International Journal of Innovation and Research in Educational Sciences
Volume 4, Issue 3, ISSN (Online): 2349–5219

Combining Physical and Virtual Realities to Enhance Students Entrepreneurial Development

Ida Lindh
Luleå University of Technology.
Corresponding author email id: ida.lindh@ltu.se

Date of publication (dd/mm/yyyy): 17/05/2017

Abstract **– The traditional ways of teaching are being supplemented with new tools and new educational approaches in order make education more authentic and aligned with the world beyond school. To prepare young people for a rapidly changing and less predictable environment, policy directives have urged the development of entrepreneurial attitudes and abilities through an education relating closely to the surrounding society (Commission, 2015; OECD, 1992). Simultaneously, new technology is suggested to provide new opportunities for learning in an increasingly digitalised society (Samuelson-Wardrip & Shaphiro, 2016; Brinson, 2015; Cheng, Lin, & She, 2015). Although the entry of ICT and entrepreneurship into the field of education may both work to prepare students for an environment beyond school, few scholars have investigated if and how these processes are interrelated, or how they might complement each other. By adopting a sociocultural perspective on learning, and incorporating literature on combined physical and virtual world contexts, this qualitative study offers insights into how various mediating tools used to relate education to the world beyond school may influence the extent to which primary school students develop entrepreneurial attitudes and abilities. The results indicate that computer-aided learning combining virtual and physical world contexts could support the development of entrepreneurial attitudes and abilities.**

Keywords **– Virtual Reality, Teaching/Learning Strategies, Elementary Education, Interactive Learning Environments, Improving Classroom Teaching.**

I. Introduction

Supra-national policy directives have urged a rethink of education in order to align it more closely with the world beyond school (European Commission, 2013a, 2013b, 2015; Matlay and Pepin, 2012; OECD, 1989, 1992). Connecting education more closely to the surrounding society is suggested to nurture future entrepreneurs and a prepared and resilient future workforce (e.g., European Commission, 2013b, 2015). Educators have therefore been encouraged to integrate entrepreneurship in education through authentic assignments and environments related to the world outside school (Commission, 2013a, 2013b). Entrepreneurship in education refers to promoting entrepreneurial attitudes and skills (Fayolle & Klandt, 2006) such as an innovative approach to problem solving, adaptability, coping with change, and becoming more self-reliant (Henry, Hill, & Leitch, 2005). Accordingly, the pedagogical approach to entrepreneurship in education has been described as one utilising teaching practices that stimulate students' entrepreneurial qualities and abilities such as self-efficacy (refering to their belief in their own ability to perform a certain task, Bandura, 1994), motivation, creativity, and risk-taking (European Commission, 2013a; Jones & Iredale, 2010; OECD, 1998).

One stated precondition for the stimulation of such entrepreneurial qualities is the simulation of a context resembling that in which entrepreneurs operate. The process involves letting students do something in ways that are described as *for real* (Hindle, 2007; Jones & Iredale, 2010) and *in a real-world context* (Gibb, 1987; Pittaway and Cope, 2007). Indeed, in contrast to traditional classroom sessions, entrepreneurship in education implies the adoption of action-oriented methods in a real-world setting (Henry et al., 2005; Ilozor, Sarki, Hodd, Heinonen, & Poikkijoki, 2006; Jones & Iredale, 2010). In addition to the call for teaching activities that relate to the world beyond the classroom or are conducted in collaboration with actors from outside school (Berglund & Holmgren, 2008; Leffler & Svedberg, 2003, 2005), another characteristic of entrepreneurship in education is the emphasis on the teachers' own creativity and entrepreneurial mindset as a prerequisite and mediator for nurturing students' entrepreneurial development (Backström-Widjeskog, 2010; Hattie, 2012; Leffler, 2009).

The increasing use of ICT in classroom practice, however, offers a new perspective on the potential of authentic learning environments. ICT-based education is related to contexts outside school, but in contrast to the emphasis on the surrounding society, the use of ICT permits the physical world to be connected to a virtual world in the classroom. Indeed, the combination and sequential use of physical and virtual experiences has been shown to develop a deeper understanding among subjects of the phenomena studied in comparison to others exposed to either a physical or a virtual experience (Gire et al., 2010; Wu, Lee, Chang, & Liang, 2013; Zacharia, 2007). Even if the learning outcome from such an approach could also be achieved through traditional education, scholars have suggested that students could learn more effectively and develop a deeper understanding through the mix of realities offered by using ICT in education (El Sayed, Zayed, & Sharawy, 2011; Mikropoulos & Natsis, 2011). Scholars have therefore suggested that technology can facilitate interactive alternatives to real life settings and that authentic learning environments can simultaneously be both real-world and virtual (Herrington & Oliver, 2000).

Although the emphasis on relating education to the world beyond school and the interrelation of the physical and virtual worlds both highlight the importance of relating education to an environment beyond the classroom, they differ in their perceptions of which outside environment education should be related to. The two approaches are however suggested to have similar outcomes. The reality-based, authentic learning environments and tasks approach has been said to develop students' motivation, their ability to deal with uncertainty, their risk-taking and problem-solving ability, and their creativity (Fayolle & Klandt, 2006; Kickul and Fayolle, 2007; Leffler and Svedberg, 2005; Peterman and Kennedy, 2003). Similarly, the ICT-based mixed-reality approach has been shown to improve students' understanding of science (Chiu, DeJaegher, & Chao, 2015) and of complexity (Rosenbaum, Klopfer, & Perry, 2007), to improve their problem-solving skills (T.-Y. Liu, Tan, and Chu, 2009), and their understanding, motivation and interest generally (Kaufmann, Steinbügl, Dünser, & Glück, 2005). The mediator of such development and learning, however, differs depending on which of the two ways of relating education to an environment outside school is selected; teacher and reality-based tasks or devices and computer games or programs. Indeed, ICT in education challenges the role of the teacher as the main facilitator of student learning processes (Säljö & Linderoth, 2002**.** This is because devices such as PCs or tablets, or educational software or games become both facilitator and mediator that develop students' learning.

