- A retrospective approach: the EDILE model was started to be developed in September 2016, when gaps for implementation due to the lack of a tool to provide a holistic view and organisational vision started to be observed. Many implementations were done as island or personal initiatives of the teachers. So, to have the historical DT implementation of NOLB a retrospective deployment, showing the past of NOLB (2015 – first year of the Project) was done to map and represent the linking of the EDILE model phase/iteration 1 with NOLB iteration 1.

The model development started by mapping the NOLB past intervention (activities, resources and initiatives deployed in the Spanish piloting use cases); under the following steps:

- The initial situation of 2016 was modelled as the reference model for iteration II but correlated as the final impact model of 2015.
 - The original situation (initial) of the school in 2015 (when the Project started), was mapped as the initial reference model of iteration I.
 - The descriptive model for iteration I, was developed following all the initiatives deployed in the school under the NOLB during that year.
- A prospective approach: the phase II of EDILE was developed following the same pace of the NOLB iteration II. At the beginning of the school year, the initial reference model was developed, and by the end of September when the NOLB plan for the II iteration was validated for the schools, the descriptive model of iteration II was developed. From here all developments of the initiatives, resources and activities were updated and developed in EDILE as they were happening (continuous updates)

6.3 Results

This section provides the results from the transformative interplay resulting from bridging the knowledge between the EDILE model and the NOLB DT deployed initiatives and results.

6.3.1 EDILE – Phase I

The EDILE Model for phase I comprises the models developed the bridge or mapping with NOLB iteration I: a) the initial reference model (original situation just before the NOLB started), b) descriptive model and c) final impact model.

INITIAL REFERENTIAL MODEL - PHASE I

Figure 19: EDILE – Phase I – Initial Reference Model

Figure 20: EDILE – Phase I – Descriptive Model

INITIAL IMPACT MODEL - PHASE I

Figure 21: EDILE – Phase I – Initial Impact Model

Figure 22: EDILE – Phase I – Final Impact Model = Phase II - Initial Reference Model

6.3.2 EDILE – Phase II

The EDILE Model for phase II comprises the models developed the bridge or mapping with NOLB iteration II: a) the initial reference model (starting from the final impact model from EDILE Phase I), b) descriptive model and c) final impact model.

Figure 23: EDILE – Phase II – Descriptive Model

Figure 24: EDILE – Phase II – Initial impact Model

6.4 DISCUSSION

This section addresses the Stage 2 of the overall research work methodology. The Stage 2 focus on the development of the EDILE model. For this purpose, the initiatives, digital activities, resources and knowledge are bridged from the NOLB to EDILE, so the model is enriched and self-contained.

The EDILE model is developed using a retrospective and prospective approach. The model starts to be developed as research activity that runs in parallel to the NOLB project, starting in September of 2016 after NOLB iteration 1 is completed. A retrospective approach was performed to reflect what happened in NOLB during iteration 1 in the Phase 1 (iteration 1) of EDILE, identifying actions, lessons learned and how everything went. A prospective approach is performed in iteration 2, updating digitalized activities, initiatives, resources and assets in Phase 2 of EDILE, as the project progressed.

6.4.1 EDILE -Phase 1

During this phase we can see that the **original and starting situation of the two NOLB** piloting schools is reflected in the **initial reference model – Phase I**, were mainly driven by an “academic success criteria”, although emotional and behavioural was approached, it was approach as what we can call systemic approach targeting the students behaviour mainly within a system (e.g. school, friends, family, etc). Also, classes were well managed under structured classroom environments where learning happened, approaching on best effort different needs, behaviours, attention spans or classes` challenges with very positive environment. However, behaviour, together with class participation and academic performance (tests, HomeWorks, etc) were valuated together; moreover, being the academic performance rewarded according to behaviour. Behaviours mainly were evaluated by observation processes.

On the opposite side of the key objective, in the same initial reference model, we can see that the main key objective is to provide students with empowerment and engagement of classes. This goal is what they wanted to achieve; however, the success criteria was mainly based on academic success. This current situation in 2015 was perceived, to be one of the drivers to participate as volunteer pilot in NOLB. In their current situation teachers will go to

find for digital resources in internet to improve their classes and get the attention of students. Although, among teachers they exchanged material and in coordination meetings approaches were shared, there was no organised or standardized way either to share or to decide in which was the digital approach to be followed. Traditional system was supported by extracurricular classes of robotics and innovative tools based on Arduino or Lego technologies were used inside and outside classes. However, as a complementary approach to the academic curriculum. In this environment key factors mainly driving the ecosystem were methodological methods, mainly focused by a constructivist approach and innovative but not widely approached, technological resources (i.e. Arduino, Lego).

NOLB started in the schools around April 2015, gathering the requirements and co-organising with the schools the main foundational activities to start the project (e.g. revising technologies, classes that will participate, revising the academic CVs to see how to integrate gaming, etc). A new approach of coding in classes (primary and secondary) to generate their own material for classes and develop games as homework was going to be adopted in 17 classes. This is reflected in the **Phase I descriptive model**.

The descriptive model was developed by two main approaches: 1) redefining the success criteria in a twofold: social-behaviour success and academic success; 2) integrating **three new key factors**: a) behavioural constructs, promoting a new model of constructs to be structured during this Phase I; b) integrating the ViPi framework (with four dimensions: educational, social, organisational and technical) enables pedagogical framework to maximize learning for variety of users (e.g. teachers and students), and c) the framework for accessibility and social inclusion; which aimed at supporting special visual oriented needs (e.g. light contrast, bigger fonts, etc) to interact with the NOLB tools being developed.

New and already existing key factors have evolved with the integration of new networked and dependent factors; which have generated a new set of measures to support the path for reaching the new success criteria.

The NOLB architecture was designed as a suite of services that interconnected four main components, which mainly both the components or the pedagogical/behaviours management tools or resources affected supported all key factors in the different models. The following figure illustrates this impact.

Figure 26: High level view of how Create@School connects

The Phase I initial impact model integrated the **Action taken boxes** (orange boxes in the model); impact reached by these actions is illustrated with the orange link arrows. Although impact reaches the success factor, we see that the main impact affects the behavioural success criteria.

The actions over key factors, with major impact during Phase I comprise:

- The implementation of actions for integrating the designed framework for accessibility (key factor e): a new definition and implementation for accessibility and inclusion was proposed, centred in implementation of the GPII; requirements were gathered and by the end of the year a preliminary framework was prototyped to be tested, generating a set of new profiles to support special needs. From functional perspective Create@School allows the personalization of the game playing platform,

through profiles: Profiles allow the personalization of the game playing platform, and at the end of the project individual profiles for people with special needs will be automatically created by the GPII framework.

Figure 27: Accessibility - Create@School connects

- The implementation of pedagogical methodologies over the tools & pedagogical resources (key factor b): which mainly was impacted for actions driven by the development of new digital tools and the development of new modules, templates and functionalities.

The teaching framework and generation of templates for developing games under a standardized approach was implement. The academic curriculums were documented, the process was standardized and documented, including the digital initiatives used in classes.

Figure 28: Teachers framework - Create@School

- The implementation of new digital tools such as Pocket Code in classes have impacted over the tools and pedagogical resources (key factor b), as well as over the game making framework, enabling the mechanics, dynamics and aesthetics, as well as an standardized the way of creating games by teachers and students. Both targeted users (teachers and students) used the same learning procedures to create templates and can use the pre-developed game templates to generate games that introduce the academic content; and could be used for deep learning. Importance of game templates generated a high impact, as the teachers and students saved much time in classes for developing games. Instead of starting from scratch, many games could start from almost finished versions; which were prepared for integrated the academic content and customised with aesthetics (e.g. backgrounds, icons, pictures, etc). From experiences in Jams, students could spend almost 7 days for coding a game. Templates allowed to seed up coding time.

Figure 29: Game Making Framework - Create@School

- Behavioural Constructs; an innovative proposal, with a matrix of behavioural constructs and game development activities were developed to provide a very innovative proposal for measuring game-based behavioural parameters; this approach opens a set of measurable factors that evaluate behaviour-oriented approaches.

Behavioural constructs (bottom-up)	Behavioural constructs (bottom-up)																	
	Match of academic & gaming objectives	Game originality	Complete/Sequence/flow w/ narrative/story structure	Work defence	Collaboration	Event Creation	Event Deletion	Coding Skills	Look & Feel/Customisation / Aesthetics	Customizes/Changes	Absolute time spent	Tracked events/actions per minute	Time spent w/playing-testing the game	Time spent in Pocket Paint	Time in Web View	Time spent in research/tutorials	Time spent in programming (remaining time)	uses brick help option
Gathering data process																		
Observational: via PMD	Teachers' observation										App related				Time Management (app related)			
Automatic: via SDK																		Support (observation)
Behavioural constructs (top-down)																		
Didactical/Cognitive																		
Academic Readiness	x		x	x														
Usage of Create@School Coding						x	x	x										
Social Behavioural																		
Confidence	x			x		x		x (*)										
Self-efficacy	x							x (*)				-	+					
Performance	x		x					x (*)									x	
Positive Affect	x	x							x	+				x				x
Interest	x					x			x					x	x	x	x	x
Creativity		x	x						x									
Self-Regulatory																		
High Thinking	x		x					x (*)										
Persistence						x								x	x		x	x
Effort/dedicated time												x	x	x	x		x	
Concentration																x (**)		
Engagement																		
Self-engagement									x	x			x	x				x
Action-Engagement						+		x	x									
Social Engagement																		

(*) only advanced functionalities of coding skills / (**) Time programming/Time logged in

Table 5: Behavioural constructs – Gathering data

Also, an action focused on recycling teachers, to support training in templates as well as reinforce coding skills was initiated and solved during the impact model.

Results from **EDILE Phase 1** are comprised in the **Phase 1 Final Impact Model**. The model gathers main results which comprise:

- On the actions of implementation of tools, the definition of accessibility was finalised to start with the deployment in phase II, for automatization of GPII.
- Regarding pedagogic methodologies advances were introduced in classes with the design of the PMD as the introduction of projects allowed teacher to manage classes by projects, with the same philosophy of game jams; this means that projects were launched as homework with a challenge related to the subject, and needed to be delivered by a certain date through the submission web area of projects. This process will carry out an evaluation process by teachers based in the socio-behavioural and cognitive constructs. 38 courses implemented game projects, all of them included in the curricula. Implementation of templates needed to be improved and enlarged in Phase II.
- Main pending issues were related with socio-behavioural assessment and the implementation of big data to gather data and monitor students.

6.4.2 EDILE -Phase 2

The phase 2 starts with the academic year 2016 -2017, by launching of Create@School, which was the enhanced version of Pocket Code; more than 60 new features including optimized blocks or engines (e.g. physics engine) to support games were developed and integrated in the new version of Create@School. This new **Phase starts with the Phase 2 initial reference model (Phase 1 final impact model)**.

The **Phase 2 descriptive model** carries out with many of the opened factors left from Phase 1, as many factors were created due to the need, but were designed in Phase 1 and are being developed or deployed in Part B. The factors regarding templates and recycling of teachers' skills have been fully approached, so are not considered in this model. **Phase 1 Impact Model** defines several actions:

Actions for accessibility: during Phase II (NOLB Iteration 2) several actions were implemented to enable

- individual profiles for people with special needs; these profiles were automatically created by the GPII framework when recognizing the user. Among features integrated to adapt the interface to the users with special needs were: Choose Font face, Larger Text, High Contrast, Additional Icons, Large Icons, Large Spacing, Starter Bricks, Drag'n'Drop Delay, Icon Contrast and Hints and Tips. The profile changing option was embedded within the Create@School menu and made profiles selectable under “a name” (to make them more distinctive and attractive for the user). Profiles were named with gods` names to make profiles unique, attractive and to avoid discrimination. Each profile is linked to a special need usage. Therefore, Argus is a profile for visual (colour) impairment, Odin for general visual impairment, Fenrir for motoric impairments and Tiro for a beginner mode.

Figure 30: Profiles for Accessibility and Inclusion - create@school

- The implementation of new digital tools such as Create@School in classes and the integration full integration of templates, have impacted over the tools and pedagogical resources (key factor b), but specially over control of timing for codification in classes and outside classes. At the end of Phase II, 13 templates, representing 13 different game genres have been developed.
- Other main implementation driven by requested actions, was the deployment of the Project Management Dashboard (PMD) during last year of the , this impacted over

the key objective related with the tools and pedagogical resources (key objective b). The PMD was deployed as a web interface that allowed orchestration of the learning environment and games area. The PMD integrated the results from the analytics allowing teachers to engage with students by using more personalized approaches, using data from digital behaviours. The data was registered by the Create@School software. Through the PMD the teachers could plan, assign and manage the delivery of game projects to support new game-based teaching approaches. Also, the PMD allowed qualitative evaluation of students regarding the completion of projects and achievements of objectives.

- Additionally, final actions also were taken to integrate the automatic socio-socio-behavioural assessment, measuring behavioural constructs based in the design done in the previous phase (see matrix Table 5). This constructs were linked to block coding monitoring using table 5 and categories of blocks as shown in the Annex.
- According to the Centre of Emotional Health (2016) behavioural assessment is defined as measuring different factors that reinforce and maintain behaviours, understanding situations and frequency of the behaviours, as well as changes on behaviours. In NOLB the cognitive and behavioural measurement was designed to be performed; using academic performance and observation for cognitive measures, and quantitative data gathering through big data was designed in Phase II to support results for behavioural assessment and measurement. The statistical analysis of collected data provided evidence and feedback to improve not only measurement but to innovate in the learning-teaching model.

