GAME-MAKING AS A MEANS TO DELIVER THE NEW COMPUTING CURRICULUM IN ENGLAND[1]

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Abstract

Integrating digital technologies into the curriculum has been a growing challenge, especially due to the failures of the majority of initiatives that were envisioned for this purpose. In an effort to comprehend and solve these issues, England has recently proposed a shift in the curricular approach, focusing in teaching technology's conceptual basis rather than technological applications. Thus, the new National Curriculum in England, valid in 2014, focuses on the development of new concepts and the empowerment of the students towards information and communication technologies (ICT). This article presents these recent discussions in the curricular field related to ICT/Computing teaching. It also describes an empirical experience carried out in England, in which students from primary schools explored game-making activities through computational and media culture perspectives as a means to promote this new curriculum. The results obtained through this preliminary research show that, although using digital games to connect Computing, Media and Arts in Education could be regarded as a complex activity, this is a possible path to reach the objectives outlined by the new National Curriculum.

Keywords*:* game-making, computing in Education, ICT, computing curriculum in England

Resumo

Integrar tecnologias digitais às escolas tem se apresentado como um grande desafio, especialmente por conta do fracasso da maioria das iniciativas que possuem esse objetivo. Em busca de compreender e solucionar estes problemas, a Inglaterra propôs, recentemente, uma mudança de abordagem curricular, com foco no ensino das bases conceituais da tecnologia, ao invés de focar no ensino de aplicações tecnológicas. Assim, o novo currículo inglês, a partir de 2014, passou a visar ao desenvolvimento de novos conhecimentos e o empoderamento dos estudantes com relação às tecnologias de informação e comunicação (TIC). O presente artigo tem como objetivo apresentar estas recentes discussões no campo curricular do ensino das TIC, bem como relatar uma experiência empírica desenvolvida na Inglaterra. Nessa experiência, alunos de escolas primárias inglesas exploraram a criação de jogos digitais dos pontos de vista computacional e da cultura midiática, tendo em vista a promoção desse novo currículo. Os resultados desse estudo preliminar mostram que, ainda que a utilização de jogos digitais para se conectar às áreas de Computação, Comunicação e Artes na Educação seja complexa, esse é um caminho possível para que o objetivo desse novo currículo seja atingido.

Palavras-chave*:* criação de jogos, informática na Educação, TIC, currículo computacional inglês

Introduction

Since the 1990s, we have noticed the rise and the dissemination of digital technologies in our societies: they are becoming even more pervasive. As Dede (2010) points out, this phenomenon is promoting modifications in different societal institutions, such as the schools. In this respect, it is possible to observe several initiatives that tried to introduce those digital technologies (commonly referred as "Information and communication technologies" – **ICT**) to the curricula, in order to integrate them into other contents already present in the educational process.

However, it is undeniable that this integration process is complex, as there are diverse types of knowledge involved. Here, we would like to raise at least three of these different types: firstly, there is the knowledge related to the disciplinary content of the subjects that are already part of the traditional curriculum; secondly, there is the knowledge related to the technologies themselves (how to manipulate them and use them in problem-solving activities); and, at last, the knowledge of how to connect them to other aspects of society, how to interpret and use them in diverse contexts (comprehending that technologies are applied to diverse environments and in different manners, and that they connect to cultural, economical and other aspects of our society). To a certain extent, some initiatives have reached this objective, approximating ICT to this "multiple" role in Education: Logo, the programming language developed for educational environments, envisioned and disseminated by Papert (1985) during the 1980s, is one example.

However, during the 1990s, as new ICT tools become available, there is a noticeable preference towards a new way to integrate digital technologies and Education. The main focus becomes the development of functional abilities, in order to allow students to operate these technologies. It is at this time that the standardised educational software packages, distributed in CD-ROMs (KAFAI; BURKE, 2013), or even the teaching of "office-related" software, such as word-processors or spreadsheets (BUCKINGHAM, 2007), become the main trend, in a process observed in many countries, like Brazil or England.

After following the results achieved after years of these practices focused on the development of technology-related "basic skills", the Department for Education (DfE), institution responsible for Education in England, published, in 2013, a new curriculum, which devoted special attention to computing. It modified the approaches related to exploration and to the competences fostered by teaching practices related to digital technologies in schools.

This shift was proposed due to many reasons: firstly, the former curriculum for digital technologies (which also defined a specific subject for this topic, called ICT) was considered inefficient or even pointless, as the majority of the students were already proficient in ICT, even in advanced uses. Buckingham (2007) argues that if at home these students could use digital technologies in a creative way, in schools the usage of ICT could be described as "limiting" and "frustrating", because most of the time the skills developed in this context were mainly functional, based in the mastery of the already cited "office" software.

In this sense, it would be naive to believe that these skills would be enough for students to engage with digital technologies. A new curriculum should teach how ICT work, what are their influences and connections to society and, obviously, how to use them in diverse contexts and in a variety of ways. In order to achieve these objectives, the students must understand the rationale behind ICT, but they also have to reflect about their presence in society.

Finally, there was also an economic argument in Britain that led to this scenario: there was (and still is) a deficit in the number of competent professionals to work in technology-related positions. In this sense, this new curriculum has been seen as a means to tackle this issue, as if this education for digital technologies would lead more youngsters to choose this professional path. However, it is important to remark that this rationale could not work in this mode, as Robertson (2013) noticed in an empirical experience carried out in the United Kingdom.

In September 2014, the new National Curriculum for England (DEPARTMENT FOR EDUCATION, 2013) became valid, making a clear shift from the focus on basic, functional ICT skills, to a more broad and in-depth understanding of digital technologies and the competences related to this topic.

This shift will pose new challenges to teachers and educational institutions, as pupils will have to develop comprehension of topics directly related to Computer Science, such as computational thinking, logic, algorithms, among other topics. It is important to note that the development of these concepts will be an extended process, as they will be developed throughout their schooling. For instance, it is expected that students in Key Stage 1 – children in the two first years of compulsory education, ages between 5 and 7 – are able to "understand what algorithms are [...]; to use logical reasoning to predict the behaviour of simple programs; create and debug simple programs" (DEPARTMENT OF EDUCATION, 2013, p. 218), tasks that sound very complicated, especially to those who are not keen in Computer Science.

In this article, we intend to explore this shift in the English national curriculum. We will present a brief review of how computers and digital technologies were integrated into England's educational process in order to comprehend the path followed by English policymakers that led to this choice of Computing. After that, we intend to point out some of the strategies that could be seen as a way to foster these skills and concepts related to the new computing curriculum.