Despite the increasing effort expended on relating education to contexts and environments outside school, there has been little scholarly interest in comparing different tools and approaches. Moreover, much of the literature on entrepreneurship in education argues that physicality such as the hands-on experience of students and tasks related to physical world contexts are prerequisites for students' entrepreneurial development (e.g., Fayolle & Gailly, 2008; Pittaway & Cope, 2007; Pittaway & Thorpe, 2012). The current study aims to explore how educational attempts to relate to the world outside school may be understood in relation to the mediating tools used and whether real-world physical contexts are a prerequisite for the development of entrepreneurial abilities and attitudes among students. Specifically, this study addresses the following questions:

How might various mediating tools in physical and virtual world contexts contribute to making education more reality-based?

How might those various mediating tools contribute to the development of entrepreneurial attitudes and abilities among primary school students?

II. Theoretical Background

This study draws on sociocultural theory and Lev Vygotskij's work (1978) on the Zone of Proximal Development (ZPD) and literature on ICT-aided learning combining physical and virtual world contexts (Ainsworth, 1999; Cheng et al., 2015; Wu et al., 2013; Zacharia & Olympiou, 2011). ZPD is defined as "the distance between the actual developmental level as determined by interdependent problem solving, and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p 86). Thus, ZDP theory suggests that there are two levels of development within a learner; one actual development level that is determined by the learner's own capabilities to learn, and one potential level of development that can be attained with the assistance of others (Vygotsky, 1980, 1986). In other words, learning creates a ZPD, a process of development enacted through interaction with others in a person's environment that is internalised and becomes part of that person's development (Lave & Wenger, 1991; Vygotsky, 1980). Thus, a central aspect of the sociocultural theory of higher levels of learning and thinking is the role of social interactions with others. Lidz (1991) argued that the mediator of higher development is someone who mediates knowledge about the world by "framing, selecting, focusing, and feeding back environmental experiences in such a way as to produce in him appropriate learning sets and habits"(Lidz, 1991, p 67).

This process of facilitation and the form of mediated assistance to students capable of reaching the higher level of development might, however, vary. Different learners may have a different ZDP; depending on how they perceive feedback from others, how they experience setbacks, and how they regulate their behaviour (Lantolf & Aljaafreh, 1995). A sociocultural perspective on learning emphasises the relationship between teaching and learning, and how the process in which learning occurs is determined by the teaching that facilitates and mediates it (Lindqvist, 1999). Mediating tools can be both physical and intellectual, and work to mediate or change how the social reality is perceived (Säljö, 2013). Thus, individual learning and perceptions of the world originate with, and are imprinted by, the sociocultural context in which the individual operates and the mediation tools that context encompasses.

The mediating tools used to relate education to the world beyond school in order to make it more authentic focus attention on perceptions of what constitutes the real world. Whereas the teacher's role as a facilitator of entrepreneurial attitudes and skills through his or her ability to provide learning tasks relevant to the world outside school is often emphasised (Fayolle & Klandt, 2006; Gibb, 1987; Jones & Iredale, 2010; Pittaway & Cope, 2007), the literature on ICT-aided education highlights the potential of digital technology to promote the development of students (Craig, 2013; Linderoth, 2004; Nilsson, 2010). In contrast to the emphasis on the physical world beyond school, ICT may offer an opportunity for students to not only connect to a virtual world, but also to create and manipulate an environment, and thus create their own world or environment through the use of avatars (Mikropoulos and Natsis, 2011). Recent streams of research have begun to emphasise the benefits of linking the physical world with the digital world for educational purposes (e.g., Craig, 2013; Linderoth, 2004) An educational approach centred on the interaction between the virtual and real worlds encourages educational experiences that transcend the time, space, and geographical location constraints of the classroom (Cuendet, Bonnard, Do-Lenh, & Dillenbourg, 2013; Pérez-Sanagustín, Muñoz-Merino, Alario-Hoyos, Soldani, and Kloos, 2015). This implies that ICT could offer new options for teachers, as virtual realities and activities can be created by the student within the classroom (Pérez-Sanagustín et al., 2015).

Researchers has compared the learning outcomes of students exposed to physical, real-world experiences (students doing something for real) through the use of real objects and materials and the outcomes of students with virtual learning experiences gained through interactive visualisation of the same objects and material, but where the students can change or interact with those objects and materials, to observe and understand a task on a deeper level (Zacharia, Loizou, & Papaevripidou, 2012; Zacharia and Olympiou, 2011). It´s been suggested that the bridging of virtual and physical worlds, sequentially or simultaneously (Blikstein, 2012; Wu et al., 2013), provides the student with multiple representations of a phenomena and makes it possible for that student to gain a deeper understanding of that phenomena than if the student were exposed to only one representation (Ainsworth, 1999; Gagatsis & Shiakalli, 2004; Gire et al., 2010; Zacharia, 2007; Zacharia & Olympiou, 2011). Sequential experience of physical and virtual worlds in education often implies tasks that can be completed in either the physical or the virtual world, but where students can draw on physical experiences to create virtual experiences impossible to perform in the real world, or indeed the reverse situation. Students can therefore create their own representations of real-world objects, and the learning doing so generates ultimately depends on the students' ability to make connections between the different representations and from one representation to another (Ainsworth, 1999; Gagatsis & Shiakalli, 2004; Hwang & Hu, 2013). Research studying the simultaneous use of physical and virtual worlds focuses on how tasks may be completed by technology that blends real and virtual information (Klopfer & Squire, 2008). In this case, students can use and change information in both the virtual and real environments to carry out a certain task. because real and virtual world objects are presented together and either could be enhanced (Wu et al., 2013). This, however, demands a technology capable of mixing realities by either adding virtual experiences to real environments or placing a real-world object within a virtual environment in order to enhance either the physical or virtual reality (Liu, Cheok, Mei-Ling, & Theng, 2007).