In this context and under this approach, the analytics engine was implemented by coupling a big data-oriented architecture, enabling a big data visualization tool to see behaviours on action while coding. The following figure shows the implemented architecture.

Figure 31: NOLB Analytics Big Data architecture

In this context, the data was automatically captured from the students tablets while students code, for example every time the student creates a new brick, opens the program, modifies an existing component, explores in the tablet, etc; all these actions were registered in the Data Lake; data coming from the professors' PMD also will be integrated in the Data Lake; this means we had monitored movements of coding blocks as shown in table 6; including data from teachers.

	A	B	C	D	E	F	G	H	I	J	K
1	MergedC	Merge_S&C	Cod_Pa	Desc_Param	Desc_Event	Desc_Scategor	C	Desc_Categ	Weigh		
2	111	11	1	ParamA	1 Match of acad	1 Match of academ	1	Teachers' obs	1		
3	122	12	2	ParamB	2 Game original	2 Game originality	1	Teachers' obs	1		
4	133	13	3	ParamC	3 Complete/Seq	3 Complete/Sequer	1	Teachers' obs	1		
5	144	14	4	ParamD	4 Work defence	4 Work defence	1	Teachers' obs	1		
6	155	15	5	ParamE	5 Collaboration	5 Collaboration	1	Teachers' obs	1		
7	211	21	1	CreateProgram	1 Event Creation	1 Event Creation	2	AppRelated	1		
8	211	21	2	CopyProgram	1 Event Creation	1 Event Creation	2	AppRelated	1		
9	211	21	3	OpenProgram	1 Event Creation	1 Event Creation	2	AppRelated	1		
10	211	21	4	CreateObject	1 Event Creation	1 Event Creation	2	AppRelated	1		
11	211	21	5	CopyObject	1 Event Creation	1 Event Creation	2	AppRelated	1		
12	211	21	6	AddBrick	1 Event Creation	1 Event Creation	2	AppRelated	1		
13	211	21	7	DropBrick	1 Event Creation	1 Event Creation	2	AppRelated	1		

Table 6: example of table that links the different behavioural approaches

Data needed to be standardized and transformed to be consumed in the front end and be visualized. A standardized gaussian/normalization methodology was used by means of dynamically customizing the developed dashboards. For standardizing a gaussian curve was used for evaluating with a 1-4 grading scale (where 2,99 was the passing threshold).

Figure 32: Gaussian / normal distribution methodology

ID_Country	Desc_C	ID_Sch	School_Name	ID_Prof	Prof_Name	Prof_Surname	ID_course	Descrip_Course	ID_Project	Desc_Project	Proj_startdate	Proj_enddate	ID_Stud	Match of academic & gaming objectives	Game originality	Complete/ Sequence/ Flow/ Narrative/ Story structure	Work/ defense	Collaboration	Teacher intervention (positive intervention /mentoring)
1	SPAIN	2	(ESP) SAFA Puerto de Santa Maria	6	Emilio	Florida	5	(ESP) 4º ESO	12	Proyecto Inicial Asistido (TrigonometrA-a)	11/05/2017	12/05/2017	nesmf0001	4	4	4	4	2	3
1	SPAIN	2	(ESP) SAFA Puerto de Santa Maria	6	Emilio	Florida	5	(ESP) 4º ESO	12	Proyecto Inicial Asistido (TrigonometrA-a)	11/05/2017	12/05/2017	nesmf0002	3	3	4	3	3	3
1	SPAIN	2	(ESP) SAFA Puerto de Santa Maria	6	Emilio	Florida	5	(ESP) 4º ESO	12	Proyecto Inicial Asistido (TrigonometrA-a)	11/05/2017	12/05/2017	nesmf0003	2	3	3	2	4	4
1	SPAIN	2	(ESP) SAFA Puerto de Santa Maria	6	Emilio	Florida	5	(ESP) 4º ESO	12	Proyecto Inicial Asistido (TrigonometrA-a)	11/05/2017	12/05/2017	nesmf0004	3	2	3	2	3	3
2	AUSTRIA	4	(AUT) Akademisches Gymnasium	10	Ursula	Sturz	9	(AUT) 3A	3	Gestalte ein Interactive Book zu deinem Ex	05/04/2017	19/04/2017	naakf0002	3	3	3	4	4	4
2	AUSTRIA	4	(AUT) Akademisches Gymnasium	10	Ursula	Sturz	9	(AUT) 3A	3	Gestalte ein Interactive Book zu deinem Ex	05/04/2017	19/04/2017	naakf0003	3	4	3	3	3	3
2	AUSTRIA	4	(AUT) Akademisches Gymnasium	10	Ursula	Sturz	9	(AUT) 3A	3	Gestalte ein Interactive Book zu deinem Ex	05/04/2017	19/04/2017	naakf0004	4	4	4	4	2	3
2	AUSTRIA	4	(AUT) Akademisches Gymnasium	10	Ursula	Sturz	9	(AUT) 3A	3	Gestalte ein Interactive Book zu deinem Ex	05/04/2017	19/04/2017	naakf0005	3	3	4	3	3	3
2	AUSTRIA	4	(AUT) Akademisches Gymnasium	10	Ursula	Sturz	9	(AUT) 3A	3	Gestalte ein Interactive Book zu deinem Ex	05/04/2017	19/04/2017	naakf0006	3	3	3	4	4	4
3	UNITED I	9	(UK) Oakfield	19	Alice	Simpson	16	(UK) Year 11/12/13	29	signs in the community	05/06/2017	14/06/2017	nuoff0013	3	4	3	3	3	3
3	UNITED I	9	(UK) Oakfield	19	Alice	Simpson	16	(UK) Year 11/12/13	29	signs in the community	05/06/2017	14/06/2017	nuoff0019	4	4	4	4	2	3
3	UNITED I	9	(UK) Oakfield	19	Alice	Simpson	16	(UK) Year 11/12/13	29	signs in the community	05/06/2017	14/06/2017	nuoff0004	2	3	3	2	4	4
3	UNITED I	9	(UK) Oakfield	19	Alice	Simpson	16	(UK) Year 11/12/13	29	signs in the community	05/06/2017	14/06/2017	nuoff0005	3	2	3	2	3	3
3	UNITED I	9	(UK) Oakfield	19	Alice	Simpson	16	(UK) Year 11/12/13	29	signs in the community	05/06/2017	14/06/2017	nuoff0010	3	3	3	4	4	4
3	UNITED I	9	(UK) Oakfield	19	Alice	Simpson	16	(UK) Year 11/12/13	29	signs in the community	05/06/2017	14/06/2017	nuoff0011	3	4	3	3	3	3
3	UNITED I	9	(UK) Oakfield	19	Alice	Simpson	16	(UK) Year 11/12/13	29	signs in the community	05/06/2017	14/06/2017	nuoff0016	3	4	3	3	3	3

Table 7: Linked of coding behaviours with academic and social constructs

This process allowed to provide automatic calculation of grades based in how students were using Create@School. Professors could see information of behavioural constructs; the following figure shows that the parameter didactical cognitive reached the highest score in average from schools in Spain, so this means projects mostly were well developed as matched game objectives, with a good flow and narrative, under collaboration and positive teacher intervention. Engagement, Self-Regulatory and Socio Behavioural reach slightly lower (over average); which meant that games met learning goal.

Figure 33: Visualization Scoring Behavioural Constructs (example)

As for socio-behavioural parameters, components related with interest (research and tackling the teacher for support) and persistence (time spent playing) had the higher scores. This meant that students were using templates as they were, creating events and levels on current templates. Also, scenes were added through Pocket Paint or using photos were highly used.

Figure 34: Visualization Scoring Socio-Behavioural by category (example)

The importance given to the socio-behavioural assessment and to create models that were able to reflect behaviours measurements was high. As a result, the **final impact model in Phase II**, was commented that to have Socio-behavioural learning and academic success as success criteria had enable to not only reach the project objectives, but to have a very insightful learning experience for them as teachers. Parameters like confidence, that before

mere measured by observation, or how students behave in a test, now this could be quantitatively measured in reference to other activities, such as the complexity of used blocks that enable the creation of events. Also, it was important for teachers (and in turn they thought it was important for parents) to know the time spent in the web as well as to analyse the type game genres and how the academic content was transferred through the look and feel (e.g. see next figure). Although, this schema, as it was designed generated doubts in how this could be transfer to the official system, it was though in generating similar approaches to measure at least some variables.

Figure 35: Visualization Socio-Behavioural by category (example Spain Pilot)

For example, in Spain the most used genres were shooting/action and electronic books. Creativity in how the game, rewards and look&feel (e.g. background) became important to the pedagogic team, especially for analysing students that were perceived to be under exclusion risk.

The presentation of these results drove to new pedagogic approaches being commented in the school but still not certain how to be implemented, due to the fact of new issues to be managed. These comprised issues related with fake news, overloading of information and not knowing what information to be used, emotional states, and aiming at raising new schemes of motivation; either through gaming or some way that content could be transferred in an interesting manner; options comprised the possibility of simulations or having 3D content. Student engagement, overall, was considered very good through NOLB.

Comments in the Final Impact model comprised the worry of how to continue with behavioural measures and parameters, as well as with big data or development of content and templates, as the project was over. One main issue for the school was that a precedent with tangible evidence were created, especially for the management of behavioural constructs, the usage of internet time, empowerment through generation of games and creation of content and the adoption e impact of adopting standardized processes (e.g. usage of templates).

7 STAGE 3: VALIDATION OF THE BEHAVIOURAL -BASED MODEL

This stage aims at taking the Phase II Final impact model of NOLB (once the project was closed) to one more EDILE phase; aiming at improving the final NOLB model from Stage 2, with final inputs and gathered final insights regarding valuable benefits, things needed to be done and gaps needed to be overcome to continue a DT process that moves towards digital wellbeing; and based in the NOLB experience. The following paragraphs describe the materials, models, results and discussion for Stage 3.

7.1 Materials

Results from Phase 2, scientific literature peer reviewed papers, market research reports, facts and news for new concepts integrated towards socio-emotional wellbeing

7.2 Methodology

To revise actions proposed in EDILE Phase III initial impact model, the focus group methodology using Cognitive walkthrough (Wharton et al) has been selected. As stated by Stewart and Shamdasani (cited in Parker & Tritter, 2006) “the most common purpose of a focus group interview is for an in-depth exploration of a topic about which little is known”, as per Kreuger (cited in Parker & Tritter, 2006), a focus group aims “not to infer but to understand, not to generalize but to determine the range, not to make statements about the population but to provide insights into how people perceived a situation.” As for the purpose to moderate the focus group, the Cognitive Walkthrough methodology

Targeted users: NOLB schools participating as pilots in Spain. Participant requested: school direction, pedagogic team, technology department and teachers (at least one person of each area).

Agenda for the focus group meeting:

- EDILE methodology explanation and model generated during NOLB (having the same foundational knowledge).
- EDILE Phase II final impact model (Phase III initial reference model) and development of the initial impact model for Phase III.
- Value propositions perspectives (by area)

Value proposition methodology: the initial model is created after the NOLB project ends; thus, the model cannot be validated as part of the pilot. For this purpose, during the focus group also insights for the value proposition will be discussed in order to gather insights from the different school areas, and structure the main areas or points of the model to be validated. To elicit the value proposition, the Canvas methodology (Osterwalder *et al*, 2014) will use the value proposition to structure the gathered insights.

The Value Proposition Canvas is a visual tool which allow to understand that the proposal (product or service) that you are development fit the customer needs. This tool was developed by Osterwalder *et al* (2014) I their work: Value Proposition Design: How to Create Products and Services Customers wants.

The main benefit is how the actions proposed in EDILE Phase III fit in the real need of the schools. For each proposal several “value proposition CANVAS” can be developed (one for each stakeholder that needs to be analysed). The value proposition Canvas tool has two mirrored quarters, with three rooms each one: in the left one the *Value Map* will be filled and in the right one the *Customer Profile*.

The Customer Profile, in which shows all the important needs, desires, gains and pains that the customers have related with our product. The first room includes all the needs and important issues that they want to be solved or satisfied, it is called *Customer Jobs*. *The second room contains the most desired benefits from a positive point of view (so called gains)*, this means to have the benefits and gains - in the form of positive outcomes - that the customer (schools) could obtain from the use of the product or service. If your product fit, the *Gains* will increase the interest of the customer to adopt the value proposition. The final section of this quarter, *called Pains*, it contains the most important risks, fears and obstacles that the customer think that could jeopardize what they wish to achieve.

From the *Value map* side, the first room contain a condensed relation of all characteristics of the *Products & Services* offered, as much of them fit with the *Customer Job* (mirrored section); this improves the opportunity to capture the customer. The following room contain the *Gain creators* (mirrored of Gains), which explicitly specifies how the value proposition addresses the customer gains. Finally, the last room, called *Pain relievers*, shows how the products /services proposed will alleviate the customers pains.

With the toll filled, some marks need to be introduced in the *Customer Profile* to identify visually the points filled by our offer (☑), the points not filled (☒) and the points that partially were filled (☐). Now visual perspectives and details about the Value Proposition are provided, and easy to select the type of customer.