In this respect, we will focus on a specific approach, the usage of game-making activities as a means to deliver this new computing curriculum, due to the engagement and motivation that game-related activities could promote in students (BUCKINGHAM, 2006). Game-making allows pupils to explore concepts related to subjects, to Computing and to how technologies are connected and applied in different contexts, thus, offering an interesting interdisciplinary proposal. Finally, we will present one pilot project that was undertaken using a benchmark software for game authoring in schools, the MissionMaker, and how it connects with the new computing curriculum, showing how game-making could be seen as a means to deliver this new curriculum.

Computers and curricula in England

Our societies are being deeply modified by digital technologies and, especially in developed countries, there was, and still is, a considerable effort to integrate them into the school. In England, our analysed context, it has not been different: Hammond (2014) provides a brief history about these initiatives and the rationales behind them, from the first "Computers in the Curriculum" project, which was set up in 1973, to the early years of the 2010s, and remarks how the introduction of technology in the educational process has consistently been a topic present in diverse government agendas[2].

Despite being a recurrent issue, we could not affirm that this attention was enough to allow an adequate integration between digital technologies and Education in England. An indication of this less than satisfactory situation was back in early 2012, when Michael Gove, the British Education Secretary at the time, announced the scrapping of the ICT curriculum that was in vigour at the moment, as it was considered unsatisfactory and even harmful to the students by several expert institutions, such as the British Computer Society – BCS – (DEPARTMENT FOR EDUCATION; GOVE, 2012). Subsequently, the role of the ICT as a school discipline was reviewed, and in 2013 it was publicized that ICT would be replaced by Computing in the 2014's National Curriculum in England, the object of study of this article.

Although it is not our intention to present an extensive review about the reasons for the failure of the previous ICT curriculum, we believe that it is important to point out some of the aspects that generated this scenario. Understanding the context and the moment before the institutionalisation of Computing as a compulsory discipline could be helpful to comprehend why this decision was taken, and what are the expected outcomes.

One issue about the way digital technologies were introduced to English schools, as pointed out by Hammond (2014, p. 194), was the approach taken by the diverse governments, whose policies tended to favour the “provision of new hardware, and the attempt to keep up with changing technological capabilities, rather than pedagogical understanding [...]”.

This critique could be understood using an economic perspective such as Buckingham (2007) who defines the educational technology field as a great business opportunity. He criticises how the policies carried out during the late 1980s and the 1990s were “a move towards a ‘free market’ in education” and, as a consequence, led Britain to notice a boom in educational technology options, most of them produced by private companies, but supported by the government.

This does not mean that the development of the educational technology industry is essentially bad, but we must be aware of the process by which it has arisen, and how it reaches schools. The critique is, in fact, that for the most part, the government policies seemed more interested in boosting the economy through educational technology, and not in how these would impact Education. This can be seen by the series of governmental programs that gave financial support for schools to acquire hardware and software, or even by the indicators used to show how technology was "integrated" into school: in general they used quantitative terms, reporting the student/computer ratio in schools (DALE; ROBERTSON; SHORTIS, 2004; BUCKINGHAM, 2007; HAMMOND, 2014) or the number of teachers that affirmed that they use computers in classes (WATSON, 2001). At the same time, these educational institutions and professionals had little advise about the process of integration, as if the simple presence of the computers in the educational contexts would enable students to "learn technology".

Buckingham (2007) also draws our attention to a consequence of the policy to stimulate the commercial industry behind educational technology. Based in the work carried out by Hativa and Lesgold (1996), he shows the fast pace of this industry, and how there is not enough time to reflect about the different trends and solutions offered:

> from BASIC and LOGO programming in the early 1980s, through CAI and integrated learning systems, the use of generic programs (such as word processors and spreadsheets), multimedia authoring and telecommunication via the internet, to the electronic whiteboards, educational games and learning platforms currently dominating the marketplace, there has been an ever-changing succession of apparently essential, ground-breaking new devices, each of which has raised new expectations (BUCKINGHAM, 2007).

This example poses a critical situation that jeopardizes the integration of digital technologies and Education. There are always "new offers", always presented as revolutionary, and they are also replaced by the next "new wave" in a very accelerated pace. This situation is aggravated by the lack of research evaluating or analysing these diverse technologies in educational contexts, as they tend to be more descriptive, explaining the innovations, instead of applied research that reflects on their educational value (WATSON, 2001).

This leads to a situation where agents involved in Education (such as teachers) see themselves surrounded by different technologies, and are overwhelmed in this process, due to the lack of support and their difficulties in comprehending technologies on their own, or about how they should integrate these technologies in their classes. The differential between the pace of technological change and the rate of appropriation by the teachers could lead to what Buckingham (2007) calls "technology fatigue", when teachers just give up on following the new trends. This situation could lead to disbelief and a consequent abandonment of the usage of technology in educational contexts.

However, the lack of advice in how to integrate digital technology in Education and the preference to boost commercial industry cannot be regarded as the only causes for a shallow, irrelevant computing curriculum, as the curriculum that was valid up until 2012 was defined (DEPARTMENT FOR EDUCATION; GOVE, 2012). There is another key argument for defending the presence of technology in Education: the supposed "economic relevance" for teaching computer-related skills to the students.

This idea is clear in the former British Prime-Minister Tony Blair's statement in 1997, highlighted by Buckingham (2007): "Technology has revolutionised the way we work and is now set to transform education. Children cannot be effective in tomorrow's world if they are trained in yesterday's skills." For sure, this is a valid claim and should not be ignored: as technology, for instance computers, are increasingly disseminated in the world, it is reasonable to expect that citizens are capable of engaging with it. However, what does it mean to know how to engage with technology?

The major issue related to this argument is that this "capability of engaging with technology" is used in a very limiting sense, considering that knowing basic, functional abilities in order to operate some hardware would be enough. Hammond (2014) identifies that this limiting sense was used to reinforce the idea that developing these (basic) skills in schools was necessary to prepare students for their future jobs. This led to what the author – and other researchers (eg. BUCKINGHAM, 2007) – has identified as "an overemphasis on 'office' software" (HAMMOND, 2014, p. 195), such as word processors or spreadsheets, as if "office" were the only possible relation between computers and the labour market.

This special attention to specific, office-related software led to a phenomenon that could be identified as one of the major causes for the failure of the previous ICT curriculum: the usage of digital technologies in school in no way resembled the type of use that these students had at home. While at home they tended to use technology in a creative, communicative way, in school it tended to be linear, limited and, according to the students, "boring" and "frustrating" (BUCKINGHAM, 2007).

