Strategies for increasing the interactivity of children's synchronous learning in virtual environments

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Abstract

Enabling distant individuals to assemble in one virtual environment, synchronous distance learning appeals to researchers and practitioners alike because of its unique educational opportunities. One of the vital components of successful synchronous distance learning is interactivity. In virtual environments, interactivity is limited by the capacity of a technological medium to transmit verbal and non-verbal signals between individuals in the class. In order to increase the interactivity of learning, teachers need strategies to enable them to overcome the medium's restrictions and reveal its interactive capabilities.

This study explores which of the strategies used by teachers in arranging children's synchronous learning in virtual environments may positively affect learning interactivity, and under what conditions those strategies are best utilised. Adhering to a qualitative approach, the study has reflected on the instructional experiences of 48 teachers, from which 154 interaction-enhancing strategies have been identified. While most strategies were found to be universal in various types of environments, others proved effective only under specific learning conditions. Field experiment was conducted to examine the applicability of these strategies across cases with similar learning conditions. Some of the strategies were found to have effects on both synchronous and asynchronous components of learning. Often, these effects appeared to be implicit or deferred. Based on the data gathered, the study suggests a conceptual model of interaction in learning environments.

The findings of the study have both theoretical and practical significance: they contribute to existing scientific knowledge on synchronous distance learning and also provide teachers with applicable methodological recommendations.

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Table of contents

1. Introduction

Appealing to educators and researchers alike because of its capability of delivering education at anytime and anywhere, distance learning has taken on a variety of forms throughout its history. The most recent revolutionary change in distance learning was dictated by the proliferation of computer networks. This shift to online distance learning has produced a new, *virtual* form of learning environment as an alternative to the traditional classroom. In turn, on-going advancements in network and computer technologies have enabled the development and popularisation of a synchronous form of distance learning leading to a blurring of the boundary between traditional and virtual classrooms.

Synchronous online learning provides unique educational opportunities in both formal and informal contexts. Alongside asynchronous distance learning, it makes education potentially accessible to a wider range of individuals regardless of their location (Mountain, 2009). Promoting collaboration and cultural exchange (Kontos and Mizell, 2005), synchronous distance learning allows multiple individuals, groups, and institutions to meet and interact in one virtual environment (Ligorio and van Veen, 2006). This particular facet of distance education enables learning from primary sources and experts, without the need for students to leave their learning site (Merrick, 2005; Townes-Young and Ewing, 2005). The breadth of application makes synchronous distance learning valuable, whether it is used on its own or combined with face-to-face or asynchronous approaches.

With regards to educational outcomes, synchronous learning in virtual environments is considered at least as effective as learning in a traditional classroom (Mountain, 2009). In comparison to asynchronous distance learning, it has a greater beneficial effect on student satisfaction (Cao, Griffin and Bai, 2009), affect (Rao, 2007), and behaviour (Stuber-McEven et al., 2009). It also allows for interplay between learners and instructors to be more socio-emotional, immediate, and meaningful (Martin, Parker and Deale, 2012). When utilised as part of comprehensive online courses, synchronous distance learning serves as an effective facilitating and humanising component (Sawyer, 1997).

Despite the multiplicity of benefits that promote the interest of researchers and practitioners in synchronous learning in virtual environments, this educational approach has a range of limitations. In particular, being technologically mediated, synchronous distance learning is highly reliant on the accessibility and quality of the technology (Graziadei et al., 1997) used by each participant in the virtual environment. Not only does the stability of the technology influence the quality of learning, so too does its specific features and their appropriate use (Carlson, 2011). Technology may be viewed as both a proxy and a barrier to effective synchronous interplay between members of virtual learning environments. At the same time, although technological restraints make arranging effective computer-mediated learning one of the biggest challenges in the virtual environment (Lu, 2011), the quality of synchronous distance learning remains greatly dependent on the instructional approach and strategies chosen by the instructors.

The key guiding strategy to consider in order to achieve successful synchronous learning in a virtual environment is the maximisation of its interactive characteristics (Chou, 2002, Muirhead and Juwah, 2004, Kobb, 2010). Interactivity of learning describes the interplay between learners, instructors, and content (Moore, 1989). Increasing the interactive qualities of synchronous distance learning has been found to have a positive relationship with student performance (Wei, 2012). A high level of interactivity also decreases the transactional distance and enhances social presence, thus narrowing the gap between virtual and real learning.