7.3 Results

This section provides results from Stage 3, which are a twofold:

- a) Results from developing EDILE Phase III, this comprises the initial impact model for EDILE Phase III, as the initial reference model is the Phase II final impact model (coming from EDILE Phase II). The following figure is the resulting initial impact model.

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- b) Results from the Value Proposition Canvas exercise. These results comprise a value proposition for the main three actions that generate most of the impact in Phase III, which are:
- The creation of a new DT department (u organisational core group with a defined entity), which is presented as generation of value for the institution/school and for the teachers/professors.

STAGE 3: VALIDATION OF THE BEHAVIOURAL -BASED MODEL

Figure 38: Canvas' Value Proposition – Customer: School – Department of Digital Transformation

STAGE 3: VALIDATION OF THE BEHAVIOURAL -BASED MODEL

Figure 39: Canvas' Value Proposition – Customer: Professor – Department of Digital Transformation

- The development of behavioural constructs for managing better insights from students and enable better coaching and/or nudging on students.

Figure 40: Canvas' Value Proposition – Customer: School – Behavioural constructs and Socio-Emotional Wellbeing

Figure 41: Canvas' Value Proposition – Customer: Professor – Behavioural constructs and Socio-Emotional Wellbeing

Figure 42: Canvas' Value Proposition – Customer: Student – Behavioural constructs and Socio-Emotional Wellbeing

- The development of teacher “recycling” meaning long term training and education, for managing better insights from teachers training in a continuous DT adoption.

Figure 43: Canvas’ Value Proposition – Customer: Professor – Recycling Knowledge

7.4 Discussion

Discussion for Phase III is driven by the results on EDILE Phase III resulting initial impact model and the value proposition driven by the Canvas model.

7.4.1 EDILE -Phase III

The phase 3 is launched at the beginning of October 2017, after starting the 2017-2018 academic year. This phase approached the fact of how to maintain objectives and developments reached after a DT long project as NOLB and see how to support continuity of some activities. For this purpose, one more phase of EDIL was launched, aiming at reaching a proposal for the school through the generation of a Phase III initial impact model, in order to set a potential group of actions. The starting point for this was the final impact model of Phase II, which was taken as the Phase III initial model.

The Phase III descriptive model was generated, having as main points to be changed the following:

New success criteria for school was digital wellbeing, under a socio-emotional approach. This approached considered several important issues:

Student socio-emotional learning: this was linked with socio-emotional teaching, which is related with new skills and capacities being requested by the new digital agenda. In this regard how to build new capacities and strong emotional states was of great interest. Looking at parameters used for socio-behavioural assessment six of them were reviewed as the most important to be measured for DT, and over which they regularly could not measure in such tangible manner; these were:

- From socio-behavioural constructs:
 - Confidence: we take it as having control over the outputs to be provided in the project, from the academic and gaming perspectives.
 - Positive Affect: links with the excitement, enjoyment within reaching goals, and sense of belonging
 - Academic self-efficacy: this is taken as academic readiness and having the academic capability to reach the goals of the academic theme that supports the gamified experience.
- From self-regulatory constructs: related with the self-effort needed to reach the goals.

- High thinking: relates with synthesis of ideas high order thinking and representativeness of the academic theme, such as the flow of the program to reach the goals.
- Learning goal orientation: learning new knowledge and skills, new challenges, like new worlds or levels, rewards, etc.
- Engagement and collaborative construct; factors that affect the connection between the learner and the learning activity or the school environment/class.
 - Social engagement comprises behaviours such as sense of collaboration with other, face to face interaction and social relatedness, improving or expanding social network or decision-making process (exchange of opinions).

In addition, this needed to relate to current issues such as: student resilience and digital wellbeing, content overload, bullying, new role of teachers and management of times, creation of content or digital resources.

Taking this in account the Phase III initial impact model was developed, generating new proposals of actions to solve the new success criteria. The set of actions comprised:

- Creation of a new department or organisational structure for DT: this comprised to have a core multidisciplinary group people (teachers, ICT experts or computer teachers, technical department, management staff and pedagogic/psychology). The role of this group goes further than DT and technologies, it goes to promote and develop digital wellbeing in the school. This also comprises to support development and/or selection of digital tools for all the school, vision or what to implement, support in generation of templates and pre-cooked reusable content, and support for generating continuous foundations of DT.
- Large positive impact of templates, actions directed to generation of pre-cooked content was considered of high priority for teachers and school management. There was consensus in taking the role of teachers as coaches and implementing more project-oriented approaches, related with deep learning, in the curriculum.
- Bring back Pocket Code for education or similar coding apps, as results from Create@School were integrated in the new Pocket Code strategy; to guarantee maintenance of the software.

- Relevance of getting a new core group, department or organisational structure also, organisational change needs to be supported, including the recycling and continuous learning programs/certification of teachers.

Overall, behavioural assessment came as an important request and need to have a standardized method for observing, describing and assessing the digital behaviour of students, in order to generate tangible insights to coach and nudge students. The nudging concept was evaluated as its alignment with the use of incentives in gaming, as well as from the concepts of traditional education.

The proposed actions and integration or selection of socio behavioural assessment (measurements) were not able to be validated as Phase III final impact model, as the project was over. In this regard a validation based on value proposition approach was selected for validation of the new actions proposed in the initial impact model.

7.4.2 Value proposition of the actions proposed for the EDILE Phase III initial impact model

The value proposition Canvas provides the matching between the proposed actions and the needs of the impacted stakeholders; thus, in this regard the following Canvas were developed with insights and answers from the focus group performed in the NOLB schools, research and experience acquired during the NOLB project.

- For the department creation proposal: match was developed for the schools/institutions and teachers as stakeholders.

Institution (school) as stakeholder: the value of the department is given by the statements in the customer jobs (right hand side of figure 38 Canvas Value Proposition).

In this context it has been observed that the value of the department creation matches in more than 80% to the needs of the school. The requirements that the schools must meet both the students and community needs and expectations, are covered almost fully covered. Los pains associated to the school are the associated costs to open and operate the new department. Also, it is important to say the cultural change required by this action will impact the school structure and employees (teachers and staff).

Teacher as stakeholder: in this case the value of the department is given by the statement in the customer job figure 39 (right hand side). In this context the needs are almost fully matched for value created by the proposed department. In this case, several pains relievers have not been covered, as teachers had doubts and questions; those comprise: a) the teachers are not confident that the current skills and capacities allow them to take coming DT initiatives easily; an over-effort in training after school hours is expected. Also doubts come from the lack of experience in working with behavioural constructs and digital wellbeing; in addition, students and parents do not have previous knowledge in the behavioural area, and teachers are in the “front” to communicate and solve doubts to both: students and parents. For implementing this proposal, the teachers feel and expect to be overworked, as well as threatened by the entrance of robots, videos, MOOCS and other devices.

- For the behavioural construct development and socio-emotional wellbeing: match was performed for schools, students and teachers

Institution as stakeholder: the value of the adoption of behavioural constructs is given by the statements in the customer jobs (right hand side of figure 40). In this context, the needs for the school and the proposed action have a high match. From the pains side time and resources to implement these constructs are expected to be high; this proposal also foresees for new specialized personnel and similar tools as the ones used in NOLB. Also, teachers and staff that do not see this as innovative and with a need of additional effort, might become a resistance to change factor.

Teachers as stakeholder: the value of the adoption of behavioural constructs is given by the statements in the customer jobs (right hand side of figure 41) and most of the needs are covered by the proposal. Among not covered pains repeats from above, which is the fact that some teachers do not feel to have the required skill and capacities to manage this approach, nor to communicate to parents and students. Moreover, teachers and pedagogic staff feel comfortable for a pilot and to create evidence, but as a formal approach they see the need of experts to back this approach.

Students as stakeholders: the value of the adoption of behavioural constructs is given by the statements in the customer jobs (right hand side of figure 42), on the not fully covered pains the students (and its parents) it is foreseen that time will be

required to internalize and understand the value of the behavioural assessment tool; specially if at some point, it impacts the academic performance evaluation.

- For the teacher “recycling” proposal: match was done for teachers as stakeholder (figure 43), the teachers` need are covered by the “recycling” training program and the new department proposal, which also aims at maintaining the schools` teachers and staff “recycled”. As it can be seen in Figure 43 all the expected gains are covered, but pains are partially covered. One of the main pains (issues) of the teachers is not to have a strong enough background to learn digital tools; also some of the teachers feel that in the future they can be replaced by MOOCs, robots, computers or other media enabled devices. The ones that do not manage in-depth the socio-emotional and behavioural are not sure to provide right answers to parents and students but feel comfortable with having a visual tool that provides the information; for sure training is needed.

8 STAGE 4: VALIDATION OF THE VALUE DRIVEN PROPOSALS INTEGRATED IN THE MODEL

This stage aims at validating the value proposition of the model; as final stage for this research work. This validation stage will provide an external perspective to the model based in the experience of Spanish schools that are going to, or currently adopting DT. The insights gathered from Stage 3 in the value proposition Canvas templates, will be used to generate a questionnaire to survey a representative sample of Spanish schools.

8.1 Materials

Results from DRM Phase 3: insights from value proposition Canvas (templates filled with its corresponding insights).

8.2 Methodology

For the validation of the value proposals a focus group methodology

8.2.1 FOCUS GROUP OBJECTIVE_1: Validation of Model for Digital Transformation

8.2.1.1 Selection of the methodology:

The EDILE model has been developed under the approach of graph representation, describing information across the node network. The information has been embedded in the nodes through different features, giving different shapes or colours. This provides an interactive working visual-based environment. However, to explain the underneath situation of the DT, and get insights for the different components, moderation is required. In this context, the focus group methodology was selected to allow the interactive participation between the moderator and the several stakeholders of schools` departments. The cognitive walkthrough approach was considered a practical approach to explain the rationale behind the model`s visual representation and generate an interactive discussion gathering opinions, valuations, comments, reactions and engagement, while also providing explanation of the

model. A small survey to participants will be applied at the end of the focus group in order to capture most of the insights.

8.2.1.2 Scope and Objectives:

- a. Scope: to show and explain how the model was developed; and show how the NOLB pilots have been integrated and how the DT approach evolves through the different phases. The participants` opinions regarding the methodology from the methodological point of view and from the practical perspectives are gathered as feedback to the model.
- b. Main Objectives:
 - i. Review how complex is the methodology for the different stakeholders
 - ii. What is the perceived as value added to reach?
 - Digital Transformation?
 - Behavioural constructs and Social-emotional Wellbeing?
 - Continuous evaluation?
 - Value for Decision making?
 - As a factor to facilitate a concurrent development of the digital, Behavioural and Wellbeing agenda?
 - iii. Viability to be implemented, expected results
 - iv. Level of interest to be part of the implementation of the Methodology in their own School.
 - v. With the inputs of the focus group make a primary validation of the methodology

8.2.1.3 Participants:

- c. **Characteristics:** A mix of stakeholders, looking for a team with capability to reach a concurrent development of the digital, Behavioural and Wellbeing agenda
- d. **Type of Stakeholders selected to participate:** Teachers and/or teachers teaching computer sciences or related subject, Pedagogist, School management staff, ICT specialist or staff from the technology area.
- e. **Nº of participants** in each focus group: 8 – 12
- f. **Nº of Focus groups:** 2 (named: A , B)

- g. **Environment:** School, classroom with mobile desk that facilitate changes of geometry, Smart blackboard, Comfortable, tape recorded.
- h. **Incentives for Participation:** Opportunity to Learn a Model that can help the selected educational centre; Involvement in a relevant research project for the educative community, to share opinions. No economic or gift incentives allowed.

8.2.1.4 Groups Configuration:

Type of Participant	Nº of participants		Observations / Notes
	GROUP A	GROUP B	
Teachers	4	3	- From 5 Schools - In two consecutive days
Pedagogist	2	2	
School management staff	3	3	
ICT specialist / Staff technology area	3	3	
Total	12	11	= 23 participants

Table 8: Focus Group – Groups Configuration

8.2.1.5 Focus group procedure:

- Moderator welcome participants and explain methodology and rules.
- Moderator open a round in which each participant makes a short introduction of himself/herself and introduces the research work, its objective and the researcher. (5-10 minutes)
- Explanation of the Model (30-40 minutes)
- Coffee break, register informal positions about the topic (8-12 minutes)
- Open discussion with pre-determined topics - managed by moderator - to be discussed in a permissive environment. Recompilation of questions, reactions, opinions, etc. by support team. Tape recorded. (60 – 75 minutes)
- Small Survey, one after every Phase (3-5 minutes x 3)
- Wrap up allowing questions and answers in individual format with all participants (5-10min@participant) with 3 interviewers (15 -30 min x 3 or 4)

8.2.1.6 Basic rules:

- The moderator's role is to guide the discussion, facilitate the exchange of ideas and assure the balanced participation of all
- No right or wrong answers, only differing points of view
- Only one person speaking at a time, remember the discussion is tape recording
- No one need to agree with others, but you must listen respectfully as others share their views
- No phones, tablets or computers are permitted, please turn off your equipment. Only phone and electronic devices are allowed during the coffee break or similar situations
- Talk to each other
- Opening questions are welcome
- Exchange of opinions and debate are very welcome

8.2.1.7 Focus group Staff:

- Moderator: External Facilitator. It is important to minimize the risk that researchers and other persons related with the investigation generate bias with the participants. Participate as interviewer in the round of individual questions.
- Support team: 4 persons.
 - Member A: Explanation of the Model and answer technical and methodological issues about the model: M. E. Beltran (Researcher): Expert in the topic. Should be controlled by moderator to minimize possible bias.
 - Member B: support inside the group, allowed to participate in the discussion, also compile expressions, reaction, opinions, etc. Participate as interviewer in the round of individual questions. During the round of individual questions will take care of the people waiting his turn.
 - Member C: Observation and reporting of expressions, reaction, opinions, etc. He/her can't participate in the discussion. Participate as interviewer in the round of individual questions.