Finally, there is also the question of how "digital competences" should be approached in schools. "Digital competencies" could be explored horizontally across diverse curricular subjects (cf. DEPARTMENT FOR EDUCATION AND SKILLS, 2003) and at the same time as its own vertical discipline (cf. DEPARTMENT FOR EDUCATION, 1999). However, as ICT was treated in a limiting sense, these views were practically incompatible in this context. The knowledge fostered in the vertical sense was not meaningful enough to support interdisciplinary projects, and the integrations between ICT and other subjects were restricted to the usage of standard educational software packages, prioritising a functional usage of technology rather than "learning" it.

In this sense, the review and the proposal of the new English computing curriculum could be seen as an effort to move technology education beyond this limiting approach to technology focused on functionality. Before analysing the proposal itself, it is important to understand some features of the curriculum as an educational artefact as presented by Almeida and Valente (2011). Firstly, curriculum is always aligned to a given ideology and to the social interests of the specialists and policy makers responsible for its elaboration. Secondly, there are noticeable tensions and conflicts between the "formal" curriculum, as it is proposed by policy makers, and the "lived" curriculum, as it is experienced in pedagogical practice, contextualized in the educational process.

In relation to the first aspect, it is clear that developing skills related to digital technologies is relevant to the policy makers, and it makes sense because technology is increasingly pervasive in our societies. However, we cannot forget the second aspect that the curriculum poses a proposal, but that the real action will be carried out by the teacher, when preparing and teaching the lessons. Teachers will re-signify the curriculum, reinterpret it in their everyday work (ALMEIDA; VALENTE, 2011; HAMMOND, 2014).

In this sense, it is not expected that teachers strictly follow the guidelines offered by the curriculum. On the contrary, it is expected that they reflect on them, and that this reflection, combined with the comprehension of the content that must be taught and how it connects to other aspects, would enable them to think about their practice and the contexts in which their practices are inserted. This reflective process would lead to better ways to connect their teaching strategies with their students. Nevertheless, this process is practically impossible if the teacher does not comprehend, or lacks confidence in, the subject matter to be explored in the classroom. This is one of the problems found in the relationship between teachers and the usage of technology (BUCKINGHAM, 2007), aggravated due to the lack of support that is offered to these professionals.

In this brief review, it is evident that the integration between digital technologies and Education was a consistent topic in the English educational policies proposed since the 1970s. However, even if the main intention of these initiatives was to prepare pupils for the new digital world, this objective was not achieved, culminating in a curriculum often criticised by its inefficiency and for being distant from students' realities. We have shown the scenario that helped to build this curriculum: government policies that prioritised hardware acquisition and the production of software without envisioning the pedagogical results, lack of support for teachers, and an excessive focus in basic skills.

Jones, Mitchell and Humpfreys (2013) have criticized the former ICT curriculum due to its rationale. According to the authors, its main focus was the technology itself, and not the technology's underlying logic. In this sense, it had more to do with hardware and software than with concepts. The authors even object to the name given to the subject, ICT, used until 2012, arguing that it "[...] focuses attention on technological artefacts rather than on principles and ideas" (JONES; MITCHELL; HUMPFREYS, 2013; p. 2).

In this sense, it could be argued that the previous proposal was more focused on developing short-term skills. Although they are relevant to a certain extent, they are fated to becoming irrelevant if the artefact (software or hardware) becomes misused, which, in the field of ICT, happens very quickly. This becomes clear in the critique made in January 2014 by the former education secretary Michael Gove:

> ICT used to focus purely on computer literacy – teaching pupils, over and over again, how to word-process, how to work a spreadsheet, how to use programs already creaking into obsolescence; about as much use as teaching children to send a telex or travel in a zeppelin. (GOVE apud DREDGE, 2014).

Another issue related to the teaching of functional applications rather than knowledge about technology is the significance of this knowledge: we do not believe that the educational process must lead students to memorise facts and information without reflecting on them. In this respect, teaching only functional ICT skills is aligned to this proposal, an approach that limits the student to the mere repetition of information, incapable of constructing knowledge, exploring and going further in these topics.

Therefore, it is possible to comprehend why the previous initiatives related to digital technologies in Education in England were not capable of achieving their objectives. In this sense, it is important to describe the modifications proposed by the new English computing curriculum and its desired objectives.

A new curricular approach for computing education in England

As in previous initiatives, the England's new computing curriculum in also looks forward to preparing students for life in a society where digital technologies are ubiquitous. However, the core of this curriculum will not be the applications and the hardware, but the rationale behind these technologies, in order to allow students to comprehend, use, and explore them autonomously.

One of the first indications of this shift towards a broader and more inclusive discipline, capable of offering long-term knowledge in order to comprehend and engage with digital technologies, is the change of name from ICT, as the discipline was called in the former curriculum, to Computing, in the 2014 document. In this sense, "Computing" cannot be seen as a synonym for "programming", but as a way to understand computer systems, how they work and how they are designed and programmed. Programming is not the end, but only one of the means to reach this objective.

It is also a means to foster "computational thinking" as defined by the Royal Society (2012, p. 29)

> the process of recognising aspects of computation in the world that surrounds us, and applying tools and techniques from Computer Science to understand and reason about both natural and artificial systems and processes.

Computational thinking should not be understood in a limiting sense, as if it were totally dependent on technologies. Wing (2008) defines it as a kind of analytical thinking, which shares traits with mathematical thinking (problem solving skills), systemic thinking (how we design and evaluate a complex system operating under specific constrains), and scientific thinking. Thus, it could be understood as a specific way to think and to analyse a situation or an artefact, influencing practically all areas of knowledge. If computational thinking is becoming increasingly pervasive, it could be claimed that this competence might be added to the repertoire of thinking abilities fostered in the schooling process, in order to empower students to take part in contemporary societies (WING, 2008).

As Grover and Pea (2013) point out, computational thinking could also be understood as a literacy (in the sense defined by Cope and Kalantzis [2009]), as it addresses the competences related to computers, and more broadly to this new digital age. Therefore, computational thinking enables one to engage interpret and produce, or "read" and "write") with digital technologies in a meaningful way.

In some sense, this idea of fostering computational thinking was envisioned by one of the pioneers in the use of computers in Education, Seymour Papert (1985). His proposal was to foster this kind of analytical thinking (which he has called "procedural thinking") through the Logo programming language in schools. However, during the 1990s, programming became more narrowly defined as an activity meaningful only to computing specialists.