Both sequentially and simultaneously combining the physical and virtual worlds has been shown to increase the learning outcomes of students, in comparison to students who only experienced either the physical or the virtual world (Brinson, 2015; Zacharia, 2007; Zacharia & Olympiou, 2011). Whereas some scholars have suggested that students learning in virtual worlds demands prior knowledge of the task at hand (Zacharia et al., 2012), others have suggested that virtual environments may actually be especially beneficial for students with disabilities and special learning needs (Lanyi, Geiszt, Karolyi, Tilinger, & Magyar, 2006; Richard, Billaudeau, Richard, & Gaudin, 2007). The dominant notion, however, has become that physical and virtual worlds should be combined; but how, when, and to what extent may vary depending on the prior knowledge and learning needs of the students (Brinson, 2015). The learning outcome may also be related to how the tasks set boundaries between the virtual world and the real world (Wu et al., 2013), which to some extent may make the framing of the task, and thus the teachers role, key to the learners' developmental processes. Combining physical and virtual worlds in education therefore has the potential to encourage students to both create their own environment beyond school and the avatars that can contribute to their attaining high levels of learning and understanding, in both the physical and virtual worlds (Cheng et al., 2015).

Table 1 shows that both ways of relating to a world beyond school share some objective and learning elements, such as the enhancement of the students' sense of initiative, creativity, collaboration, and the ability to cope with complexity and uncertainty. In that way, both are capable of developing entrepreneurial attitudes and ability. Table 1 also shows, however, that the role of the mediator of development and higher knowledge and understanding is presented somewhat differently in the two approaches and research areas.

Table 1: Learning Elements when relating education to physical environments and Learning elements when combining physical and virtual environments

Learning elements	Elements of learning in physical real world environments	Elements of learning when combining physical and virtual environments
Objective	Focus on the process of learning, rather the content. Objective to develop entrepreneurial attitudes and abilities	Leading to a deeper understanding of phenomena's (Gire et al, 2010; Zacharia, 2007, Wu, Lee, Chang and Liang, 2013)
The role of the student	Students as active players in the learning process (Fayolle and Klandt, 2006)	Students as active learners (Price and Rogers, 2004)
The role of the teacher	Facilitator and guide for students entrepreneurial development (Jones and Iredale, 2010)	ICT as medium for learning and deeper understanding (Craig, 2013; Linderoth, 2004)
Learning environment	Simulation of contexts similar to those in which entrepreneurs learn, outside the classroom in real-world settings (Fiet and Samuelsson, 2000; Pittaway and Cope, 2007)	Happens in the classroom by connecting the physical world to a virtual (Wu et al, 2013)
Authenticity	Real-world problems and authentic learning environments, for example through collaboration with entrepreneurs and actors outside school, leads to entrepreneurial development (Kirby, 2007)	Students creating their own virtual world in relation to physical environments contributes to develop a deeper understanding and learning among students (Linderoth, 2005; Rosenbaum et al, 2007)

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International Journal of Innovation and Research in Educational Sciences
Volume 4, Issue 3, ISSN (Online): 2349–5219

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Learning elements	Elements of learning in physical real world environments	Elements of learning when combining physical and virtual environments
Elements of uncertainty	Provide complex-real world problems that encourage students to challenge their assumptions (Pittaway and Cope, 2007) and deal with a broad range of unstructured problems (Honig, 2004)	Helps the learner visualise complex relationships and abstract concepts (Arvanitis et al 2007)
Initiative and students belief in their own ability to solve problems	Students are required to think independently (Jones and Iredale, 2010). Action in real-world settings required (Pittaway and Cope, 2007)	Students need to engage in order to achieve results and the result achieved is clearly evident (Anetta, Minogue, Holmes and Cheng, 2009; Cheng, Lin and She, 2015; McClarty et al, 2012, Nilsson 2010)
Creativity	The development of creative thinking and problemsolving is an objective of entrepreneurial learning (European Commission, 2013a, 2013b, 2015)	Aids students creativity and problemsolving ability (Wei et al, 2015; Hwang and Hu, 2013)
Collaboration with others	Ability to collaborate with others is a entrepreneurial ability (European Commission, 2013; OECD, 1989)	Providing a community of learners, sense of being in a place with others (Squire and Jan, 2007)

In sum, the literature on entrepreneurship in education highlights two prerequisites of students entrepreneurial development; authentic, real-world contexts and the teachers' own entrepreneurial attitudes and abilities such as their flexibility, proactivity, and innovativeness in planning and organising their programmes (Kickul & Fayolle, 2007). Overall, the literature describes the teacher as a mediator and facilitator of students' motivation, in that teachers assist students not only to creatively apply what they already know, but also to identify entrepreneurial opportunities in new and complex situations, to set goals that are creative and innovative, and to act to achieve goals.

The literature on ICT-aided learning in combined virtual and physical environments has not been expressly related to the development of entrepreneurial abilities and attitudes. Extant research, however, has shown that utilising digital devices in school and the combining and sequential use of physical and virtual experience could contribute to developing students' learning (Gire et al., 2010; Pérez-Sanagustín et al., 2015; van Joolingen & Zacharia, 2009; Winn et al., 2006; Wu et al., 2013), as well as fostering attitudes and abilities like creativity and motivation (Brinson, 2015; Hwang & Hu, 2013; Wei, Weng, Liu, and Wang, 2015) and increased self-directed learning (Liu, Tan, & Chu, 2009). Despite the similarities to the process in which students learn and develop entrepreneurial attitudes and abilities through reality-based tasks in a real-world context (Commission, 2013b, 2015; Kickul & Fayolle, 2007; Kirby, 2007), the use of ICT in education has not been considered a part of that process. The present study aims to address this apparent research gap.