8.2.1.8 Bulleted Outline

- Presentation of the model
- Questions about the model
- Coffee break

- First opinion about the model

Phase I:

- What have been the changes introduced that have caught your attention in the descriptive model?
- Relevant issues regarding phase I procedure
- What's your opinion about the introduction of the following Key factors or success criteria?
 - (C) – Behavioural Constructs
 - (D) – VIPI Framework
 - (E) - Framework for accessibility and social inclusion
 - Socio Behavioural Learning (SBL) success
 - What's the opinion about the Action Taken
- Team members fill individually a small survey for Phase I (scale from 1 to 5)
 - Q1: What's your general evaluation of the model?
 - Q2: How complex is the model?
 - Q3: Comparing the initial referential model Phase I and the final Impact model Phase I, what do you think about the model?
 - Q4: How efficient could be the model for achieving Digital Transf.?
 - Q5: For a similar project, do you want to be part of the team working with this model?

Phase II:

- Relevant issues regarding phase II procedure
- What's your opinion about the introduction of the following Key factors or Success criteria?
 - Big Data
- (QA5-2) Recycling of teacher's skills or new professors with required Skills
- What's the opinion about the **Action Taken** ?
- Team members fill individually a small survey for *Phase I* (scale from 1 to 5)
 - Q1: Comparing the initial referential model *Phase II* and the final Impact model Phase II, what do you think about the model?
 - Q2: How valuable are the big data integration
 - Q3: How valuable is the reinforcement to develop new modules and templates?

- Q4: For a similar project, do you want to be part of the team working with this model?
- Phase III:
- Relevant issues regarding phase III procedure
 - Do you have an opinion about the **Action Taken** ?
 - Team members fill individually a small survey for Phase III (scale from 1 to 5)
 - Q1: Comparing the initial referential model Phase III and the final Impact model Phase III, what do you think about the model?
 - Q2: How valuable are the Digital transformation Department?

Q3: How valuable is Social-Emotional Wellbeing success criteria?

8.3 Results

Table 9: Questions and Issues commented during the explanation of the model - principal concepts included.

		GROUP A	GROUP B
PHASE I	Initial reference model	<ul style="list-style-type: none"> Who define the success criteria? School direction/board, but in a concurrent environment all stakeholders involved can be part of this definition What are the Measurable factors? any factor than you can measure with a fixed criterion and can help to indicate the evolution on the DT established. Could be used like KPIs. Who defines KPIs? Digital Transformation Team = DT Team References: Is it necessary? If you want to eliminate from the model, the model still will provide a holistic view, but it is not recommended to do so. The references enrich the model enabling why the relation is established or who might be the responsible behind the modelled initiatives. In general, easy to understand 	<ul style="list-style-type: none"> Model is flexible, everyone can draw its own reality (general comment) Key Objective is difficult to determine: Who does define it? School direction Board or Digital Transformation Team. What would happen if during the project the school determine that Key Objective is other? Nothing, it is an open and flexible system and is allowed any change, but you should be conscious that it could imply big changes and maybe the loss of work done. It is so open, difficult In general, easy to understand With the experience of the previous day, explanation solved some of the questions
	Descriptive Model	<ul style="list-style-type: none"> The group understood that it describes the desired situation, their main concern was the difficulty to reach an agreement among the members of the DT Team to define the new Key Factors, Factors, measurable success factors & success criteria Not all participants have knowledge of <i>Behavioural Constructs</i> (BC) and <i>Social Behavioural Learning</i>; an exchange of ideas was done, and most people agree that it is necessary as a <i>Success Criteria</i> in a Digital transformed School. Minor questions about connecting blocks and figures. The BCs were well understood, but much of the participants indicated that they would hardly have reached that deployment in a first approximation. Still some time needed to be automated. A manual or no big data approach is recommended to generate trust among teachers to be used. 	<ul style="list-style-type: none"> The group easily understood that it describes the desired situation. Some comments talk about the convenience of a graphic method to manage the process. As well as the other group their main concern was the difficulty to reach an agreement among the members of the DT Team to define the new Key Factors, Factors, measurable success factors and success criteria Idem second point group A. Pedagogist take a relevant role in the discussion. The inclusion of Socio-Behavioural Learning Success as Success Criteria was disruptive, some participants assigned high value to the flexibility of the model to be adapted to changing requirements Introduction of Evaluation matrix was a great contribution for most of the participants, especially professors.

Stage 4: Validation of the value driven proposals integrated in the model

		GROUP A	GROUP B
	Initial Impact Model	<ul style="list-style-type: none"> The “action taken” blocks were catalogued as a powerful tool. Teachers, ITC members and School Staff start an interesting discussion about the implications of the support blocks in human and technical resources but was cut because it is not the topic in this session. ITC staff comment that they also should be training in some educational areas to be an effective support for teachers. All the players coincide that required Skills should be Pocket Code was explained by the expositor, most of participants shows a good feeling with it. 	<ul style="list-style-type: none"> Most of participant were impacted by the support scheme, powerful but Complex. More than questions about the model the participants wondered about the implications in their responsibilities and skills needed, which was quickly cut off as it is not the issue to be addressed in this stage of the Focus group Some people indicate that colour in orange blocks and lines to indicate how “action Taken” affected factors is a good help, but other said that it is an overwork and is not necessary. Pocket Code was explained by the expositor
	Final Impact Model	<ul style="list-style-type: none"> The outputs of the <i>Phase I</i> were well evaluated, participants recognize that the model help to understand from a holistic point of view all the actions to be taken by the members of the team and how it affects to other players. 	<ul style="list-style-type: none"> This group also give relevance to the “measurable success factors and KPIs as a key information to understand the advance of the project.
PHASE II	Initial reference model	<ul style="list-style-type: none"> Graphic design help and facilitate the comprehension and communication Initial confusion to understand that Final impact Phase I is the initial reference model Phase II. After explanation was understood for most of the participants Some members 2/12, felt a little lost 	<ul style="list-style-type: none"> Idem point 2, and 3 of group A. the violet boxes have been well considered by the group but indicate that the map is overloaded. There is a tendency to think that you work on the same paper all the time, it explained that it is not convenient
	Descriptive Model	<ul style="list-style-type: none"> Some participants, moved by the expositor, were in capacity to explain clearly the changes included to evolve from the <i>initial reference model</i> Phase II to the descriptive model Big data introduction and coding skills & Capabilities help to complete the understanding of the model, and the added value for the team looking to reach the objectives Idem point 3 of Group B 	<ul style="list-style-type: none"> In general, same output from group A. 2 participants indicated: the method is complex & difficult to follow Again, specific issues of the case of study distract participants from the main point of this stage. Main concepts were explained but not discussion about responsibilities were allowed. Participants were asked if a theoretical case could be better to explain the model and 10 of 12 said that is better use a real case as this one. 4 participants indicate that they will need support at the beginning.
	Initial Impact Model	<ul style="list-style-type: none"> Change of Pocket Code by Create@ School was explained. Idem point 2 of Group A 	<ul style="list-style-type: none"> Idem point 1 of Group A The elimination of “Action Taken” (QA-1 Introduction of VIPI Framework solve any pending doubt about the areas which needed

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		GROUP A	GROUP B
		<ul style="list-style-type: none"> Some participants don't like the references over the model, they don't recognise its sense and value 	support or not. The effect of introduction of QA7-2 Reinforce development of new modules, templates and functionalities had the same result.
	Final Impact Model	<ul style="list-style-type: none"> Participant get awareness of the step back generated when resources were not assured and loss in the time Idem point 2 of group B. 	<ul style="list-style-type: none"> Idem point 1 of group A. <p>A debate about Skills required and School organization was open. High participation in the discussion, roles were questioned, training and recycling were highlighted. Point of view of professors – Management Staff – ITC were different</p>
PHASE III	Initial reference model		
	Descriptive Model	<ul style="list-style-type: none"> Interesting debate about the i Key Factor (F)_ New Organizational structure – Department of Digital Transformation. Well received in general new Final Success Criteria: Socio-emotional Wellbeing Most people show good understanding of the methodology and value it positively 	<ul style="list-style-type: none"> Idem point 1, and 2 of group A. Concern about the changes in the job responsibilities and skills needed with the new organizational structure.
	Initial Impact Model	<ul style="list-style-type: none"> Participants complete the exercise showing good understanding 	Participants complete the exercise showing good understanding
	Coffee BREAK	<ul style="list-style-type: none"> 5 participants very interesting in the model, looking for more experience. 2 Management Staff, 2 professors and one ICT 3 participants show interest in the model, main issues related about how it will affect their job in the future. In general, they think that the model could be good option 2 participants were a little lost, for them the model is complex, and they don't have interest in the big picture 1 participant was totally lost + 1 participant was all time talking by phone 	<ul style="list-style-type: none"> 5 participants very interesting in the model, looking for more information: 2 Management Staff, 1 professor, 1 ICT and 1 pedagogist 3 participants interested in the model, positive comments 2 participants out conversation 1 participant was totally lost

Table 10: Questions, Issues and exit mini-survey - Focus Group - revision: Phase I of the model - principal concepts included.

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		GROUP A	GROUP B
PHASE I	What have been the changes introduced that have caught your attention in the descriptive model? Positive (+) Negative(-)	<ul style="list-style-type: none"> The evaluation matrix is an important and necessary tool . (+). The inclusion of Behavioural Constructs, it is a new concept for us. Why it is related with Digital transformation? (+) VIPI Framework: Is it necessary if Behavioural constructs was included? (-) The openness of factor to related with the development of tools, its good because the activities are clear for all people. (+) Introduction of project management Dashboard (+) 	<ul style="list-style-type: none"> Introduction of Social inclusion is mandatory today, big step in the right direction. (+) Key objective was changed in the first step, from digital tools to empowerment and engagement to Socio Behavioural Learning (+) → importance of include Behavioural constructs → All change, it is a deep transformation (+) Definition of frameworks and methodologies to standardize bases of tools and systems, it will help to a uniform development. Evaluation Matrix included. (+) Pocked Code (+)
	Relevant issues regarding <i>phase I</i> procedure	<ul style="list-style-type: none"> The sequence of the different models that conform the Phase were clear. Each step of the Phase has its importance, gives the opportunity to reach the level of detail decided by the group, members decide when next step should be done. It is complex, only for specialist This graphic method helps to understand the activities and its relations Because factors should be classified (external, critical, measurable, etc.) a deep understanding of each is necessary and it is a good practice. The other side you need a lot of time to do it, reach consensus will be difficult. In the theory is perfect, but it is a long run, the system implies a lot of work and coordination. Research is needed to use this model, it is not common in my organization, maybe could be useful. The procedure aims to all members to work as a team. Managing staff should be open and generate empowerment of the team, it is not common in small and medium size schools. 	<ul style="list-style-type: none"> The procedure is coherent, help to work with focus and order. All team members understand what is happening and the implications. Use of KPIs and Measurable factors are the clue to really understand if the project is going well Complex but powerful. A lot of discipline and teamwork is needed The School direction Board must be committed and must provide the necessary resources, if not will be difficult to complete the second phase The model showed is handmade, then will be difficult to maintain in the time. Some software could be useful to have a digital support tool... in blacksmith's case wooden knife It's an impressive tool, flexible, graphical, help to have a Holistic view, I like it. I am open to use it, but I will need a specialist in the team during the first project Very good to establish relations among different factors.