We cannot ignore how the educational technology industry was an important player in this decline of programming in schools. Kafai and Burke (2013) remark on how the ascension of educational software packages distributed on CD-ROMs played a major role in this shift. This new trend led schools to modify their objectives and practices, prioritising other knowledge based on teaching through applications produced in a commercial context (RESNICK et al., 2009; KAFAI; BURKE, 2013), deviating students from programming and, consequently, from computational thinking in educational process.

Nevertheless, during the 2000s, it is possible to observe a revival of this topic in educational contexts (GROVER; PEA, 2013). The return of computational thinking to schools is seen not only as a means to foster meaningful knowledge related to digital technologies, but as a way to develop this kind of thinking, promoting an additional cognitive skill for students.

It is important to highlight that the economic argument presented above has played a major role in this revival of computational thinking and programming in Education. One of the issues that led to the review of the computing curriculum in England was the lack of British skilled workers for technology-related positions. This concern was even expressed by technology companies such as Microsoft and Google, who also participated in the elaboration of the new curriculum (DREDGE, 2014). Certainly, this is an aspect that cannot be ignored when analysing the new English computing curriculum: the influence of private companies in the production of this document surely will impact education process. However, it is impossible to evaluate this influence without a profound analysis of the outcomes after the introduction of this new curriculum in schools and, as it is an extremely recent document, it would be risky to take a definitive position at this time.

Therefore, the new computing curriculum in England is greatly influenced by the revival of computational thinking, focusing on the rationale behind the digital technologies rather than the artefacts themselves. However, this does not mean that technological artefacts will be wiped from the classroom. The intention of this new discipline is to produce a blend of fundamental concepts, skills, and competences in order to make the knowledge fostered by the discipline meaningful to students in the long-term and, at the same time, connected to their everyday use of technologies. This new view is aligned with Almeida and Valente (2011, p.16-17 – translated by the authors), when they claim that, to teach it is necessary,

> to identify the logic structure of each area of knowledge; review the concept of subject and its place in the schooling process; and make it permeable in order to

> include the common sense knowledge that the student brings from his/her context, as well as the student's perception of reality based upon his/her family, friends and everyday experiences.

Using the logic structure of the given area of knowledge avoids the previously described need to keep up with the fast-paced changes in technologies. By basing the core of the curriculum on fundamental Computing concepts, teachers are no longer totally dependent on technological artefacts and the fast pace of innovation. Thus, they can concentrate on the mastery of, and the preparation of teaching strategies for conceptual knowledge. This does not mean that teachers are no longer expected to renew their knowledge; however, this process would happen at a less frenetic pace, enabling them to reflect on their practices.

This shift requires support for teachers to promote new knowledge. Fortunately, with the new curriculum, the English government envisions greater support for teachers in relation to digital technologies. Dredge (2014) points out that BCS will receive around £ 1.1 million in order to develop a programme for primary school teacher training in computing. Grout and Holden (2014) show that this is an important measure because, according to a BCS estimate, the deficit in ICT/IT teachers prepared for the new Computing curriculum is of the magnitude of tens of thousands.

Furthermore, this approach, which connects base concepts with skills and competences for everyday life, could be seen as a means to empower students to engage with technology in a more autonomous way, being capable of understanding how it works and even to use it in their own favour. Gove, in the same speech, also outlined one important aspect of the new computing curriculum.

> Our new curriculum teaches children computer science, information technology and digital literacy: teaching them how to code, and how to create their own programs; not just how to work a computer, but how a computer works and how to make it work for you. (GOVE apud DREDGE, 2014).

Instead of being organised according to the perspective of a single subject as was the previous curriculum built around ICT, the new computing curriculum is structured in a tripod: Computer Science, Information Technology, and Digital Literacy. Berry (2013) briefly explains these three components. Computer Science could be understood as the core of computing, in which pupils will learn principles and concepts of computation, digital systems and programming. It is important to recognise that it deals with two related aspects: the theoretical, conceptual ideas behind computing, as well as the practical aspect of programming. This construction of this knowledge will enable students to use Information Technology, in order to create their own programs and systems. Finally, there is special attention towards Digital Literacy (cf. LANKSHEAR; KNOBEL, 2008), to ensure that students are able to engage with digital technologies in competent, creative and expressive ways, connecting this knowledge to several areas, including everyday life.

By blending theoretical and practical knowledge, the new curriculum could be seen as a manner to open up technology. It would no longer be a "black box" for the students because they would have the means to comprehend the technology and use it in their own favour. To a certain extent, this process could be related to the empowerment process of a literacy (in the sense of the Multiliteracies theory [COPE; KALANTZIS, 2009]) as it would enable students to interpret and produce meanings using digital technologies.

However, what about the practical teaching experience? What about the approach that will be used to deliver this new Computing curriculum in the schooling process?

How to deliver this new Computing curriculum? Game-making as a means to foster Computational Thinking

Diverse paths could be taken in order to explore these topics, some of them very ingenious, such as Computer Science Unplugged (COMPUTER SCIENCE UNPLUGGED, [n.d.]), a programme designed by the University of Canterbury, New Zealand, which looks forward to teach Computing without using technological devices. In this sense, this initiative could be an important alternative for introductory Computer Science, as it does not rely on programming abilities, but intends to develop comprehension of basic computational concepts, such as algorithms, how computers represent information and computational thinking, through physical activities, real-life objects and social interactions (PAUL, 2014). Considering that, according to the new computing curriculum, students as young as 5 years-old might be learning about algorithms, and creating and debugging their own simple programs, it might be a reasonable choice to explore this approach, as the skills and concepts that are the focus of this initiative would be the base for solid computational knowledge.

However, Grover and Pea (2013), in spite of recognising the value of this kind of introductory activity, claim that it might keep pupils away from crucial computational experiences, such as programming. As the authors remark, programming cannot be seen

> only [as] a fundamental skill of CS [Computing Science] and [as] a key tool for supporting the cognitive tasks involved in CT [computational thinking] but [as] a demonstration of computational competencies as well (GROVER; PEA, 2013, p. 40).

In this sense, this kind of initiative could lead students to create an idealised view towards computing, "romanticising" it, or to prevent students from engaging with computing totally, as programming is a crucial practice for this field.