As long as, in virtual environments, technology is a proxy for interactive messages, the level of learning interactivity is highly dependent on the medium's capabilities of transmitting both verbal and non-verbal signals between the participants (Daft and Lengel, 1986, Cobb, 2009, Yanika-Agbaw, 2010). However, it is not only technology that influences interactivity in virtual learning environments (Gunawardena, 1995). Rather, interactivity is defined by a multifaceted interplay between technological, instructional, and social variables (Roblyer and Wiencke, 2003). Therefore, high interactivity levels in distance learning can only be achieved provided the communication medium is used efficiently. Not surprisingly, the most effective strategies in virtual environments can significantly differ from those acceptable in the traditional classroom (Gillies, 2008). Following from this, in order for remote students to have a positive learning experience, it is vital that instructors' pedagogical and technical skills are tailored for synchronous distance learning (Lonie and Andrews, 2009).

Existing research, however, fails to provide any extensive information on strategies that are effective in increasing the interactivity of synchronous distance learning. While some studies disclose specific conditions for high interactivity, the information is either sketchy or contextually narrow. Noticeably, existing research focuses mainly on higher education, and it is doubtful that these interactive strategies are suitable for children's education. Studies on ways of increasing the interactivity of children's synchronous distance learning remain relatively scarce. This forces the teachers involved with children's distant learning to adhere to a method of trial and error and to rely on personal experience when arranging synchronous distance learning sessions. Hence, research is needed to find a variety of strategies that could contribute to interactivity in children's synchronous distance learning, and to examine the relationships of these strategies with different learning contexts.

This study aims to determine which of the strategies used by teachers in arranging children's synchronous learning in virtual environments have positive effects on learning interactivity and under what conditions. To accomplish this goal, the research qualitatively examined a multiplicity of teachers' experiences gained across various learning contexts. The findings of the study have both theoretical and applied significance: they simultaneously extend existing scientific knowledge on synchronous distance learning and provide teachers with applicable methodological advice.

The following chapters of this paper provide a comprehensive review of the literature relevant to this study, explain and justify methodological decisions that the study is built on, present and describe collected data, and discuss the research findings with relation to existing body of scientific knowledge.

2. Literature review

In order to situate this study within the existing body of research surrounding the notion of synchronous learning in virtual environments and the context of children's education, a comprehensive literature review was undertaken. This review provides a terminological basis for the research, justifies the enquiry's focus, reveals key themes and gaps in relevant scholarly literature, and establishes a theoretical rationale for the study.

2.1. The place of virtual learning environments in distance education

2.1.1. Distance and online learning

Distance learning is an educational process occurring beyond traditional classroom settings (Sawyer, 1997) with the instructor and student being located in different physical places (Parsad and Lewis, 2008; Rich 2011). As an alternative to face-to-face learning, the distance form of instruction appeared as early as the eighteenth century, when lessons by mail were first introduced (Holmberg, 2005). However, it was not until the 1920s that distance learning came to the masses. This period is associated with the rapid spread of educational radio and television (Cassidy, 1998) and is identified by Blackmun et al. (2001) as the first generation of distance education.

The initial forms of distance learning were asynchronous and one-way in nature (Lever-Duffy and McDonald, 2007), so students were unable to interact directly with their teacher (Rich, 2011). Real-time feedback became available with the introduction of teleconferencing, which is associated with the second generation of distance learning (Blackmun et al., 2001). Following this, computer-mediated communication, enabled by networked computers, gave rise to the third generation of distance education (ibid.). Computer networks have since brought to the fore a new aspect of distance education called *online learning* (Rich, 2011). In turn, the internet as a form of computer networks that facilitates rich learning interactions (Sugar and

Bonk, 1995; Kerka, 1996) and allows instructors to replace the simple knowledge transfer model of teaching with advanced constructivist approaches has enriched *online learning* and has gradually become the dominant technology in distance education (Rich, 2011).

2.1.2. Virtual learning environments

Given that teachers and students lack a physical connection in distance education, their interaction usually occurs solely in a virtual context. In general, for something to be 'virtual', its physical components are simulated and social events are modelled in non-physical form, primarily through computer technology (The Oxford English Dictionary, 2010). However, in practice, the boundary between virtual and physical is often vague in distance education. Dillenbourg (2000) perceives 'virtuality' as more of a "philosophical issue, more complex …[than] the simple difference between computerised and non-computerised elements" (11). He infers that the physical and virtual often co-exist and that there is no need to separate them artificially: an example would be students learning in front of a single screen, each using their own inputting device, which would allow for all the communication to occur in a physical space while their actions would be performed in the virtual world.