Stage 4: Validation of the value driven proposals integrated in the model

	What's your opinion about the introduction of the following Key factors or Success criteria? (C) – Behavioural Constructs	<ul style="list-style-type: none"> • Very interesting, it could be a big change in student empowerment. • What this model could be more feasible the implementation of the Behavioural program • It is a good way to uniformize the 	<ul style="list-style-type: none"> • Necessary and well explained, it is clear for all the School. • For me the graph of the behavioural constructs has been enlightening • Nothing to object: clear, concise, coherent, also easy to understand and explain
	(D) – VIPI Framework	<ul style="list-style-type: none"> • Its Ok, but not necessary in this model • Only theory no practical for implementation 	<ul style="list-style-type: none"> • there's no leftover, but it's not necessary • Take out in <i>Phase III</i>, not aggregated value in the model
	(E) - Framework for accessibility and social inclusion	<ul style="list-style-type: none"> • I like it, it is part of the day to day responsibilities but always is relegate, separated; in this model it is part of the system. • Social inclusion in not only for special cases, all people under special circumstances could have accessibility limitations or be in the border of social exclusion. The model shows an initiative that is part of the system, for all, with special details for the special cases • The behavioural measurement and analysis could detect students with accessibility or social exclusion problems that is not easy to detect... the model shows an excellent solution 	<ul style="list-style-type: none"> • The integration of accessibility and social inclusion in a holistic system is perfect • It is a good way to evolve, be part of the system not an appendix of the system • The same tools for everyone are inclusion by itself. • I agree with the proposal • The graphical approach makes easy to see the real integration of the special necessities in the general process
	Socio Behavioural Learning (SBL) success	<ul style="list-style-type: none"> • New for me, I like this concept • It is an interesting concept, looks good • Powerful, it is a trend in Europe, our school is reviewing its implementation 	<ul style="list-style-type: none"> • Sounds great • It is necessary in a digital environment; academic success is only a portion of the school objectives • It is the way for an overall evaluation
	What's the opinion about the Action Taken	<ul style="list-style-type: none"> • It is one of the powerful tools used in the model, help to understand were the Weaknesses are and apply the resources focused in the root cause. • It is a nice approach to maximize the resources. Concentration of specific resources in the key factors and measurable factors available to review if the resources are giving the desired results...very useful • Nothing negative to said, seems a good approach. • I agree with this approach 	<ul style="list-style-type: none"> • For me is the core of the model, change the way to understand the project and facilitate that all the team understand and play attention to the selected critical issues. I will use it in other projects. • It is no easy to determinate what are the critical points, but the model is a good approach to go for the objectives. Measurables factors are critical whit this approach • Clever, it makes the difference • I like it. No questions

Stage 4: Validation of the value driven proposals integrated in the model

		<ul style="list-style-type: none">Painting in orange the impact of the action taken is an excellent way to understand the factors in which improvement should be	<ul style="list-style-type: none">A specialist is needed to determine the critical points and how the <i>Action Taken</i> affect other factorsNot enough time to review and understand implications, but in general sounds good.	
Q1: What's your general evaluation of the model? <i>Average = 3,87</i>	1= no Good good 5 Excellent	2= No so good 3= Good 4 Very	1= no Good 4 Very good 5 Excellent	2= No so good 3= Good
	4 3 4 4 3 4 4 3 4 5 4 4		5 4 3 4 4 5 4 3 3 4 4	
Q2: How complex is the model? <i>Average = 2,74</i>	1= Extremely complex Little complex 5 Not complex	2= Very complex 3= normal 4 a	1= Extremely complex 4 a Little complex 5 Not complex	2= Very complex 3= normal
	3 2 3 3 1 4 3 2 3 4 3 3		3 3 2 2 2 4 4 2 2 3 2	
Q3: Comparing the initial referential model <i>Phase I</i> and the final Impact model <i>Phase I</i> , What do you think about the model? <i>Average =4,13</i>	1= no Good Very good 5 Powerful	2= No so good 3= Good 4	1= no Good 4 Very good 5 Powerful	2= No so good 3= Good
	5 3 5 4 3 5 4 3 3 5 4 4		5 4 3 5 4 5 5 4 3 4 5	
Q4: How efficient could be the model for achieving Digital Transf.? <i>Average = 4,00</i>	1= no Good good 5 Excellent	2= No so good 3= Good 4 Very	1= no Good 4 Very good 5 Excellent	2= No so good 3= Good
	4 3 4 4 2 4 4 3 4 5 4 4		5 4 3 5 4 4 4 4 3 4 5	
Q5: For a similar project, do you want to be part of the team working with this model? <i>Average = 3,83</i>	1= never probably 5 without doubt	2= it could be 3= Probably 4 Very	1= never Very probably 5 without doubt	2= it could be 3= Probably 4
	5 3 5 4 2 5 4 2 3 5 4 5		5 5 2 5 3 5 4 4 3 4 5	

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Table 11: Questions, Issues and exit mini-survey - Focus Group - revision: Phase II of the model - principal concepts included.

		GROUP A	GROUP B
PHASE II	Relevant issues regarding <i>phase II</i> procedure	<ul style="list-style-type: none"> The Phase II is more complex, but more interesting The model is really powerful, the incorporation of big data is a radical change that spur the digital transformation The templates are so useful, the scheme invite to think in a Knowledge Data Base that will facilitate the use of digital tools and the evolution of these tools in a collaborative manner Big improvements in digital tools development and evolution, big data is the clue Control of timing in student's codification is a big advance. Analysis of 	<ul style="list-style-type: none"> Few changes, but deeper implications, the model help to understand the changes and its implications Big data is a clue Recycle yourself or be fired, hard but realistic Evolution from <i>Pocket Code</i> to <i>Create@School</i> is a consequence of the project, it is a great improvement With resources and the right model, the objectives could be reached
	What's your opinion about the introduction of the following Key factors or Success criteria? Big Data	<ul style="list-style-type: none"> Necessary, but also technical support is necessary It is the way, better support from ITC group is necessary Most of Professors are not prepared to capture and/or analyse this data, external support is needed 	<ul style="list-style-type: none"> It is necessary in any digital School; it is the basic platform to start evolution For mi should be a Key Factor I want it at my School Specialist are needed, the case presented reinforce my opinion
	(QA5-2) Recycling of teacher's skills or new professors with required Skills	<ul style="list-style-type: none"> Sad but real Is so difficult that one baby boomer can get the attention of a Z's student without digital tools → recycling is necessary 	<ul style="list-style-type: none"> Recycle yourself or be fired, hard but realistic Welcome to my world, I am scare It is important that the training and recycling be included as a part of the system.
	What's the opinion about the Action Taken	<ul style="list-style-type: none"> The Reinforcement of development of new modules, templates and functionalities is very interesting. Standardization, sharing, open access tools is a good option The Reinforcement of development of new modules, templates and functionalities is and interesting option, shows that the team has a deep understanding of the situation and the points that can generate good advance See the points reported in Recycling 	<ul style="list-style-type: none"> The Reinforcement of development of new modules, templates and functionalities call my attention, sounds good Maintain most of the support actions because the work wasn't done and introduce few but interesting new <i>action taken</i>. The model is useful, flexible and efficient. See the points reported in Recycling
	Q1: Comparing the initial referential model <i>Phase II</i>	1= no Good Very good	1= no Good 4 Very good

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	and the final Impact model <i>Phase II</i> , what do you think about the model? <i>Average = 4,30</i>	4	5	4	4	5	4	4	4	4	5	4	4	4	5	5	4	4	4	5	5	4	4	4	
	Q2: How valuable are the big data integration? <i>Average = 4,65</i>	1= no Good Very good2= No so good 5 Excellent3= Good4												1= no Good 4 Very good2= No so good 5 Excellent3= Good											
		5	5	5	4	5	4	5	5	4	5	4	5	5	4	5	5	4	5	5	5	4	5	5	
	Q3: How valuable is the reinforcement to develop new modules and templates? <i>Average =4,61</i>	1= no Good Very good2= No so good 5 Excellent3= Good4												1= no Good 4 Very good2= No so good 5 Excellent3= Good											
		4	5	5	4	5	5	4	5	5	5	4	4	5	4	4	5	4	5	5	4	5	5	5	
Q4: For a similar project, do you want to be part of the team working with this model? <i>Average = 4,26</i>	1= never probably2= it could be 5 without doubt3= Probably4 Very												1= never Very probably2= it could be 5 without doubt3= Probably4												
	5	4	5	4	5	4	4	3	3	5	4	5	4	5	3	5	3	4	5	5	4	5	4	4	

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Table 12: Questions, Issues and exit mini-survey - Focus Group - revision: Phase III of the model - principal concepts included.

		GROUP A	GROUP B																							
PHASE III	Relevant issues regarding <i>phase III</i> procedure	<ul style="list-style-type: none">Disruptive change, a new organization structure. Seems ideal. But Possible?Not only a change in the organization, the roles are also no traditional, Ideal but difficultOther big change is the new Key objective, and a new Success Criteria "socio-economic Wellbeing → this focus group is a nice magistral classKey objective evolves because whit the model when one or some factors reach the objectiveThe model works	<ul style="list-style-type: none">With the finalization of the project, of the technicians went out and the project suffered recoil and lost speed in the development of new tools and its implementations... the idea of creating the new department is logical and justified, the best option.No matter the recoil because the loss of technical resources, the areas with improvement maintain its development, the new success criteria Socio-emotional Wellbeing is a great example.																							
	What's the opinion about the Action Taken	<ul style="list-style-type: none">The creation of an Action Taken for "Support organizational change" is the logical application of the modelThe model allows the continuous support in the areas that need attention to reach the objectives it invites to evolve to next level	<ul style="list-style-type: none">The "Support organizational change" is necessary to support the big challenge proposed. In my opinion it needs a big change in the mindset of the Schools' directors, professors and ITC staff because the roles of all people will change.The Action Taken is clever in this case because not only "Support organizational change" but also the development of new functions & skills.																							
	Q1: Comparing the initial referential model <i>Phase III</i> and the final Impact model <i>Phase III</i> , what do you think about the model? <i>Average = 4,65</i>	<div>1= no Good 2= No so good 3= Good 4</div> <div>Very good 5 Excellent</div> <table><tr><td>4</td><td>5</td><td>5</td><td>5</td><td>5</td><td>4</td><td>4</td><td>5</td><td>5</td><td>5</td><td>4</td><td>5</td></tr></table>	4	5	5	5	5	4	4	5	5	5	4	5	<div>1= no Good 2= No so good 3= Good</div> <div>4 Very good 5 Excellent</div> <table><tr><td>4</td><td>5</td><td>5</td><td>4</td><td>5</td><td>4</td><td>5</td><td>5</td><td>4</td><td>5</td><td>5</td></tr></table>	4	5	5	4	5	4	5	5	4	5	5
	4	5	5	5	5	4	4	5	5	5	4	5														
	4	5	5	4	5	4	5	5	4	5	5															
Q2: How valuable are the Digital transformation Department? <i>Average = 4,91</i>	<div>1= no Good 2= No so good 3= Good 4</div> <div>Very good 5 Excellent</div> <table><tr><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>4</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td></tr></table>	5	5	5	5	5	4	5	5	5	5	5	5	<div>1= no Good 2= No so good 3= Good</div> <div>4 Very good 5 Excellent</div> <table><tr><td>4</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td></tr></table>	4	5	5	5	5	5	5	5	5	5	5	
5	5	5	5	5	4	5	5	5	5	5	5															
4	5	5	5	5	5	5	5	5	5	5																
Q3: How valuable is Social-Emotional Wellbeing success criteria? <i>Average =4,83</i>	<div>1= no Good 2= No so good 3= Good 4</div> <div>Very good 5 Excellent</div> <table><tr><td>4</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>4</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td></tr></table>	4	5	5	5	5	5	4	5	5	5	5	5	<div>1= no Good 2= No so good 3= Good</div> <div>4 Very good 5 Excellent</div> <table><tr><td>4</td><td>5</td><td>4</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td></tr></table>	4	5	4	5	5	5	5	5	5	5	5	5
4	5	5	5	5	5	4	5	5	5	5	5															
4	5	4	5	5	5	5	5	5	5	5	5															

		GROUP A												GROUP B												Avg.
DEPARTMENT OF DIGITAL TRANSFORMATION	Q1-1: Do you think that a school with a traditional organization could reach the objectives of digital agenda and social-wellbeing on a sustainable manner ?	1= never 2= it could be 3= Probably doubt 4 Very probably 5 without																								2,04
		the model 1= services office 3= Support Office 5 developer																								
	Q1-2: Do you think that ICT is a services office, or it should be a centre of development and Knowledge in digital transformation?	5 5 3 5 5 5 5 3 5 5 5 5 5 5 5 5 3 5 5 3 5 5 5 5																								4,65
	Q1-3: If the decision making to open a Department of digital transformation in the way showed in this project, What would be your decision?	1= Maintain status quo 3 = Involve actual ICT in development 4of tools 5= Make an organization structure change, open the dept																								4,74
	5 5 3 5 5 5 5 3 5 5 5 5 5 5 5 5 5 5 3 5 5 5 5 5																									
COMMENTS:																										
<ul style="list-style-type: none">Digital transformation is a huge change, School structures should change, transform or die.It is a unique opportunity to make a deep changeWill be difficult but necessaryIt is impossible at this moment; pilot school should experiment and with the developed solutions other schools will star the change.																										
		GROUP A												GROUP B												Avg.
BEHAVIOURAL CONSTRUCTS AND SOCIAL-EMOTIONAL WELLBEING	Q2-1: Do you think that behavioural Constructs should be part of any Educational Digital transformation program?	1= never 2= it could be 3= Probably 4																								4,70
		Very probably 5 without doubt																								
		5 5 4 5 5 5 5 4 5 5 4 3 5 5 5 5 4 5 5 5 4 5 5 5																								
	Q2-2: Do you Think that Behavioural constructs should be measured as a special issue or it should be measured through the tools used in digital learning	1= Special Issues 2= Mostly as Special Issue 3= Hybrid 4= Mostly whit digital tools used 5= Only with digital tools used																								4,00
		4 5 3 4 4 4 4 3 4 4 4 2 5 3 4 4 4 5 4 5 4 4 4 5																								
	Q2-3: Do you Think That Social-Emotional wellbeing should be a mandatory success criterion for a digital transformation project in education?	1= never 2= it could be 3= Probably 4																								4,61
		Very probably 5 without doubt																								
		5 5 4 5 5 5 5 5 5 5 4 3 4 5 5 4 4 5 4 5 5 5 4																								
	Q2-4: Do you think that training in this topic is necessary to teachers, professors, staff, students and Parents																									4,91
		5 5 5 5 5 5 5 5 5 5 5 4 5 5 5 5 4 5 5 5 5 5 5																								
COMMENTS:																										
<ul style="list-style-type: none">Digital education is changing all the relationship among students, professors, staff, school management, government, etc; the behavioural and the wellbeing approach is an important way to do itI will take care of this, mi knowledge of these concepts is testimonialIn my School one group is working in this issueIt seems to be more important that I believe																										