III. Method

3.1. Research approach

This study adopts a longitudinal exploratory qualitative approach with multiple data sources. An interactive research design was chosen (Johansson, 2008; McKenney & Reeves, 2014) in which both the researcher and teacher took an active part in designing lectures and in continuous discussions about ideas for different assignments, and on the results of those assignments. The co-creational approach also allowed for a direct exchange with the teacher and the students in question, which is an appropriate way to understand students' developmental and sense-making processes (Charmaz, 2006).

3.2 Research setting

Prior to data collection, the author had to address several sampling issues to ensure sufficient sample size, that there were sufficient informative observations, and that protocols were observed (Onwuegbuzie & Leech, 2007). This study followed a typical case sampling approach (Miles, Huberman, & Saldaña, 2013; Onwuegbuzie and Leech, 2007) in that it sought teachers who had not yet engaged their students in entrepreneurial learning or conducted education in relation to a real-world context to any meaningful extent. One such teacher was then chosen to participate in the study, which gave access to a group of ten-year-old students in primary school who were on special education programmes to address barriers to learning. Over an eight-month period the teacher and researcher discussed different assignments and approaches designed to make education more related to the outside world and also the results gleaned from each activity. The lectures that the study encompasses mainly included two types of sessions; those in which the teacher set the students assignments related to the world beyond school, and virtual learning sessions employing the computer program, Minecraft.

The first type of sessions included tasks where the students were required to solve mathematical problems with the aid of different materials such as blocks, string, and a paper and pen. The students were encouraged to create tasks based on their own experience, and some of the tasks also demanded the students leave the classroom to ask questions of people, take measurements, or apply their knowledge in relation to real-world objects.

The other type of session involved the use of Minecraft. Minecraft was developed in Sweden around 2011 and is now used globally (Minecraft, 2015). Players use avatars and can construct and build almost anything by collecting and using materials such as rock, wood, coal, or gold. The game has different modes: the survival and adventure modes are about overcoming challenges, and the creative mode is about constructing buildings. It is also possible to add further modes, objects, or properties, to complement the original standard settings. Minecraft was chosen for several reasons. All the participating students were familiar with the game and reported that they played it in their spare time. As Minecraft has been used for different purposes in educational settings, there was also teaching material available that could be used for inspiration, as well as a version of the game that was appropriate for educational settings (Minecraft Edu), which allowed the teacher access to the students' virtual worlds. Moreover, although the literature suggests that the use of new technology within a school setting may be conducive to a student being motivated to learn (Annetta, Minogue, Holmes, & Cheng, 2009), other scholars have suggested that it might also challenge educational practice. It may lead to students being distracted, to an increase in off-topic activity, and to the consolidation of previous habits rather than the development of new ones (Aagaard, 2015). This made Minecraft a suitable tool for the study of students' learning outcomes and development.

3.3 Data collection

This study used multiple data sources. As illustrated by Figure 1, data were collected over an eight-month period by way of interviews of students and of the teacher, pupil survey reports, and weekly observations. To understand how different ways of relating education to the world beyond school can spur the development of entrepreneurial attitudes and abilities, the study was inspired by policy and literature portraying entrepreneurship in education as the promotion of entrepreneurial attitudes and skills such as self-efficacy, creativity, an innovative approach to problem solving, an ability to cope with uncertainty and to collaborate (European Commission, 2013b, 2015; Fayolle & Klandt, 2006; Henry et al., 2005; Jones and Iredale, 2010; OECD, 1989, 1998). Hence, individual semi-structured interviews conducted at the beginning and end of the period elicited from the students what such attitudes and skills meant to them (if anything) and their thoughts about how, if, when, and why it might be beneficial to develop these skills further. The interviews also covered the students' perceptions of their own problem-solving skills and the role for innovative problem solving in mathematics. The students then reported continuously through self-assessment in writing, drawing and in group interviews (14 times in total) throughout the eight months the project was running. Those self-assessment reports spanned their creativity, belief in their own ability to solve problems and to collaborate, and to cope with uncertainty. In addition, the teacher was interviewed about the students' motivation and problem-solving abilities at the beginning and end of the project and also ranked the students' self-efficacy, creativity and ability to cope with uncertainty at the beginning and end of the period. In addition to the focus on discerning whether a particular approach contributed to changing students' attitudes and abilities, the study also attempted to explore how and why this development had occurred. The students were asked twice each month for their impressions of the learning process, in terms of whether they found it meaningful and useful. They were also quizzed on their motivation to learn and the learning outcomes of each activity. To ensure validity and as the accuracy for the students' assessment of their own ability may have been influenced by bias, the teacher's opinion was canvassed monthly on the students' motivation, development, and learning outcomes in relation to the learning task. This was also complemented by the weekly observations in the classroom setting (1h/week).