The use of computerised elements alone does not constitute a virtual learning environment unless individuals interact over learning content (Oliver, 1996; Dillenbourg, 2000). Some authors (Dillenbourg, 2000; Ligorio and van Veen, 2006) emphasise the role of interactions in distance education and regard virtual learning environments as exclusively social spaces that are 'populated' and reliant on communication. However, it is also argued that individuals can interact not only with each other but also with content or a mediating interface (McBrian, Jones and Cheng, 2009). Therefore, although interactions are seemingly inevitable in virtual learning environments, they are often deferred and established implicitly (Henri, 1992) through saving and transferring learning content, which enables virtual environments to allow not only group but also individual forms of learning. With this in mind, *virtual learning environments* can be defined as "computer-based learning environments…allowing interactions with other participants, resources, and representations" (Wilson, 1996: 8).

Both *asynchronous* and *synchronous* methods of instruction can be utilised in virtual learning environments (Lu, 2011; Martin, Parker and Deale, 2012). While asynchronous instruction

does not require teachers and learners to be present in the virtual environment at the same time, synchronous instruction is characterised by richer real-time interactions (Rich, 2011). Virtual learning environments that utilise synchronous instruction are capable of emulating multiple features of the traditional classroom in the *virtual classroom*'s settings.

Based on critical analysis of relevant literature (Appendix A), it is summarised in this paper that the virtual classroom is a type of virtual learning environment where the nature, potential efficiency and effectiveness of synchronous interactions closely approaches those inherent in face-to-face settings. Consequently, it is suggested that virtual classrooms take an intermediate position between face-to-face and distance environments, allowing for '*face-to-face'* distance learning.

2.2. Key themes in research on synchronous learning in virtual learning environments

2.2.1. Reasons for implementation: pragmatic benefits

The potential benefits of synchronous distance learning are widely discussed in the literature. In general, the reasons for the implementation of real-time distance instruction may be pragmatic and educational (Clark and Kwinn, 2007).

First, pragmatic benefits, drawn from multiple studies, mostly emphasise the unique practical opportunities provided by synchronous distance learning compared to face-to-face instruction. Thus, there is a great body of research underlining the capability of synchronous distance learning in providing a variety of disadvantaged students with equal educational opportunities and access to vital courses, which otherwise could not be delivered (Falck et al., 1997; Mulrine, 2003; Andreson and Rourke, 2005; Rao, 2007; Mountain, 2009; Adewale, Ibam and Alese, 2012). To achieve this, not only can instruction be delivered to individual students, but also anytime and anywhere a connection can be established between distant classes and institutions (Ligorio and van Veen, 2006; Mountain, 2009). For example, Falck et al. (1997) have studied the project that linked the classrooms of two Finnish schools through videoconferencing, one being located in a geographically isolated village. With the aim of

providing secondary education to students in the rural area, 502 lessons were delivered by one teacher to two groups of children over three years. As Falck et al. summarise, "despite technical and instructional problems virtual classroom has worked" (222). Ultimately, the children in the rural school received secondary education and achieved academic results as good as those obtained by the children in the other school. Similarly, the availability of synchronous learning ensures that the potential for virtual environments to enhance collaboration and cultural exchange between students and educational institutions is met, regardless of location (Sembor, 1997; Kontos and Mizell, 2005). In particular, this can be achieved through linking remote learning sites as noted above (Ligorio and Van Veen, 2006), or directly connecting students online (Patterson, Carrillo and Salinas, 2012).

In addition, given the fact that access to real-time interaction can supplement instruction by learning from primary sources (Merrick, 2005), synchronous distance learning can be used to replace physical field trips to good effect (Pachnowski, 2002; Patterson, Carrillo and Salinas, 2012). It can also provide students with direct connection to experts, without leaving the learning site (Townes-Young and Ewing, 2005). This promotes context-rich instruction by enabling access to alternate forms and sources of knowledge that can facilitate learning (Richey, 1996; Merrick, 2005; Mountain, 2009).

A range of organisational outcomes are also inherent in synchronous distance learning. This method reduces both the financial and time-based expenses associated with designing, delivering and accessing synchronous instruction. For instance, as demonstrated by Rao's study (2007), distance courses provided for learners from different Pacific island communities gave them the opportunity to continue higher education without leaving the islands or taking time off work. Along with these benefits, the opportunity to record synchronously delivered lessons allows them to be reused in an asynchronous format (Clark and Kwinn, 2007), specifically for the purpose of reaching students who are unable attend the session (Carlson, 2011).

As this section has shown, it is clear that many of the benefits inherent in synchronous distance learning can also be provided by asynchronous forms of instruction. Nonetheless, the availability of real-time interactions can enrich distance learning and teaching, and provide unique educational opportunities to students.

2.2.2. Reasons for implementation: educational effects

It can be argued that virtual learning is similar to the traditional form of learning, in that they share the same theoretical principles (Ally, 2007) and are comprised of the same foundational educational elements (Rich, 2011). An effective virtual learning environment allows for various learning strategies based on different learning theories to be utilised (Ally, 2007). As with face-to-face learning, no single strategy in virtual learning can be considered better than others, unless specific learning goals are taken into consideration (Rich, 2011). Online learning theory supports the notion of theoretical flexibility and suggests that all three key educational theories – behaviourist, cognitivist and constructivist – can be implemented in virtual learning environments (Ally, 2007).