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		GROUP A												GROUP B												Avg.	
KNOWLEDGE	Q3-1: what is the % The professors at your school that have the necessary digital Skills required to digital transformation?	In % (multiples of 5%)																								17%	
	25 % 10 % 10 % 10 % 5 % 20 % 10 % 20 % 25 % 5 % 5 % 10 % 15 % 10 % 20 % 30 % 10 % 25 % 20 % 25 % 15 % 35 % 25 %																										
	Q3-2: what is the % The professors at your school that need training to reach the necessary digital Skills required to digital transformation?	In % (multiples of 5%)																								47%	
	35 % 50 % 60 % 55 % 70 % 50 % 40 % 40 % 50 % 45 % 60 % 30 % 45 % 50 % 50 % 40 % 30 % 50 % 60 % 55 % 50 % 30 % 35 %																										
	Q3-3: what is the % The professors at your school that need a recycling program to reach the necessary digital Skills required to digital transformation?	In % (multiples of 5%)																								36%	
	40 % 40 % 30 % 35 % 25 % 30 % 50 % 40 % 25 % 50 % 35 % 60 % 40 % 40 % 30 % 30 % 60 % 25 % 20 % 20 % 35 % 35 % 40 %																										
RECYCLING	Q3-4: what is the % The professors at your school that need training to Implement Behavioural constructs and Social Wellbeing at your School?	In % (multiples of 5%)																								61%	
	70 % 50 % 60 % 65 % 50 % 40 % 60 % 65 % 75 % 50 % 70 % 80 % 75 % 50 % 65 % 60 % 40 % 70 % 65 % 60 % 60 % 65 % 50 %																										
	Q3.5: Do you Think that the DEPARTMENT OF DIGITAL TRANSFORMATION will be a solution to solve the necessities of training or recycling for professor and Staff?	1= never 2= it could be 3= Probably doubt 4 Very probably 5 without																								4,30	
	5 4 4 5 4 3 4 4 5 4 5 5 5 4 5 4 3 5 5 4 4 5 3																										
	Q3.6: Do you think that RECYCLING KNOLEDGE should be consider as a part of the model	1= never 2= it could be 3= Probably doubt 4 Very probably 5 without																								4,52	
	5 5 5 5 4 4 5 4 5 4 5 5 5 4 5 5 4 4 5 4 5 4 3																										
COMMENTS:																											
		<ul style="list-style-type: none">It's so difficult to answer the questions, it is only an appreciation (common comment)Observation: Most people (around 50%) no problems with Q3-1, neither with Q3-2 but when should match with the 100% fixed Q3-3 and then select Q2-2.Regarding Behavioural constructs and social wellbeing, Most of professors and staff know about it, but not enough to establish a system oriented to digital transformation (Common comment)																									

Table 13: Personal Survey – Validation of Value Proposed Actions

8.4 Discussion

This stage aims at validating the value proposition of the proposed actions to be integrated in the EDILE model; as final stage for this research work. This validation stage will provide an external perspective from two Spanish schools (external and different from the NOLB Spanish pilots, located in the north of Spain) that are adopting, DT. The insights gathered from Stage 3 in the value proposition Canvas templates, will be used to discuss results in a focus group, where participants will be further surveyed.

The Focus Group has been very valuable to know how complex it can be to explain the EDILE model. In a first phase the case that has been studied was explained; starting from presenting the initial situation, showing two complete phases and presenting the third.

Overall the response has been better than initially expected. In general, participants have enthusiastically engaged in the proposal, interested in the model and most have captured how it works and its added value. When explaining the first phase of the model (Phase I coupled with the Iteration 1 of the NOLB project), it was not evident how the model flowed or represented the DT progress in NOLB, but the participants had an overall understanding of the mechanism of the model and the operation. However, when we reached the Phase II of the model and participants saw what was achieved in the 1st Phase and how the model was progressing to the Phase III, participants liked the flexibility of the model and how to go from one phase to the other, and see how the progress by year was done. The feedback obtained at Coffee Break was very positive and augured a dynamic validation phase.

8.4.1 Validation of the EDILE model with external (to the Spanish pilots) focus groups

When evaluating the Phase I of the model (1st iteration), each of the progressive models (referential, descriptive, initial impact and final impact models) was evaluated separately. This gave participants the opportunity to review concepts and review at each stage. The comments obtained are broadly favourable, they have found in it their potential to add in an organized way the factors that are added, changed, adjusted or eliminated to search for the target. Talking about the Initial reference model, participants point out that the model is flexible, and everyone can draw its own reality

About the references, people argued that were not really necessary and ask for deleting them. Some doubts were generated by how identify Factors (critical , key, measurable, etc.) but they understand that it is only question of time, i.e. use and experience

Phase I Descriptive Model: The groups understood that it describes the desired situation; and in both focus groups their main concern was the difficulty to reach an agreement among the members of the DT Team to define the new Key Factors, Factors, measurable success factors and success criteria. Not all participants have knowledge of Behavioural Constructs (BC) and Social Behavioural Learning (SBL) then training is needed as the model shows them, and most people agree that it is a Success Criteria in a Digital transformed School. As a graphic oriented method, it is easy to manage the process and have a good idea of the overall process and how DT is being deployed or adopted. Participants assigned high value to the flexibility of the model to be adapted to changing requirements. The Introduction of Evaluation matrix as a factor was a great contribution for most of the participants, especially professors. In general, the model is well accepted at this point.

Initial Impact Model: The “action taken” blocks were catalogued as a powerful tool. A highlighted intervention was when ICT staff commented that they also should be trained in some educational areas to be an effective support for teachers. All the participants commented and coincided that required Skills should be acquired when having implemented DG. Most of participant were impacted by the support scheme, “powerful but complex when developing”. Most of the participants indicate that highlight blocks and lines to indicate how “action Taken” affected factors is interesting and useful.

Final Impact Model: The outputs of the Phase I were well evaluated, participants recognized that the model help to understand from a holistic point of view all the actions to be taken by the members of the team and how it affects to other players. There was an initial confusion to understand that Final impact Phase I is the initial reference model Phase II, but after explanation was understood for most of the participants. Both groups also commented on the relevance to the “*measurable success factors and KPIs as a key information to understand the advance of the project*”, and most of the participants liked very much the graphic design and how the model helps and facilitates the comprehension and communication.

In conclusion we can say that with the analysis of the first Phase the participants have acquired a good knowledge of the model and appreciated its advantages. The exit questions

include a good acceptance of it, with a general evaluation of the model near the very Good (3.87/5), the assessment of the complexity of the model is acceptable (2.74/5), with a very good impact when seeing the evolution of the initial situation to the output of this class (4,13/5). When asked how the model fits to be used as a system to achieve digital transformation in Schools the answer has been very good (4,00/5) and very similar has been the answer on whether the participant would be willing to candidate himself to use this method in a project (3.83/5), then they accept that the model is evaluated as a good tool.

Reviewing the Phase II, participants indicated that it was more complex, but more interesting, participants reported that the model is really powerful, the incorporation of big data is a radical change that spur the digital transformation and the control of timing in student's codification is a big advance. Available Resources was the big question but if you have it the models looks good and the objectives could be reached.

Talking about some Key factors or Success criteria introduced in this phase the Big Data and usage of standardized procedures like templates, were identified as necessary. Regarding Big Data it was reported that good technical support should be available because most of Professors are not prepared to capture and/or analyse this data. A consensus was reached, Big Data is necessary in any digital School; it is the basic platform to start evolution

Recycling of teacher's skills or training of new professors with required skills: participants were concerned about the necessity of training and "Recycle", a discussion highlighted that it is so difficult that one baby boomer can get the attention of a Z's student without digital tools. The continuous training and learning are a must. As a conclusion ***"Recycle yourself or be fired, hard but realistic"*** and It is important that the training and recycling be included as a part of the system.

Reviewing the Actions of Phase II (iteration II). The participants reinforced the development of new modules, templates and functionalities as a very interesting idea, and considered to be easy applicable. It was very well taken the fact of having in the next phase those support actions (actions to be taken) that have not been completed in the previous phase; it was considered as interesting to have these previously not completed actions with the new proposed actions in the same view although progresses in both areas were different. The model was considered interesting, useful, flexible and efficient. The participants reported the practicality of having the complete view of the situation at all stages.

The exit questions of this phase showed an improvement to the already good acceptance of over the first part of the meeting, when presenting the Phase I; specially the participants liked the fact of comparing between the entry situation to phase II against the output (exit) situation of Phase I; the evaluation exceeded to Very Good (4.30/5). The assessment of the integration of Big Data achieved a high score (4.65/5) and the reinforcement was activities for the development of new modules and templates obtained a rating of 4.61 over 5. When asking if a similar project to NOLB they would use the EDILE model, the participants' responses reached a high acceptance, (average evaluation was 4.26/5).

Phase III revision; some participants indicated that in this Phase a disruptive change was done: a new organization structure, they considered it as ideal, but they doubt that it can be made possible. For them this idea implied not only a change in the organization, but also changes in the role of staff and professors, *"Ideal but difficult to implement"* was the main insight. They recognize that the model can be a good support to selling the idea to senior management. Other big changes are the new Key objective, and the new Success Criteria "socio-behavioural Wellbeing". They recognize that the model can be a good support to sell the idea to senior management.

It was commented in the group that when the NOLB ended, many of the technicians went out and the DT implementation in the schools lost speed in the development of new tools and its implementations... *"the idea of creating the new department is logical and justified, the best option"*. The participants highlighted the lesson learning. However, the improvements of the areas and progress in DT, culturally, educationally, from skills and capacities acquired, as well as from technical perspectives, was considered a big success in NOLB. To move as an organization to think in a criterion such as Socio-emotional Wellbeing is a great example of cultural and organisational change. The presentation of socio-emotional behaviour constructs was reported very innovative, not seen in the previous implementations and reported as a tool that provides a "hope" to get closer and help students to focus in the importance of "deep learning" and understand what it is being studied.

When talking about "Action Taken" regarding the creation of **"Support organizational change"**, the participants reported that it was the logical application of the model. It is evident that the model helps allows with continuous support in the areas that need attention to reach the objectives and it invites to evolve to next level, on the other hand the "Support organizational change and new visions" is necessary to develop the big challenge. However, the feasibility will depend on the mindset of the Schools' directors, professors and ICT staff

because the roles of all people will change; as well as on the needed resources. Some participants agreed that Action Taken is clever in this case; because not only provides “Support organizational change” but also the development of new functions and new skills.

Also, to be able to represent the main components of the project in two phases and “six” models, also was considered for both, the participating schools and the participants of the focus group as a big result of modelling the situations. *“The model works”*.

The answers to the exit questions improved again with this last stage of the investigation, when comparing entry status and the expected exit the participants evaluate it with an excellent 4.65/5. Regarding the inclusion of the Digital transformation Department the answer was almost perfect 4.91/5 being the evaluation of the Social-Emotional Wellbeing success criteria at almost the same level with 4.83/5.

As a general conclusion The model is well received by the participants, they consider it as clear, visual, intuitive so it is validated that it is an appropriate useful and effective model to achieve the proposed objectives

8.4.2 Validation of Value Proposed Actions

There have been three actions to be introduced as an integral part of the model, that is to say that they will be considered as part of integrating solution needed to achieve the objectives of Digital Transformation and Social-emotional wellbeing. To validate these options, a survey was conducted at the end of the Focus Group

The first proposal to be evaluated is the introduction of the Digital Transformation Department. The first question required participants' opinion on the feasibility of a school with a traditional structure being able to achieve the stated objectives. The scoring given to this action is low (2.04/5) so the proposal made of having a new department and change the organisational structure is seen as appropriate by the groups (although difficult to be seen as real). With regard to the functions of the ICT, the participants agreed with a high score 4.65/5, that their role should be more than technical support and be part of the multidisciplinary teams. It was also reported that if they, as participants, would have to make the decision to organise and open this department, the probability of doing so will be high (4.74/5), as the participants overall highly endorsed this need. There is no doubt that the group validates that this proposal is integrated into the model.

Asking about the desirability of introducing as part of the model the Behavioural Constructs and Social-Emotional Wellbeing, (average 4.70/5) the participants considered as important that the behavioural Constructs should be part of any Educational Digital transformation program and that these should be measured not as a particular aspect but as part of a whole; as a result, it was agreed that behavioural constructs should not be measured or used as a separate approach, but as an integrated initiative that comes with the digital learning tools (4,0/5); the implementation of the new digital tools is what allow the monitoring and the feedback. Finally, there is unanimity that the recycling of the knowledge of the main stakeholders is simply necessary (4.91/5). In conclusion the introduction of Behavioural Constructs and Social-Emotional Wellbeing is validated to be included as a fundamental part of the project.

Recycling Knowledge action was also validated as a core part of the model. In average participants reported than only 17% of professors have the necessary skills to run this digital transformation, around 47% require specific training and about 36% should be recycled to contribute with the Digital Transformation Agenda. Also, the participants indicated than around two thirds of teachers and staff should be trained in Behavioural constructs and Social wellbeing. With 4,3/5 people indicate that the Department of Digital Transformation will be really important in the training and recycling and that Recycling Knowledge should be considered as a part of the model (4,52/5)

As a final conclusion All three proposals should be considered as integral part of the model.