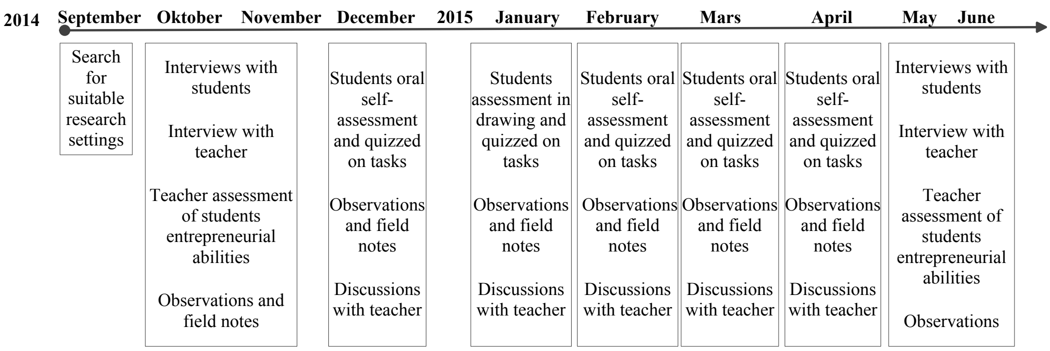

Figure 1: Data collection

3.4 Data analysis

To ensure validity and data analysis triangulation, and to detect both if the students development process had changed as well as why and how that had happened, this qualitative study utilises two different data analysis techniques (Leech & Onwuegbuzie, 2008; Lincoln & Guba, 2002). An interpretative analyst approach was adopted in which latent content analysis (Leech & Onwuegbuzie, 2008) was used to uncover the underlying reasons for changes in students' action and behaviour toward entrepreneurial attitudes and abilities. The pattern of what and how that contributed to a change in the students' way of thinking and acting was detected through the use of multiple data sources with indicators for entrepreneurial attitudes and abilities. When students were labelled as having developed their entrepreneurial skills and attitudes, this implied that they reported having developed their self-efficacy, creativity, and ability to cope with uncertainty, and that the teacher's assessment and researcher's impression confirmed an enhancement in their innovative problem-solving approach and motivation to complete the task at hand. As such observations, reports, and self-assessment input were collected at several points in time, they were related to the assignments and the reality-based approach.

The analytical approach was complemented by an enthnographic analysis (Leech and Onwuegbuzie, 2002; Spradley, 1979). That analysis included an examination of how the students related to the world outside school and made meaning from that interaction in various assignments, and how that, in turn, related to the students' development. The interactive approach made it possible to constantly revert to the students to ask questions and to test different assignments to determine which enhanced the analysis (Spradley, 1979). All the data were compared, both in relation to the different sessions and to the students' different developmental processes, to elicit the differences and similarities, and to map how the students constructed meaning from different reality-based assignments. This data analysis approach is especially conducive to conducting research with young children whose reflections and perspectives may not be clearly articulated or known to the researcher, and when multiple analytic techniques are necessary to ensure validity (Leech & Onwuegbuzie, 2008)

VI. Results

The participating students initially reported having varying levels of belief in their ability to solve problems. All the students suffered from some form of learning challenge, and that clearly had an impact on their belief in their ability to solve problems, and also on their patience and concentration when doing so. The teacher stated that their low level of self-belief was to some extent compensated for by their creativity. Although the students were described as being capable of an innovative approach to problem solving, this had not proved to be beneficial for their motivation or learning outcomes up to that point.

The lessons that this study encompasses can be divided into those sessions focusing on relating education to the physical world outside school, and those combining the virtual and the physical worlds. As shown in Tables 2a and 2b, the different types of teaching-learning activities shared the same learning outcomes, focusing on enhancing the students' mathematical knowledge through problem solving. In the following sections, the outcome of these two types of sessions will be discussed further.

Table 2a: Sessions related to the physical world outside school

Features of the teaching and learning activities	Mediating tools	Learning outcome	Illustrative quotes from students	Illustrative quotes from teacher
Related to every-day problems in their school or local surroundings Learning outcome related to mathematics, such as division and proportion Physical instruments to measure, calculate on or compare with Physical objects to the students disposal for solving the problems, such as blocks, stripes Encouraged to contact others for clues	Teacher framing the session and mediator for higher levels of learning and entrepreneurial development Peers: collaboration between students were emphasised	Relating a mathematical assignment to a real context Learning about the information needed to solve a problem but not understanding the mathematical content of the assignment Collaboration in terms of looking at, and copying, others solutions Doing, without learning.	*"We cared more about the (context) than about problem solving as such"* *"It was boring. Mathematics is only fun when you don't know that it is mathematics* *"We cared more about the (context) than about problem solving as such"* *"It was boring. Mathematics is only fun when you don't know that it is mathematics"* *"We cared more about the (context) than about problem solving as such"* *"It was boring. Mathematics is only fun when you don't know that it is mathematics"*	*It was difficult… as when we discussed the importance of collaboration, about taking responsibility…. It just did not happen"* *They found it too complex and they were too shy. In addition, it was difficult to turn what they learned into practice"*

4.1 Sessions related to the physical world outside school

The sessions with a focus on relating education to the physical world outside school included problem-solving tasks in which the students were confronted with real-world problems that demanded creative solutions, collaboration, initiative, responsibility, and the ability to cope with uncertainty (Table 2a). The main focus of the sessions was to develop the students' problem solving in mathematics, and their understanding of probability, multiplication, fractions, and geometry. A typical session started with the teacher giving the students a task or a problem to solve. The assignments were related to real-world, everyday problems and thereby brought the outside world into the school context or the reverse. Assignments could, for example, include studying a physical construction or building (such as their school yard, their immediate surroundings, buildings, or the school canteen) and how it should change to meet new demands. The students had physical instruments to measure with and pens and paper to make calculations with, or to sketch with. They could touch the relevant artefact, compare it with other objects, and were sometimes encouraged to ask people in the surrounding area for information to solve a puzzle. In addition, they had physical objects at their disposal, such as blocks, tape, wooden cubes, and lengths of string. In many sessions, creative solutions were encouraged as there was more than one potential solution to the problem in question, which could instead be solved by applying a number of different techniques and ways of thinking (Levenson, 2011). The students were encouraged to collaborate and discuss different ideas on how the task could be approached. The teacher, in turn, had a clear idea of the desired learning outcome of the task in terms of mathematics. She also offered the students support and contributed ideas during the lessons intended to help them further develop their thinking.

The students, however, still found it difficult to engage with the task, and their confusion meant they struggled to persevere with their attempts to complete it. When faced with challenges, the students asked the teacher for help and she helped them complete the task but it did not lead to an increased motivation to deepen their understanding. Moreover, the emphasis on collaboration did not enhance the learning outcome but instead served to separate students who had a clear idea of how to resolve the task and the knowledge and the skills to do so, from those students who struggled to grasp the content of the task. Thus, their solutions to the problem illustrated that neither group of students developed their thinking but instead focused more on knowledge they already possessed.