However, our proposal for promoting the new computing curriculum is based on the diverse activity of game-making. There are several reasons to select this method. Firstly, games (both digital and non-digital) are, in their essence, systems (SALEN; ZIMMERMAN, 2003). Thus, understanding games and how they are designed is a path to comprehend systems, one of the core concepts of Computing. Secondly, videogames are a consolidated cultural form and are a significant part of children's cultural capital (BUCKINGHAM; BURN, 2007). These arguments would be sufficient to justify studying games on their own, in order to empower students to engage with them. However, in addition, it is undeniable that these artefacts have strong bonds with Computing, due to programming, 3D modelling, rule structuring etc. In this sense, game-making could be explored as a means to connect Computing to the everyday life of students. Furthermore, the position occupied by videogames in contemporary youth culture draws a Constructionist argument. According to this theory, the learning process is deeper when learners work in projects that are personally meaningful to them (PAPERT, 1985; RESNICK et al., 2009). As games are a recurrent cultural product consumed by children, it is reasonable to claim that they might have a personal interest in developing their own videogames, thus taking advantage of this meaningful learning process.

Thirdly, videogames could be seen as multimodal texts (BURN, 2007) and capable of building bridges across the curriculum, in order to connect diverse disciplines around the same project. In this sense, it could be claimed that digital games could work as a means for reaching the vertical and horizontal roles that Computing is supposed to have across the curriculum, as shown by relevant results regarding the usage of game-making activities in educational contexts (BURN, 2007; BUCKINGHAM; BURN, 2007; PELLETIER; BURN; BUCKINGHAM, 2010). These accounts of game-making in schools, however, are not based in the Computing area of the curriculum, but in media education, which has traditionally been more closely related to literacy and mother-tongue curricula in Europe, and indeed more broadly internationally. The emphasis here, then, has not been on computational thinking, programming, or indeed competence in digital media for its own sake. Rather, the emphasis has been on cultural, critical and creative aspects of the exploration of media texts, institutions and audiences with young people (BUCKINGHAM, 2007; BURN; DURRAN, 2007).

We can see, then, a very broad picture which in some ways follows the history of new media as outlined by Manovich in The Language of New Media (MANOVICH, 2002). One version of this history follows the development of the computer as a computational device for information-processing, from Babbage's conception of the Analytical Engine through to the modern micro-computer. The other history is of the development of the visual representational technologies, from Daguerre's Daguerrotype to the modern camera and the moving image apparatus. In schools, we can see a micro-history following these patterns. ICT teachers have followed the computer as information-processor; media educators have followed the history of visual culture. When the two histories converge in the multimedia computer, a crisis is caused for both communities. ICT and computing teachers have good theories and pedagogies related to information-processing and computational thinking; but no preparation to deal with conceptions of culture, narrative, representation. Conversely, media and literacy teachers have adequate conceptions and pedagogies for culture and narratives, but no way to conceive of the implications of their representational cultures and technologies becoming computable.

The aspiration of the software developed in the project reported on in this article is to bring these communities together. To do this, games are exploited as a cultural form in which the language of programming meets the language of narrative and visual design. In broad terms, it serves as an example of how (Computer) Science can meet Arts and Communications in Education.

In the case here explored, then, we opted for the software MissionMaker[3], which was developed during a research project called "Making Games", undertaken by the Centre for the Study of Children, Youth and Media (Institute of Education, London) in collaboration with the company Immersive Education in mid-2000s (BURN; DURRAN, 2007; PELLETIER; BURN; BUCKINGHAM, 2010).

However, before exploring the empirical experience regarding game-making in schools and the outcomes achieved, it is important to present an overview of how this software works and the rationale behind it.

A brief explanation about MissionMaker

As pointed out before, MissionMaker was produced as a part of a research project, under a well specified scope. It was designed to fill in an existing gap at that time when researchers were envisioning the power of game-making for developing competences in educational contexts, but the tools were limited or relied too much on coding skills. Furthermore, it was practically impossible to create a game that looked like the commercial games that the students are used to playing at home – an immersive 3D experience in first-person perspective – without investing a great amount of time, not to say the complex activities involved such as 3D modelling.

In this sense, MissionMaker was produced to enable pupils to produce games that looked like those that they would consume in their everyday life, without requiring complex knowledge and letting them focus in other aspects of game-authoring, such as the narrative. The possibility of focusing on diverse aspects other than programming allowed MissionMaker to be used successfully in different interdisciplinary projects, connecting diverse knowledge areas such as English, Media and Arts (BUCKINGHAM; BURN, 2007).

Thus, one of the main features of this software is to avoid "hardcore" programming. However, this does not mean that the games created in MissionMaker do not demand computer-related skills, or even computational thinking. This is easily observed if we realise, for instance, that games are, in their essence, systems (SALEN; ZIMMERMAN, 2003), thus, demanding that game-creators exercise their systemic thinking. In this sense, even if computation was not the main objective when it was produced, MissionMaker could be used as a means to foster the Computing skills demanded by the new computing curriculum and, at the same time, connect these skills with other disciplines. However, how are these computer-related competences fostered in Mission Maker?

The software consists of several ready-made assets (rooms, doors, objects, pickups, characters, etc.) that are available to the user. The game-maker can also import media files (audio, video, image) to his/her game, but the core dynamics of game-making in this software is, as Pelletier, Burn and Buckingham (2010) point out, to assemble ready-made assets and specify relations between them. These relations are specified through logical rules in rudimentary object-based programming, expressed in a simple conditional form “if condition, then action”. In figure 1 below, it is possible to observe an example of a rule created in MissionMaker Classic: “If the door is clicked, the door opens”.

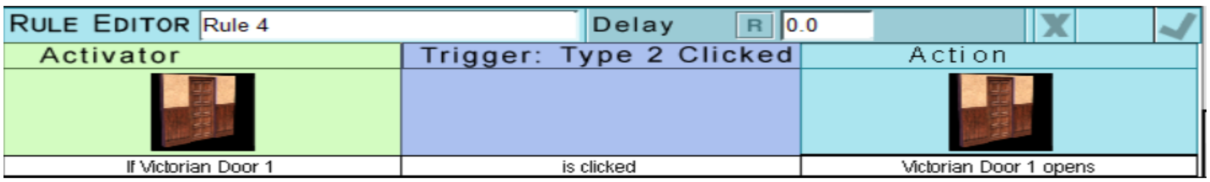

Figure 1: Rule created in MissionMaker Classic (Font: Authors)

Thus, one of the core dynamics of game-making in MissionMaker is the creation of rules, which is based in the concept of cause and effect. In this respect, it could be seen as an entry for understanding the concept of algorithm (a sequence of precise and unambiguous instructions) and consequently for coding, especially as the “if” command plays important roles in this practice. Even if the “programming language” used in MissionMaker is simple, it cannot be regarded as weak, because MissionMaker can be used to build very complex and powerful games.