9 CONCLUSIONS AND DISCUSSION

Overall, all stakeholders (teachers, staff, direction and/or students) are happy with implementing digital transformation and aim at having an effective adoption of DT for supporting all teaching-learning processes. Going from digital games, to hardware, to simulators or 3D, the ultimate goal of DT in schools, can be seen as a twofold:

- To prepare the future generation with the needed skills and capacities
- To make education relevant, effective, attractive, engaging, motivating and inclusive for all the students.

The research work carried out, has developed a model framework able to evolve with the process of digital transformation and provide a validated path to go from an initial situation to a desired one, independently of the level of maturity or adoption of DT in the adopting school. This model innovates the way DT is adopted, managed and deployed in schools. The EDILE model can accompany any school in the journey of DT.

After analysing the research work, we can say that the process of DT is dependent of a holistic vision and from a structured framework that supports the implementation of the selected priorities; if the aim is to have not only and evolving DT, but a sustainable one. In this context, like EDILE, the evolutive and continuous integration of actions or digital proposals, enable to map the DT processes being developed, merging the physical with the virtual approaches, creating a knowledge bridges to advance in DT.

This, also expands the possibilities of more digital and virtual opportunities; which with the student in the center of the DT priorities, school can support new transformed digital enabled environments that enhance the quality and innovation in the teaching-learning process, as well as in the generation of the desired future skills.

For this purpose, this research work proposes, and has validated, the following elements or components that aim to make a model in this context successful; this mean to have a model like EDILE that:

- Enables a common, shared understanding and synergy for what ICT and digital transformation projects means among all stakeholders in education; and:

- Can show the environment, mechanisms and priorities for ICT deployments when integrating a digital project.
 - Is scalable, flexible and visual
 - Allow a better view of the data collected and need of analysis for progression measurement e.g., attendance levels, goal attainment scaling.
 - Review school capabilities and external factors impacting
- Reflects key factors or actions for the needed infrastructure (digital, technical, organizational, economic, etc) for:
 - Developing modern and relevant content, fulfilling the needs and expectation of students and teachers.
 - Learning about the positive and negative aspects from the experience of No One Left behind project (integrating Pocket Code and Create@School in classes and academic curriculum), its final pilot or any other pilot/experience.
 - Strengthening the schools or organisation's effort to create transferrable evidence of the digital transformation implementations.
 - Provides continuous and certified training
- Enable nudging and/or coaching from teachers is of great advantage and interest; is to change or implement with knowledge some reward system; which besides to be done in games, it was also done in the more traditional school. Several of the teachers see this process to be implemented as a midterm activity, as it is perceived as not easy of integrate and/or defend in front of the students or parents by teachers. However, the approach and information provided is perceived as a very good and helpful; specially for supporting teachers' teaching and tutorial approaches, as well as for students. With behavioural informant students can be empowered and develop, together with teachers, a strategy to work in their strengths and weakness. This can shape resilience, attitudes, behaviours and skills for the next 10 years.
- Promotes the creation of a new department or core group is proposed to be created, which among other things organise training and continuous long-term training for teachers and allocate resources and digital resources for helping teachers in supporting activities, the generation of digital content, standardize process or activities (e.g. create templates) in digital content generation. Also, the department will measure processes and behaviours, and defining the capabilities and behaviours, as well as the way of measuring them through game analytics and progression of learners (e.g., engagement, collaboration, etc.)

- Calls for continuous training and education for teachers, coupled with the evolving nature of DT. The existing workforce is likely to require sustained interventions for training and overcome cultural backlash.
- Brings implicit the change in the culture and structure of the educational organisations and its status quo, as among first actions also favours the creation of a multidisciplinary department that manages DT.

9.1 Discussion of research questions

The following paragraphs present how this research work reached the objectives to answer the proposed research questions ; which were illustrated in figure 2.

Question #1 (RQ1): is it feasible to generate a model that assist the development of digital tools and infrastructure that support the digital transformation in schools? Will this model allow evolving digital transformation?

Inspired in the DRM methodology, EDILE was developed by adapting the phases and simplifying its design-oriented approach of DRM. EDILE has been validated through two cycles of the NOLB project and enhanced after finishing the NOLB project and its financing. At this stage, new components based in learning experience and from meeting with the NOLB pilot schools. The newly proposed components were validated through focus groups.

The EDILE model is based in graph networked nodes, which allows easy interaction and high-level visualization of the DT process. The model supports digital progression, which characterizes the scalability and flexible of the model. This can be applied to any school that wants to set a path to go from current situation to the desired one. EDIL is the resulting output of the activities carried out in the Stage 1 (Chapter 7) of this research work; which reaches the Objective 1 (to select, adapt and/or develop a visual, flexible and scalable model that will provide a holistic view that enables to move from a current situation to a desired situation in an evolving DT environment.) and positively answer the first question in RQ1.

As for the second question, we can see that EDILE can increment as many iterations as needed, allowing an evolutive process of continuous improvement or deployments of DT. We can keep previous iterations as historical and enable to show, with documented research through the nodes links or responsible why those steps or processes were adopted; having

represented in the nodes the vision from which DT started, the scope and the aim approached at some point in time.

The development and validation of EDILE model during the NOLB project (being able to map and represent the flow of DT in the project retrospectively and prospectively), validation of the initial impact model by the NOLB Spanish pilot schools, and validation of EDILE by two external schools (no participants of the NOLB project) leads to demonstrate that it is possible to have a model that support digital transformation in schools as well as representing the evolving and continuous nature of DT (RQ1).

In this aspect, further than reaching the objective 1 and answering the research question, it is a conclusion of this research work the evidence of the dynamic interdependence of the innovation process and outcomes of DT; by creating the knowledge bridges between the virtual digital approach and the real analogic processes, the resulting outputs T become an integral part not only of the model but of the DT innovation process as such.

Question #2 (RQ2): would it be possible to incorporate parameters that allow measuring and analysing behavioural constructs within DT tools designed for learning?

Following the integration of behavioural constructs in EDILE, it was aimed not only at presenting the importance of this theme for the schools (as the integration of behavioural constructs, also led the piloting school at the end to new success criteria) but the possibility to represent these constructs in an overall mapping of the holistic view of a DT process. The actions and impact caused overall over the integration as integral part of DT not only has been taken as very positive but understood that it is coming as an integral part of new technologies. Currently the behavioural feedback is used by technology providers to feedback and improve their products, but if this information is shared then schools also can get closer to students and innovate in their teaching-learning process.

Through Chapter 8, the objective 2 has been reached by developing the EDILE behavioural based model, enabling a positive answer for the RQ2. The model has been validated as a good model; and that the proposal of the behavioural component is very important when adopting or deploying DT. Importantly in this is the faces of teachers when looking at the possibility of having this information to be used as part of their teaching strategy and get closer to understand how and for what technology is highly used. Integrating the behavioural constructs in Big Data and/or in other technology to be implemented in DT, is a good step to

start using technology for improving life and learning and going further than just improving technological products as such.

The integration, validation as well as collected insights and needs regarding the presence of behavioural constructs as a component of EDILE, leads to demonstrate that RQ2; being possible to integrate these constructs as parameters or factors of the model.

Question #3 (RQ3): if school organisations maintain their classical organisation structure, would it be possible to reach the DT objectives?

The EDILE framework model has not only be validated during two iterations in NOLB, but its value propositions regarding the components also have been endorsed by participants from external schools not participating in the NOLB project.

In this context, it can be said that the model was developed in parallel during the last year of NOLB following, updating and mapping main activities of the project; also, the model was retrospectively developed for the first year of NOLB. Overall, for two years, NOLB has been a good opportunity and big advance for the schools implementing DT, providing not only new technologies, but processes to be implemented in classes, frameworks, resources, tools, etc. However, the school structure and approach for innovation remained traditional and with no changes. Thus, it not only can be said (as it has been validated) that a school can maintain a classical and traditional origination while implementing DT, as well as to reach the objectives set for this purpose.

However, the issues are that although the school reach the proposed objectives, if it does not change the organisation the school will not be able to sustain the progress. This could be seen when the NOLB project finished. The NOLB team went back to other projects and the strong support given to evolve and implementation could not be replaced. This crated a recoil in the DT progress, as some of the initiatives then were maintained. Moreover, although the structure of the organisation remained the same, the culture, attitude, initiative and some adopted processes had created an implicit change in people (teachers, staff ,direction) and students; specially in students, which demand, skills, way to approach subjects and, no less important, **expectations** for the next course where totally different than years before.

The “action taken” approach of creating a department, or a core group but with some departmental entity, came from the focus group that supported the creation of Phase III initial

impact model. It was recognized by the schools that changes needed to be done to sustain initiated DT and cope with students' engagement and expectations. Under this context, this research work defines digital transformation as the process of responding to the challenge **and opportunities** to create bridge knowledges for continuously adapting organisations to the digital world. In the author's perspective, when the organisations understand that, they have also progressively or disruptively had to change, then organisations understand that the transformative power of digital transformation; moreover, organisations start to understand the opportunities and how to leverage DT to drive sustainability. Referring with this, not to the potential of the technology, but to the potential and opportunities to successfully address new digital journeys that support the students, teachers, school staff, parents, and in general, peoples' lives, skills and potential.

With current trends on DT at the societal context, schools and teachers are not now the only source of information or to study; thus, probably the school physical spaces and the way to teach might totally change in 10 years from now; but the schools and professors have a main role to study and transfer the knowledge, skills and capacities that government and policy makers believe is the one needed by future generations to succeed, support socio-economic growth and jobs. Thus also to create the needed changes to maintain the teachers skills and capacities in continuous process of learning ("recycling") in the long term, is what is going to provide the needed empowerment in teachers to innovate and support the teaching-learning process, independently of the digital means used for this purpose.

Last but not least, the validation of the NOLB project and development of EDILE in the piloting schools for two years, lead to demonstrate that organisations can maintain their classical organisation structure to reach their envisioned DT objectives (RQ3); however maintaining the structure is not going to allow to make the DT process or objectives sustainable. This philosophy is embedded in EDILE, as one of the components is organisational change through creation of a department, an initial approach in this area becomes implicit to ensure sustainability of DT developments

Question #4 (RQ4): what are the components and/or concepts needed in an evolving DT model that supports digital wellbeing of the main schools' stakeholders?

For schools to have at the end of the EDILE model the vision and success criteria is socio-emotional wellbeing; four components have been developed, integrated and validated to be part of the EDILE model structure. Moreover, validation comprised to have a multidisciplinary

vision, not only to have insights from all perspectives, but to have as output a multidisciplinary value proposition of the components for the model, that could be used by schools to internally (or externally) sell the rational of the need for these components; specially for the socio-emotional behavioural constructs.

In this context, it can be said that we have two types of components:

- The behavioural constructs: which are those that directly help to build a methodological approach to measure towards wellbeing and manage behaviours.
- The DT components: which provide the structural bases to make the socio-emotional wellbeing a feasible component to be practically used.

Processes and activities performed in Chapter 8, have supported to reach Objective 4, and answer this research question; further, the validation of the model and the proposed components from a multidisciplinary perspective, and as valuable proposals, have led to demonstrate that the behavioural construct, recycling knowledge and organisational change through the creation of a new department, are components needed in an evolving DT that envision socio-emotional wellbeing (RQ4).

9.2 Original Contributions

The most significant contributions of this research work are the following:

- 1) Development of the EDILE model as a framework to assist multidisciplinary teams to develop and innovate through Digital Transformation (DT) at Schools

EDILE is a model inspired and builds on the DRM model by Blessing and Chakrabarti (2009); the model has been developed to accompany schools in the journey of DT. It has been designed support educational institutions to have a strong, flexible and easy-to-implement model framework that will allow the project team to easily reach a digitally enable goal, by: defining in a practical and working manner practical the factors (activities, resources, processes, etc); seeing the path to define or reach to achieve their objectives; estimate their impact; deciding and illustrating this decision action in the model, highlighting which area or factor requires reinforcement to ensure success; and how these reinforcement actions affect the other factors; evaluate the results and start a new phase that continues with the development of the project or enters continuous improvement phase.

Another contribution of EDILE is its flexibility to be used in the design and/or piloting and/or operation phase. It also includes the use of measurable factors and KPIs which facilitates the monitoring and assessment of the actual impact of the supports implemented.

Also, the different modelling stages or approaches of each Phase (initial reference model, descriptive model, initial impact model and final impact model) contribute to integrate the strategic point of view (focus), tactical development and consider the operational requirements and actions; providing a good holistic perspective and enabling the possibilities of success.

Being a graphical system, EDILE facilitates the understanding of the model and a collaborative multidisciplinary participation.

2) Introduction of Behavioural constructs as way to manage digital wellbeing and focus this vision as a success criterion of DT

One of the main contributions is the validation that the behavioural constructs are needed to understand and evaluate, how students connect and react to technologies to use that information to take teachers and tutors close to them, and coach them in the leaching-learning activities, as well as supporting inclusion, motivation, engagement, etc.

Academic and cognitive measures are not anymore, a unique measure of student success, as other skills and capacities (e.g. emotional such as resilience) are needed to success in the future. Coupled with knowledge and academic success, other capacities and skills such as adaptability, creativity, empathy, integrity, resilience, persistence, sense of belonging, being able to decide among thousands of content, and/or imagination are well needed to build the knowledge bridge between technology and the increase prosperity of the future. This is why the concept of digital wellbeing in this research work connects the academic and the socio-emotional behaviours.