To bolster the students' motivation to persist with the task, develop their knowledge, and to strengthen the pre-conditions for entrepreneurial development, the teacher involved the students in developing their own tasks and real problems they considered it important to solve. Putting the students at the centre of learning and making them responsible for their own learning tasks and those of their classmates meant the teacher to some extent let them assume a mediator role for their peers. The departure point for the development of a mathematical problem for the other students to solve was something each child found related to their own lived experience, such as sports or other personal interests. The motivation was initially high, but the students found it difficult to frame the task and relate it to a real-world context. The problems were either related to the world outside school, but failed to develop a deeper knowledge related to the task at hand, or were suitable targets for mathematical problem solving, but failed to relate to the world outside the mathematics class. Overall, the assignments did not develop their belief in their own ability to solve problems. The students were asked to comment on each other's tasks and this led to some degree of collaboration; however, they reported that this taught them more about constructing a problem for their classmates than developing their mathematical problem-solving skills in relation to the world outside school.

In sum, when the teacher integrated the physical world outside school into the context of mathematical problem solving, the students were encouraged to engage in creative problem solving, and to communicate and learn mathematics through discussing and trying different solutions in relation to a real-world setting. The students' own interests were prominent as they were responsible for developing problems for their classmates to solve and were encouraged to do so by accessing their own experience and extra-curricular interests. With the teacher acting as mediator, they managed to complete the tasks, but did not report having developed a deeper understanding of the topic at hand. Nor did the activity help the students to develop a perception of themselves as efficient problem solvers. In both interviews and self-assessment reports, the students reported not having developed their entrepreneurial skills and abilities. In fact, they stated that they had difficulties grasping what the training of entrepreneurial attitudes and abilities could offer them in practice, thereby questioning its usefulness and relevance. Furthermore, the students' self-assessment is evidence that their motivation to learn mathematics did not improve and that they learned more about problem solving per se than about how to actually resolve the teacher's problems in mathematical form or, for that matter, their real-world equivalents. This conclusion was also supported by the teacher and confirmed through observations.

Table 2b: Sessions combining physical and virtual world contexts

Features of the teaching and learning activities	Mediating tools	Learning outcome	Illustrative quotas from the students	Illustrative quotas from the teacher
Related to every-day problems in the school or students surroundings Learning outcome related to mathematics, such as division and proportion Virtual instruments Physical instruments Virtual objects to the students disposal for solving the problems, such as blocks, stripes, avatars Avatars	Teacher: Framing the session Minecraft Avatars in their own environments Fellow classmates	Mathematical understanding in relation to the task Collaboration in terms of pushing each other further Creativity in terms of thinking outside the box and an innovative approach to problem solving Self-efficacy in mathematics and other contexts, situations and school subjects Initiative and motivation to learn	*"It's easier to understand", "In Minecraft, it is possible to construct and build almost anything I want, just like I want it", "It is more real than using paper and pen, you actually do it for real... in Minecraft, I mean". "I can relate the real world to the Minecraft world completely"; "also learned to collaborate better"; "I could just ask a classmate for help and they, in turn, needed help with something else, "I learned about everyday things in Minecraft as well", think more about maths in everyday life"*	*"develop their ability to think in mathematical terms. I was just so obvious"* *"They collaborate and take responsibility...* *"...it was so obvious that they really understood how to do it, how to connect the dots, in Minecraft and in the real world. That made all the difference"* *"They can't help making their assignment more complex"* *"Mindcraft is good, but has to be related to the real world to develop a deeper understanding".*

4.2 Sessions combining physical and virtual world learning environments

In the subsequent sessions, the students were set tasks to solve using Minecraft. The sessions shared the same learning objectives as the physical world and traditional teacher-led sessions, such as improving the understanding of probability, multiplication, fractions, and geometry. These sessions too involved blocks, counting, measuring buildings and constructions related to artefacts outside school, and thus to some extent brought the outside world into the virtual game (Table 2b). As with the real-world task, the assignment could, for example, include a construction or a building (such as their school yard, their immediate surroundings, buildings, or the school canteen) and questions on how the artefact in question should change to meet new demands. In these sessions, the students had virtual instruments but could also use physical items such as pens and paper to record calculations, but they obviously could not touch artefacts, easily compare them, or ask outsiders for information. The did have a variety of virtual objects (such as blocks they agreed with the teacher would represent one cubic metre in size) and avatars at their disposal. The students were informed that they would later be given mathematical assignments related to their constructions, the first of them involving fractions. The students were very keen to start using technology in class. This also led them to make more creative and complex solutions, despite being aware that they would have to make more complex calculations involving fractions later on paper, based on their constructions. As the teacher described it, *"They definitely made it more complex than they needed to…they really dared to think outside the box, to challenge themselves how to think";* one pupil confirmed that impression, saying, *"As soon as I am in the creative mode of the game, I become more creative as a person".* The game allowed the students to create avatars, and those avatars were used to enhance the complexity and creativity in the students' different solutions. In addition to becoming more creative, the students also developed their ability to cope with uncertainty. The teacher further noted that, *"Minecraft gives the students courage to create but more importantly, to show and explain to others what they have done and why".*

In addition to students reporting an increased level of motivation and engagement, combining the assignments with Minecraft also contributed to developing the student's self-efficacy. Both the students and teacher were surprised how quickly they developed a belief in their own ability to solve complex problems and to learn new mathematical methods in relation to their constructions in Minecraft. The interviews and self-assessments offered evidence of perceived creativity, an ability to cope with uncertainty and to collaborate. One explanation is related to the changed role of the teacher, who while remaining the expert on mathematics, did not have prior knowledge of Minecraft. This empowered the students and evened out the classroom power dynamics. Because the students played Minecraft in their spare time, they reported feeling comfortable enough to challenge themselves and increase the elements of uncertainty within the virtual world. The game thus helped them to develop their knowledge by motivating them to challenge themselves. As in the prior sessions, the teacher still decided on the assignments, she framed the lessons in the sense that she decided how the students' work in Minecraft would relate to tasks in the real world and traditional mathematics executed with pen and paper. That made Minecraft as used in school different from Minecraft used at home, but nevertheless the teacher was not the expert on Minecraft, and her mediator role was in many respects transferred to Minecraft, the students' own avatar, and to the other students.