These rules can be combined in chain effects, in order to create a more sophisticated scenario. In this sense, it could be claimed that the software is aligned to the idea that a digital creative-related environment for children must be “low floor, high ceiling” (RESNICK et al., 2009; GROVER; PEA, 2013) in that it must be easy for a beginner to use it properly (low floor), but at the same time it must satisfy the needs of an advanced user (high ceiling).

In this scenario, the new computational curriculum in England was seen as an opportunity to undertake a new pilot project, investigating how MissionMaker could be used according to the ideas defined by the new guidelines. In the next section, we will present the project itself, which was carried out in two London Primary Schools, during June 2014.

The Pilot Project

The project was designed during April and May 2014, and executed in June of the same year. Two teachers who had previous experiences in this area were invited to participate. Both of them are teachers linked to Primary Schools (which, from now on, will be referred as school A[4] and school B[5]), located in London, and both of them are also ICT coordinators in their institutions, thus, accumulating this function with the role of primary school teachers.

Three game-authoring sessions of approximately one hour and half each were held in these two distinct contexts: two in school A, and one in school B. The sessions in school A were organised as a special class, composed of voluntary students that were in Key Stage 2, from Year 3 to Year 5, whereas, in school B, the session was attended by a regular class from Year 3.

Before the in-class experiences, the two teachers who were invited to the research experience attended a meeting with the research group responsible for the project. During the meeting there was a discussion about the new computing curriculum, and a presentation of MissionMaker. The teachers also received a copy of the software in order to explore it, and the sessions were scheduled in order to define which researchers would be following each session. In all three sessions, the sessions were followed by at least one of the authors, who provided support to the teachers. During the classes, the students engaged with the software and the researchers could observe these activities and interview the pupils in order to understand their decisions, actions and feelings toward the experience. A few complementary paper-based activities and questionnaires were also introduced, and they also offered some interesting data in order to enhance our analysis.

Although fostering coding skills was one of the objectives for both teachers, it was possible to observe that diverse approaches were taken. While in school A there was greater focus on pushing students to reflect about games as a cultural form (ex: what are the features that define a game, or to think about a videogame that they want to produce, imagining a narrative and objectives) and their relationship with digital games in everyday life, in school B the main focus was the development of coding principles themselves. In this respect, it is important to understand how the initiatives were carried out.

The Case of School A

In school A, the participating students met the researchers and the teacher in the ICT lab. The class was composed of 22 students, from Year 3 to 5. The first session started with a paper-based activity done in pairs, which asked the students to think about their gaming habits and to define the features of a game. After that, they were introduced to MissionMaker Classic and, in spite of doing the introductory activity in pairs, they were rearranged in a one pupil per computer scheme when using the software.

The students were introduced to MissionMaker in a functional manner, in order to help them to manipulate the interface, choosing and assembling the ready-made assets. However, the teacher opted for a less instructional and more exploratory approach and consequently the rule-making topic was not covered in these first instructions. The students were then asked to think about a narrative and start designing it. Unfortunately, there were some technical problems due to the way the software was installed, requiring the assistance of the school's IT technician. Although the fix was possible, it took practically the remaining time of this first session. The students were asked to save their work and finish thinking about their game narratives as homework, and the class was dismissed.

The paper-based activities offered an interesting overview of the class and their view toward videogames. It was possible to observe that all of the students had a strong bond with digital games, as all affirmed that they play videogames regularly, and 21 out of the total of 22 play games in at least two different platforms, PC (computer) being their favourite , as shown in figure 2:

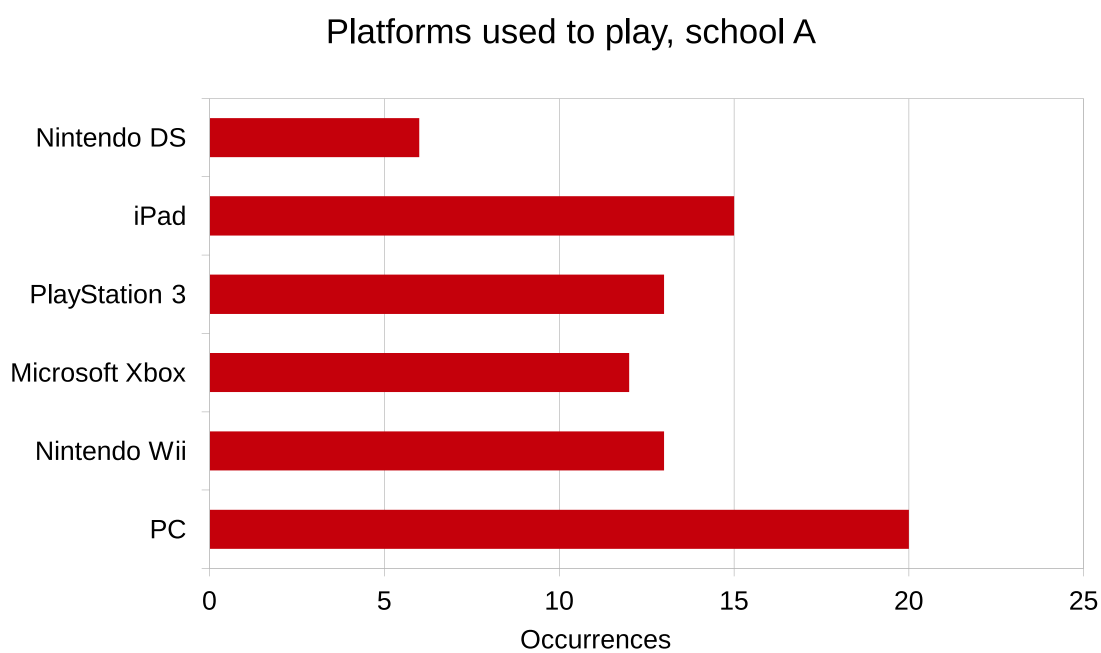

Figure 2: Occurrences of platforms used to play games by kids in school A (Font: Authors)

Although these children are very used to digital games, we cannot claim that all students have the same knowledge about games, both in terms of technical as well as cultural aspects. This difference about their knowledge towards videogames could be noticed from their responses to the question regarding the features that a game must have to be considered a game, shown in the table in figure 3:

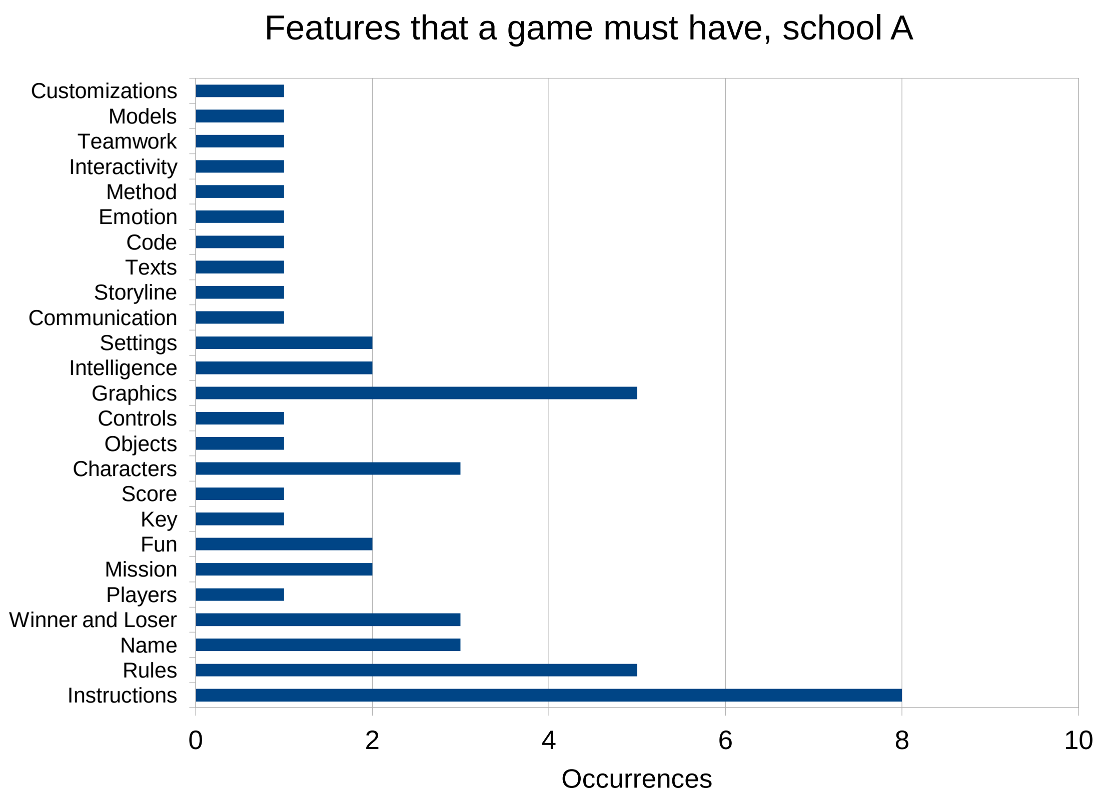

Figure 3: Occurrences of features that a game must have according to pupils from school A

According to this data, it is possible to observe that some responses were very specific, describing graphics, code or the 3D models used in some videogames, showing they could grasp technical vocabulary, while other responses were more generic, such as Emotion, Fun or Mission. This difference could be interpreted as evidence that, despite all the students play videogames, they do not have the same interest or literacy towards this topic.

The second session occurred two weeks later, and the students were asked to continue their previous work and to start building their games. However, the exploratory approach was followed again, and although the pupils were able to develop complex narratives and environments, they were not able to program the rules and, therefore, to conclude their games. Some pupils, especially the older ones, tried to overcome this difficulty on their own, but they were not able to create a rule successfully.

It was possible to draw some interesting outcomes from this experience. Firstly, although all students that took part in the project play videogames, the levels of knowledge and interest toward this medium is diverse. Furthermore, in relation to the development of programming principles, no matter how used to digital games the students are, when talking about game design and developing coding abilities, they must have greater support and guidance.

In this respect, we cannot ignore that this was an atypical situation, in which the class was not homogeneous, as there were children from Year 3 to Year 5. It could be argued that it would be difficult to create an approach to explain coding that could engage all the students, especially due to the differences regarding age and previous knowledge. On the other hand, it was interesting to notice that the inability to create the rules was not a disengagement factor for these students, as they were very focused on creating and exploring their worlds and sharing their experiences with their peers.

However, even with this positive outcome regarding the engagement in the activity, we cannot claim that the initiative was a success, as its main objective, the development of programming principles, was not achieved. On the other hand, it would be an overstatement to define the experience as a total failure. Even without concluding their games, the pupils were able to reflect about videogames as cultural artefacts, including the way they consume this media, how they are produced, and how this process connects to expression and communication through the games. Therefore, even though they were not capable of developing knowledge about technical aspects related to the use of digital technologies, it was possible to present principles related to these technologies, culture and everyday life.

The Case of school B

The experience in school B was quite different from the experience in school A. In school B, the session was conducted with the teacher's regular Year 3 class, and it focused specifically on developing coding principles. It was carried out in their regular classroom using laptops. In addition, the students worked in pairs during all the activities,.

As in the school A, the session started with a paper-based activity, but instead of focusing on comprehending games in cultural and conceptual terms, the students were asked to propose a brief narrative for their game. They were provided a small storyboard composed of 9 small rectangles that the pairs had to complete. After some time to think and develop their game narrative, the students were introduced to MissionMaker, and how to operate it functionally (how to navigate, use its interface etc).

The students were given time to explore the software and create the environment that they had imagined for their game. It is important to note that, in this case, the teacher had a stronger control of the environment. The students were limited to design a world with no more than 4 rooms, and initially, they were not to place all sorts of assets in the rooms, only doors. After some minutes, the teacher asked the students to close their laptops. In this moment, the teacher offered a brief lecture about the main topic of the class: understanding the condition-action paradigm, a base concept for programming logic. Initially, the students were asked to present some examples of mundane conditioned actions. After understanding the idea, they offered some models like "if it is 10PM, I should go to bed", or "if I am hungry, I eat something".

In the sequence, the teacher organised an experience closer to digital games, but without relying on digital artefacts: based in pupils' cultural capital, he promoted a role-playing activity based in the videogame *Sonic: The Hedgedog* (SEGA, 1991). In this game, one of the challenging elements are hidden spikes, which become visible according to the proximity to the main character and, if the character is hit by a spike, the character is punished by losing rings or even one life. In the activity promoted by the teacher, one student was selected to represent Sonic, another three students to represent the spikes, and the rest of the class became the "code" of the game. "Sonic" must run towards the "spikes" and, when the character was close to them, the "code" should alert the "spikes" that they must reveal themselves. In this dynamic, when the pupil representing Sonic was far away, the "spike-pupils" were crouching; when "Sonic" approached, the class shouted (transmitting the message) and the "spikes" stood up.