The development of a behavioural evaluation system linked with the educational tools allows the measurement of the behavioural variables in a tangible manner, supporting teachers (together with parents and students) on the specific socio-emotional skills and capacity needed. This goes a Step further than usual models for innovation in education and has been validated not only as very interesting but as needed by the participants in the validation stage. Although, many of them were not sure if having the enough knowledge to manage them, both technicians and teachers/staff look forward further training and as a mid-term tool

to be integrated in the schools. Although, not many comments were made on the accessibility tool, as it was seen as automatically enabled, the connection of tools such as GPII with socio-behavioural constructs open a big door of opportunities in the area of inclusion and behavioural support.

3) Introduction of core behavioural constructs for managing socio-emotional wellbeing in Digital transformation projects for Education:

Several behavioural constructs were selected during the last year of NOLB to try to measure or represent the needs of teachers to enable a closer coaching to students. In a Digital Transformation Project although no mandatory we provide the possibility of using all of several of them under a common defined understanding

(section 4.3 and 6.4.3). The mix of didactive/Cognitive, socio-behavioural, self-regulatory and engagement provides a set of behavioural constructs that can support socio-emotional wellbeing. The piloting done in NOLB, the results of the focus group during this research work and the results of the individual survey validate that it should be considered as a core part of the Digital Transformation in the School. These results drove the author to integrate the constructs as an important component of the EDILE Model; and it will be part of any project supported with the EDILE Model.

4) Introduction of Recycling Knowledge as integral part of any Digital transformation project:

The intergenerational digital divide becomes evident when implementing digital transformation project in schools, or any other place. The quantity of new technologies, approaches and content is overwhelming. To go at the same pace and get a foundational ground of knowledge is important to succeed in this area. Providing training to all stakeholders, and even supporting extending part of it to parents at some point, it is what it will enable collaboration and communication.

Somehow, with the advances and adoption of technologies driven by adopting DT, also it is needed the advancement of human skills and knowledge. In a near future advances in digitalization as well as in areas such as big data and artificial intelligence will make that many jobs will be altered and have people working with and next to robots, due to automation process; so the need of deep technical skills as well as the need of more abstract and educated skills such as social and creative intelligence will be needed to generate more

value; humans and machines are a better combination and source of valuable work. So, training and “recycling” become necessary, in the schools and for the students being prepared for future job. After validating this need, the contribution of this research work is based on integrating the recycling of skills such as core part of any DT project and in particular its incorporation into EDILE.

5) Redefine the organizational structure of the school to assure DT, by creating the Digital Transformation Department:

The development of piloting the NOLB demonstrated that schools with classical organisational structure can reach DT goals and integrate DT to enable new digital based services, such as it was to deliver and produce academic content through digital game based schemas to and for students; creating empowered students and teachers that innovated in the teaching-learning process (e.g. classes managed as jams, homework delivered as game projects, finishing games in a customized and appealing manner to consume academic content, etc). However, although possible it is not sustainable. Thus, as commented in the section above it was validated in the proposal to generate new organisational entities (such as the proposed department for DT) that enables a core group of multidisciplinary people to enable the “school digital transformation agenda.” Organisational and cultural changes are not only needed for adopting DT, the aim at EDILE is that linked with the behavioural constructs, DT also will promote as criteria of success digital wellbeing, which integrates at the same time the behavioural and skills components. The rationale underneath is the vision is to contribute with the opportunity to approach the advances in technologies, together with the generation of digital resources, organisational changes, inclusion, skills and emotional capabilities that will drive to have DT coupled with big opportunities driven by other needed areas such as problem-solving, adaptability, collaboration, leadership and emotional intelligence.

9.3 Future work

The main research lines to follow this research work comprise:

- To continue and improve the EDILE model aiming at generating an digital automated version of the model, looking also for easy visual features that allow multidisciplinary teams to co-work and support DT from a multi-stakeholder perspective.

- Establish the Canvas value proposition work and experiences as part of the current EDILE model, as this practice was seen as fun, collaborative, big source of information and able to generate co-creative and collaborative working sessions for innovation.
- To increase and adapt more use cases as pilots, a retrospective or prospective manner use the EDILE methodology, to validate and be able to create tangible evidence that can be provided to schools (also may be for other organisations in other domains), to better adopt and sustain DT. A data base of good practices using EDILE is also recommended. EDILE modelling approaches (descriptive, initial impact and final impact) and the set of the three main components integrated in the model, standardize a way of working that shall support a level of similar components that will allow comparison and some structured insights.
- Last for not for least to advance in the integration and link of behavioural constructs to be integrated and highly linked with DT processes, frameworks and models. Areas related with digital wellbeing, socio-emotional learning, bullying, fake news and overloading content, as well as ethical and privacy, are recommended to be integrated.

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ANNEX

Create@School events grouped in functional sub-categories

List of coding block classification to allow Big Data to process socio-behavioural parameters. The following table shows an example of how this process was done, presenting the 170 most used events in Create@School. Overall, more than 400 events were listed and grouped into sub-categories and categories. (Source: D.4.3 – Integration of Analytics and Dashboard, by: Paula Collazos (ZED), Fernando Pérez (ZED), Maria Eugenia (Xenia) Beltran (Inmark), Yolanda Ursa (Inmark) – 30/06/2017.)

Absolute time spent		
end (Sessionduration)		init
Advanced bricks: New/modified/Used conditional statements		
<ul style="list-style-type: none"> AddBrick AddItemToUserListBrick BroadcastWaitBrick CameraBrick ChangeBrightnessByNBri ck ChangeTransparencyByN Brick ChangeVolumeByBrick ChangeXByNBri ChangeYByNBri ChooseCameraBrick ClearBackgroundBrick ClearGraphicEffectBrick CollisionReceiverBrick ComeToFrontBrick DeleteItemOfUserListBri ck DropBrick FlashBrick GoNStepsBackBrick 	<ul style="list-style-type: none"> IfLogicBeginBrick IfThenLogicBeginBrick InsertItemIntoUserListBri ck NoteBrick PenDownBrick PenUpBrick PlaySoundAndWaitBrick PointInDirectionBrick PointToBrick RepeatBrick ReplaceItemInUserListBri ck SceneStartBrick SceneTransitionBrick SetBackgroundAndWaitBr ick SetBounceBrick SetBrightnessBrick SetFrictionBrick 	<ul style="list-style-type: none"> SetGravityBrick SetMassBrick SetPenColorBrick SetPenSizeBrick SetPhysicsObjectType Brick SetTransparencyBrick SetVelocityBrick SetVolumeToBrick SpeakAndWaitBrick StampBrick StopScriptBrick TurnLeftSpeedBrick TurnRightSpeedBrick VibrationBrick WaitUntilBrick WhenBackgroundCha ngesBrick WhenConditionBrick
app support		
hintsOption ("allowHints":"false" or "true")		OpenBrickHelpOption
Collaboration		
ParamE		

Complete/Sequence/flow/ narrative/story structure		
ParamC		
Customisation of characters/images/backgrounds in templates: Edit, Create		
CreateLook	CreateSound	UseTemplate
CreateObject	EditLook	
Customizes/Changes GPII		
ApplyAccessibilitySetting		
Event Creation		
<ul style="list-style-type: none">• AddBrick• CopyBrick• CopyLook• CopyObject	<ul style="list-style-type: none">• CopyProgram• CopySound• CreateLook• CreateObject	<ul style="list-style-type: none">• CreateProgram• CreateSound• DropBrick• OpenProgram
Event Deletion		
<ul style="list-style-type: none">• DeleteBrick• DeleteList• DeleteLook	<ul style="list-style-type: none">• DeleteObject• DeleteProgram• DeleteScene	<ul style="list-style-type: none">• DeleteSound• DeleteVariable
Game originality		
ParamB		
Look&Feel: Create your own ressources (Pocket Paint, Camera, Recorder)		
<ul style="list-style-type: none">• CreateLook ("source":"Camera")• CreateLook ("source":"PocketPaint")	<ul style="list-style-type: none">• CreateObject ("source":"Camera")• CreateObject (source":"PocketPaint")	<ul style="list-style-type: none">• CreateSound ("source":"rec ord")
Look&Feel: Use ressources from other sources (Media Library, Device)		
<ul style="list-style-type: none">• CreateLook ("source":"Device")• CreateLook ("source":"MediaLibrary")	<ul style="list-style-type: none">• CreateObject ("source":"Device")• CreateObject ("source":"MediaLibrary")	<ul style="list-style-type: none">• CreateSound ("source":"device")• CreateSound ("source":"MediaLibrary")
Match of academic & gaming objectives		
ParamA		
Merge programs		
MergePrograms		
Modify scoring: formula change of the variable brick		
OpenFormula	SaveFormula	
Simple bricks: Coordination and Synchronization: wait block, x&Y coordinates, broadcasting		

<ul style="list-style-type: none"> • AddBrick • AskBrick • BroadcastBrick • BroadcastReceiverBrick • ChangeColorByNBrick • ChangeSizeByNBrick • ChangeVariableBrick • CloneBrick • DeleteThisCloneBrick • DropBrick • ForeverBrick • GlideToBrick • GoToBrick • HideBrick • HideVariableBrick 	<ul style="list-style-type: none"> • IfOnEdgeBounceBrick • MoveNStepsBrick • NextLookBrick • PlaceAtBrick • PlaySoundBrick • PreviousLookBrick • SayBubbleBrick • SayForBubbleBrick • SetBackgroundBrick • SetColorBrick • SetLookBrick • SetSizeToBrick • SetVariableBrick • SetXBrick 	<ul style="list-style-type: none"> • SetYBrick • ShowBrick • ShowVariableBrick • SpeakBrick • StopAllSoundsBrick • ThinkBubbleBrick • ThinkForBubbleBrick • TurnLeftBrick • TurnRightBrick • WaitBrick • WhenCloneBrick • WhenScreenTouched • WhenStartedBrick • WhenTouchDownBrick
Teacher intervntion (positive intervention / mentoring)		
ParamF		
Time in Web View		
StartExploreSession / StopExploreSession (durationOfWebSessionInMillis)		
Time spent in Pocket Paint		
StartPocketPaintSessionCreateLook / StopPocketPaintSessionCreateLook (durationOfPocketPaintSessionInMillis)		
StartPocketPaintSessionCreateObject / StopPocketPaintSessionCreateObject (durationOfPocketPaintSessionInMillis)		
StartPocketPaintSessionEditLook / StopPocketPaintSessionEditLook (stopPocketPaintSessionEditLook)		
Time spent in programing (remaining time)		
remaining time		
Time spent in research/tutorials		
StartWebTutorialSession / StopWebTutorialSession (durationOfWebSessionInMillis)		
Time spent w/playing-testing the game		
StartProgramExecutionSession / StopProgramExecutioSession (durationOfProgramSessionInMillis)		
Tracked events/actions per minutes		
Eventsp/minute		
Usage of templates		
UseTemplate		

Usage of variables and lists, broadcast messages		
createBroadcastMessage	CreateList	CreateVariable
Use of advanced functionalities: backpack/object groups/		
<ul style="list-style-type: none"> BackpackScene / UnpackScene BackpackScript / UnpackScript BackpackSound / UnpackSound 	<ul style="list-style-type: none"> AddGroup AddScene BackpackLook / UnpackLook 	<ul style="list-style-type: none"> BackpackObject / UnpackObject MergeScenes
Work defence		
ParamD		

Likewise, the subcategories were grouped in categories which reflect capacities of students, for example capacities regarding aspects of design (look & feel) or coding level (use of simple or advanced coding bricks). The following table presents the created-subcategories linked to its respective capacity oriented category.

Create@School I sub-categories grouped in categories

Absolute time spent	
Absolute time spent	
app support	
app support	
Coding Skills	
<ul style="list-style-type: none"> Advanced bricks: New/modified/Used conditional statements Merge programs Modify scoring: formula change of the variable brick Simple bricks: Coordination and Synchronization: wait block, x&Y coordinates, broadcasting 	<ul style="list-style-type: none"> Usage of templates Usage of variables and lists, broadcast messages Use of advanced functionalities: backpack/object groups/
Collaboration	
Collaboration	
Complete/Sequence/flow/ narrative/story structure	
Complete/Sequence/flow/ narrative/story structure	
Event Creation	
Event Creation	
Event Deletion	
Event Deletion	
Game originality	
Game originality	
Look & Feel/Customisation / Aesthetics	

<ul style="list-style-type: none"> • Customisation of characters/images/backgrounds in templates: Edit, Create • Customizes/Changes GPII 	<ul style="list-style-type: none"> • Look&Feel: Create your own resources (Pocket Paint, Camera, Recorder) • Look&Feel: Use resources from other sources (Media Library, Device)
Match of academic & gaming objectives	
Match of academic & gaming objectives	
Teacher intervention (positive intervention / mentoring)	
Teacher intervention (positive intervention / mentoring)	
Time in Web View	
Time in Web View	
Time spent in Pocket Paint	
Time spent in Pocket Paint	
Time spent in programming (remaining time)	
Time spent in programming (remaining time)	
Time spent in research/tutorials	
Time spent in research/tutorials	
Time spent w/playing-testing the game	
Time spent w/playing-testing the game	
Tracked events/actions per minutes	
Tracked events/actions per minutes	
Work defence	
Work defence	