Indeed, when faced with challenges or obstacles, the students did not ask the teacher for advice but asked each other. The game, and their peers, became mediators of their enhanced knowledge, and in comparison to the former sessions, the students became more open to discussing their own solutions and perceptions of the task and were also eager to show their classmates their own solutions. This collaboration between the students thus meant they pushed each other further and solved problems in an enterprising way. Adopting their own avatars also encouraged the students to try different solutions to solve a problem. Overall, the assessment showed that combining virtual and physical worlds strengthened the students' belief in their capabilities in a range of areas, and, moreover, the enhanced belief was transferable, for example, when design constructions in Minecraft were printed out and the students were required to calculate areas or volumes. The data shows a clear connection between the students heightened belief in their ability and having the courage to challenge themselves in relation to mathematical problem solving.

Although the virtual world worked to enhance the students learning outcomes, it was the combination of the different realities that really extended the students' understanding. For example, in one of the assignments the students were to build a swimming pool and later calculate the volume of the pool and how many people the pool could accommodate. The creative solutions applied to the design of the pool, with many featuring curves, made the subsequent pen and paper calculations of volume more complex for the students than if they had chosen to design a small rectangular pool. Answering the question about how many people the pool could accommodate was complicated by there being a range of options and mathematical formulae available to use. After the students had made a suggestion, they discussed each other's answers, and it was clear that the students' assessments varied considerably. To extend the mathematical reasoning further, they were given the opportunity to create a scale model of their pools in the classroom. The combination of creating something in the virtual world (which contributed to the student's motivation and effort), with later pen and paper or physical construction assignments related to their virtual constructions (which helped them to develop their mathematical problem-solving skills), and finally, testing the probability and accuracy in a real-world setting, worked to develop both their understanding of mathematics and nurture entrepreneurial attitudes and abilities, such as self-efficacy, creativity, and the ability to solve problems.

To summarise, bringing a computer game into the classroom and relating the students' own virtual world to the physical world outside school as well as the classroom context, not only served to motivate the students in school, as they also reported adopting more mathematical reasoning when playing the game at home, and thinking more realistically when constructing buildings and settings within the game. Overall, using the game in relation to the real world facilitated the students' development, learning, and motivation to keep learning. Moreover, the students reported that the virtual reality sessions made the importance and usefulness of entrepreneurial attitudes and abilities more apparent and meaningful to them.

V. Discussion

Educators have been encouraged to relate their education to the world outside school through authentic task and learning environments in order to prepare their students for a more uncertain and constantly changing environment. Authentic environments and real-world assignments in school have also been highlighted as a prerequisite to the development of students' entrepreneurial abilities and attitudes. The results of this study, however, indicate that combining physical and virtual worlds may advance the development of entrepreneurial attitudes and abilities in primary school education. Thus, doing things in a virtual world may be just as real as its physical equivalent.

To address the first research question and the issue of how various mediating tools in physical and virtual world contexts might contribute to making education more reality-based, the results of this study indicate that the use of virtual worlds may be a fruitful way of designing authentic learning tasks in relation to the world beyond school. A sociocultural perspective on learning suggests that learning occurs, is mediated, through others and that our perceptions of the world are a product of social interactions and that the learning outcome therefore depend on the mediator for such understandings and perceptions about the world (Säljö, 2013). Overall, the findings of this study suggest that the *other* in question does not necessarily have to be the teacher, and instead that computer games and the use of virtual worlds can play a mediating role in enhancing students' understanding and the learning they acquire from each other. The theory of the proximal development zone argues that culture and context is important to learning and development outcomes (Vygotsky, 1978, 1980, 1986; Vygotsky, Hanfmann, & Vakar, 2012). The result from this study adds to the understanding of ZPD by suggesting that the young people's actual experience, in which computer games are an important and common context for interaction, may have a crucial effect on how they are intrinsically motivated to extend their learning. In this study, the ZDP was most apparent when the students faced challenges and obstacles. When the students worked on authentic tasks related to the physical world outside school, they used the teacher as a mediator to assist in completing the tasks. When faced with obstacles, they found it difficult to understand and relate the mathematical assignments to a real-world context. Overall, the observations and reports produced indicated that the students struggled to transfer knowledge between the school context and contexts outside school, and did not see the point of doing so. In contrast, when exposed to a combination of the physical and virtual worlds, the students used the game, their peers and avatars as mediators for their development Their learning was reinforced as reflection and learning also took place in playground conversations at breaks and lunchtime or after school play. Indeed, the students' individual ZPD is formed by current societal norms, and the students' own understanding of the world becomes more apparent when projecting it into a virtual world. This is in line with prior research demonstrating that multiple representations of reality are beneficial to students' learning outcomes (Ainsworth, 1999; Cheng et al., 2015; Wu et al., 2013; Zacharia et al., 2012).

However, the results also confirm that any attempt to relate to a world outside school will be complex. It could, for example, be argued that the urge for a form of education more closely related to the world outside school would contribute to distancing school from the world outside school. The perception of education as something preparing students to enter the outside world in order to implement their knowledge, or that students should *go outside* school to bring new perspectives and perceptions *back in*, is noticeable when we think of learning as a social act. In that case, education is already part of the social world outside school. Education can thus never really provide a real-world context but only perceptions of what constitutes reality, authentic tasks, or representations of such understandings. The teacher working as the facilitator of learning and development through authentic, real-world assignments might mean that students become part of the teacher's perceptions of what constitutes reality and reality-based assignments, which may in reality be different from the students' perceptions. Indeed, for young students, virtual environments may actually be more real and authentic than the society surrounding them. The topic of combined physical and virtual worlds is interesting in that it contributes to the ability to apply knowledge in different realities and contexts, and in that the creation of avatars and environments served to deepen the students understanding of both their own perceptions of reality and what reality could be like.