After these explanatory activities, the main objective of the class was revealed: the students should be able to create at least one simple rule in the MissionMaker. The first selected example was "if the door is clicked, the door opens". At this point, it was possible to observe that some of the students were able to comprehend the concept, while others needed limited assistance. However, in the end all the students were able to at least create and execute this simple rule.

After understanding this idea, the students were stimulated to continue developing their games, making their games even more complex by adding more objects and elements. It is important to remark that some students were able to go deeper in the rule-making activity, adding other elements to create them, such as "if the player picks up a crate, the door closes", amplifying their comprehension of the way the condition-action paradigm works. A leap observed in this extrapolation of the initial example is the perception that there is no need to necessarily connect the object that defines the condition to the object that suffers the action, a crucial element for the comprehension of this concept.

In this sense, it could be claimed that the experience carried out in school B was successful in the main objective, as it presented the students some programming principles, even if the levels of comprehension were variable. However, although the narrative aspects of a game were explored as an introductory element, they were not explored continually, being relegated to a secondary element after the explanation and the development of the rules. In this respect, it is possible to claim that the initiative carried out in school B did not generate significant results under the "cultural" perspective, as the students did not reflect on a deeper sense of the narrative aspects of a game, or even their own game consuming patterns.

If we analyse both cases presented here, game-making showed itself as an important strategy for teaching concepts and even to reach the objectives of the new computing curriculum. The students were able to reflect about videogames and their game consuming patterns, they created narratives to their own games, and they explored rules, defining and implementing them through the software. In this way, they developed important principles to comprehend digital technologies both in "technical" (what are systems, programming logic) and "cultural" (how games are played, what messages they carry, how they connect to contemporary culture) aspects.

However, if we reflect about the outcomes obtained separately in each case, we will notice that neither of the cases were capable of exploring all aspects in the same depth. In this sense, this project shows how the development of an initiative like this is not trivial. Even using the same software, the results obtained were different: in school A, the students could reflect about the nature of digital games and their role in the culture, but were not capable of developing programming principles. On the other hand, in school B, the results were practically the opposite: the pupils presented a grasp off programming principles (condition-action, the usage of *if* command), but they were space to establish a reflection about games in the culture and how they connect to everyday life.

With these outcomes, we could argue that game-making could be seen as a means to promote the new English computing curriculum in both senses ("technical" and "cultural"), however, the challenge is how to organise an experience that balance both aspects, combining them in the same initiative.

The difficulty in finding this balance is establishing experiences that use digital games (and, more broadly, digital technologies) in an interface between diverse areas, such as Computing, Literacy and Media. As we presented in this article, in general, teachers have a better understanding about one or other of these aspects ("technical" or "cultural") which they tend to prioritise, relegating the other to a secondary status. To establish an initiative that explores both aspects equally, favouring this congruence, greater interdisciplinary effort is necessary which could involve collaboration between teachers from diverse areas. In this sense, it is necessary that this kind of experience be promoted both through grassroots activities and through a top-down policy that facilitates and promotes it.

Final Considerations

The new national curriculum in England for Computing could be seen as an effort to address a constant objective in the educational process, and has not yet to be achieved: to prepare students to understand and engage meaningfully with digital technologies. It could be seen as an attempt to fix the issues that technological education has faced historically, especially due to its focus on teaching technology for its own sake (technological artefacts) rather than the rationale behind the technology.

To achieve the objectives described above and to tackle these issues, the new computing curriculum in England focuses on the development of a more solid conceptual base, a move that could be seen as a return to the early moments of the use of computers in Education, when programming was more important. However, this movement should not be seen as a pursuit to value the technique for its own sake. It is necessary to comprehend that these computational aspects are connected, are mutually influenced, and have impacts in contemporary societies. In this sense, the development of the tripod that supports these new guidelines (Computer Science, Information Technology and Digital Literacy) should not be seen in an isolated manner, as if they were auto sufficient, but connected to other areas of knowledge, enabling students to understand how to use these digital technologies for their own favour, in diverse contexts.

But how does one promote this curriculum in practice? We claim that game-making activities could play an important role in this context, being used as a means to foster computing-related principles and competences and, at the same time, create bridges for interdisciplinary projects that deal with diverse knowledge, from different areas. In this sense, game-making could promote the exploration of Computing in both horizontal and vertical senses across the curriculum.

In this pilot project, we were able to verify that game-making can be used to favour the development of the new computing curriculum, both in "technical" (such as programming) and "cultural" (such as the relations between digital artefacts, society and culture) aspects. However, it was also possible to see the complexity involved in the establishment of an initiative such as this, as in both cases analysed one aspect overshadowed the other. In this sense, a greater interdisciplinary effort is necessary, which combines efforts from teachers from diverse areas, organising experiences that could deal with both aspects equally.

It is also important to remark that the announcement of the new English computing curriculum in 2013 was seen as an opportunity to develop a new version of MissionMaker (entitled MissionMaker Core), creating software capable of dealing with more advanced computational elements expected to be explored in the schools according to the new curriculum, such as Boolean logical operators[6]. This new version is being developed at the London Knowledge Lab[7] (a research centre composed of researchers from Institute of Education and Birkbeck College). MissionMaker Core can be seen as an update of the software, which will bring new functionalities and will allow the production of even more sophisticated games. In this sense, it is a "renovation" of the previous version, which will maintain the "low floor", but will turn its "ceiling" even "higher", as it will enable its users to produce even more complex rules and, consequently, the development of deeper knowledge.

Finally, we point out that research regarding the use of games in educational contexts must be ongoing. In spite of the motivational effect of games, and the success of other initiatives based in these artefacts, Grover and Pea (2013) argue that games have been sub utilised in the development of skills related to digital technologies, such as computational thinking. In this sense, it is reasonable to expect more experiences in this regard, exploring the potential of game-authoring in learning.

Notes

1. We thank FAPESP and CNPq for supporting this research.

2. A timeline referring the major developments in Computing in schools in England is available in the report "Shut down or Restart? The way forward for computing in UK" (ROYAL SOCIETY, 2012).

3. http://magicalprojects.co.uk/

4. Public School, from Nursery to Year Six, about 600 students

5. Public School which also receives funding from a religious order, from Nursery to Year Six, around 30 students in each class.

6. Logical operators used in conditional commands to combine two or more conditions in a single command, which returns a Boolean answer (True or False). The most common are "AND" (returns true if all conditions tested are true, and false if at least one of them is false), "OR" (returns true if at least one condition is true, or false, if all of them are false) and "NOT" (is the negative of the condition; the result is the opposite of the original one). For further information, check Fisher, Perkins, Walked and Wolfart (2003).

7. http://www.lkl.ac.uk.

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