The other research question asked how those various mediating tools contribute to the development of entrepreneurial attitudes and abilities among primary school students. In this study, the combination and sequential use of physical and interactive worlds worked to develop students' understanding of a complex world, but also empowered them with entrepreneurial attitudes and abilities to act and create within both worlds. The results therefore illustrate how entrepreneurship in education can be understood by, and be meaningful for, very young students. The use of virtual games and avatars can act as a mediator and help develop students' beliefs in their ability to create and make almost anything they want, but also their ability to deal with uncertainty and complexity. This not only led to an increased understanding of the task at hand but also provided a deeper understanding of what complexity, uncertainty and creativity are all about. This development was further enhanced through the interaction of several realities in which the students could create their own environments and representations of reality, and could also transfer knowledge between those environments. This ultimately nurtured their entrepreneurial attitudes and abilities, described as development of high self-efficacy, creativity and ability to cope with uncertainty (Commission, 1998, 2013b; OECD, 1989). Although introducing new technology into schools might automatically lead to enhanced motivation in comparison to using pen and paper, the results of the current experiment go further in showing that students could relate their visions to a real-world context, and then work to develop entrepreneurial attitudes and skills alongside the motivation to learn, and to understand and solve complex problems.

It should be noted that prior research has indicated that students are more engaged when using media they are familiar with, and when they feel a sense of ownership, in contrast to using media they perceive to be formal and academic (Deng & Tavares, 2013). The fact that the teacher did not have any prior experience of Minecraft allowed the students to be experts and thus made the educational approach more student-centred. Nevertheless, even if the technology itself contributed to the students' motivation to complete the task, the learning process also unfolded differently compared to the alternative teacher-led approach.

This study adds to the literature on entrepreneurial learning, which often highlights doing something in a real-word context as a prerequisite for students' entrepreneurial development in terms of their developing creativity, an ability to cope with uncertainty and to collaborate and develop an innovative approach to problem solving (Cope and Watts, 2000; Gibb, 1987; Kirby, 2007; Pittaway and Cope, 2007; Pittaway and Thorpe, 2012). The results of the current study contribute to this dialogue by showing that students can perceive a virtual world to be more real than the physical equivalent. Furthermore, letting students work in a virtual world can support the development of their entrepreneurial abilities and attitudes. Moreover, when students learn to relate their own perceptions and a virtual world to physical contexts, they can come to appreciate their ability to solve everyday problems. The literature also tends to highlight the role of the teacher's own entrepreneurial attitudes and mindset in students' entrepreneurial development (e.g, Jones & Iredale, 2010; Leffler & Svedberg, 2003, 2005). The result from this study shows that such understandings may need to be reconsidered. In this study, the teacher was not the mediator or facilitator that developed the students, instead it was the students' belief in their own abilities with Minecraft and their avatars that spurred development and change. Overall, the results suggest that a real-world context and the teacher's degree of entrepreneurialism should not necessarily be considered the main facilitator or mediator of entrepreneurial development.

Prior research on combining physical and virtual teaching and learning environments has indicated that children act and learn by relating different representations of reality and employing their prior knowledge of what a game represents in the real world (Cheng et al., 2015; Linderoth, 2004). How, when and to what extent physical and virtual environments should be combined is suggested to vary depending on the prior knowledge and learning needs of the students (Brinson, 2015). This study adds to this dialogue by showing that ICT-aided learning combining the virtual and physical world contexts is suited to enhancing the development of creativity and the ability to deal with complex situations, and to encourage devising multiple solutions to problems among very young students. Whereas the emphasis on the teacher's role may be overstated in literature on entrepreneurial learning in general, it might be understated in the literature on physical and virtual teaching and learning environments. Indeed, although the teacher may not be the direct mediator of enhanced development and learning, the framing of tasks allowing different realities to be related is crucial for learning and development to take place in the first place. Moreover, the current research makes an important contribution to the literature on the combining of physical and virtual worlds by revealing its relevance for entrepreneurship in the education of young people.

The results of the current research also have practical implications. First, they should encourage educators working on entrepreneurial learning to extend their use of virtual environments and both the sequential and simultaneous bridging of multiple realities. The strong focus on real-world contexts and learning by doing in a real-world setting can be a challenge for teachers struggling to find time to take learning outside the classroom. Using multiple representations of reality to advance learning makes it possible to develop students' entrepreneurial attitudes and abilities within a classroom setting and within the timeframe of a lesson. Second, the results from this study also suggest that the teacher's role is indeed important for framing the assignments and in daring to let students learn through other mediating tools as well, but that the development of students' entrepreneurial abilities and attitudes is a far more complex process than a teacher merely conveying his or her entrepreneurial attitudes and abilities or perceptions of the world to the students. Indeed, technology can also be key to making students responsible for developing their own learning and, moreover, make them keen to do so. Third, supra-national policy directives have stressed the importance of integrating entrepreneurship in education throughout the school system. There is, however, no consensus on what this means in practice, and especially for very young children. This study adds to the understanding of how the development of entrepreneurial abilities may be realised in a primary school setting. Educators who already use virtual worlds in their teaching may be able to accelerate their students' development by bringing the entrepreneurial learning elements to the fore.

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AUTHOR'S PROFILE

Ida Lindh (ida.lindh@ltu.se) is from Entrepreneurship and Innovation at Luleå University of Technology, Sweden. Her research interest is entrepreneurial learning processes, and how such learning interplay with affect and cognitions. She has published in Management Learning and Entrepreneurship & Regional Development.