At the same time, synchronous instruction's distinctive capability to promote effective collaborative learning within diverse contexts is often emphasised. This highlights the openness of virtual classrooms to social constructivist educational approaches. Using technology as the primary means of synchronous communication, students in virtual learning environments are encouraged to share and construct common knowledge under multiple viewpoints (Ligorio and Van Veen, 2006; Stahl, Koschmann and Suthers, 2006). Learning in such settings often occurs within students' zone of proximal development[1] and is thus facilitated through problem solving under the instructor's guidance "or in collaboration with more capable peers" (Vygotsky, 1978: 86). The distribution of cognition among a diverse set of participants allows for communities of learners to be established (Salomon, 1998). In comparison to asynchronous forms of virtual learning, interactions in synchronous communication can be more socio-emotional, immediate, and meaningful (Martin, Parker and Deale, 2012).

Findings regarding the overall cognitive effects of distance forms of learning appear to be consistent, particularly with respect to synchronous instruction. Thus, distance education is considered to be at least as effective as face-to-face instruction (Greenway and Vanourel, 2006; Yenika-Agbaw, 2010), which is in line with research on the synchronous form of distance learning (Mountain, 2009). As synchronous distance learning is accompanied by the range of

[1] The zone of proximal development "is the distance between the actual developmental level as determined by independent 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: 33)

pragmatic outcomes discussed above, the effect of 'no significant difference' may contribute to the consistent level of interest that the topic receives.

Real-time interaction in virtual environments has a positive impact on student satisfaction (Cao, Griffin and Bai, 2009). Though certain forms of distance learning have been characterised by students as "tedious, slow or boring" (Falck et al., 1997: 222), a substantial body of research has found that the use of technology such as videoconferencing in distance learning positively influences student affect (Freeman, 1998; Gerstein, 2000; Comber et al., 2004; Rao, 2007) and behaviour (Stuber-McEven et al., 2009).

2.2.3. Contextual richness

As a distance form of education, synchronous learning can be delivered regardless of instructors or students' dispositions and across a variety of contexts. Thus, virtual classrooms can be established across school, local, regional and state settings (Falck et al., 1997), as well as worldwide, allowing for global competency to be promoted (Kontos and Mizell, 2005; Patterson, Carrillo and Salinas, 2012). In addition to being used solely as a form of instruction, synchronous learning can be enhanced by asynchronous elements (Vess, 2004) or serve as a facilitating or humanising component for comprehensive online courses (Sawyer 1997; Martin, Parker and Deale, 2012). It is notable that both forms of distance learning can be complemented with face-to-face instruction enabling hybrid, or blended, instruction (Aydin and Yuzer, 2006; Yenika-Agbaw, 2010).

The synchronous form of distance instruction can be useful in both informal and formal settings, offering unique opportunities to educational institutions (Pachnowski, 2002; Mountain, 2009). Although "the thought of gaining 'formal' education in a virtual classroom…[may sound] not only radical but also unfathomable" (Yenika-Agbaw, 2010: 112), positive student outcomes are widely indicated by relevant studies. As a result, universities, colleges and even schools have been found to modify their curriculum in order to incorporate distance learning (Ramaswami, 2009). Finally, the role of distance or blended formal education comes to the fore specifically in virtual schools – state approved or locally accredited institutions offering credit courses using distance learning (Clark, 2001).

Real-time distance instruction can be beneficial regardless of the age of students (Mountain, 2009). However, while a substantial body of research discusses the practices of synchronous learning in virtual environments with relation to professional and higher education (e.g. Graziadei et al., 1997; Powers and Mitchell, 1997; Wang, 1999; Ashkeboussi, 2001; Aydin and Yuzer, 2006; Rao, 2007; Beem, 2010; Lavolette et al., 2010; Parker, Grace and Martin, 2010; Carlson, 2011; Kupczynski, Mundy and Maxwell, 2012; Martin, Parker and Deale, 2012), little research spans multiple age groups (e.g. Mountain, 2009) or focuses specifically on children's education (e.g. Falck et al., 1997; Morris, 2005; Mulrine, 2007; Cavanagh, 2009).

2.2.4. Challenges for implementation

Since technology mediates real-time communication in distance education (Falck et al., 1997), it is vital that the technological components are stable when arranging learning in virtual environments. Accessibility and the quality of technology are the primary conditions that determine the extent to which it can be incorporated into educational processes (Graziadei et al., 1997). As might be expected, technology-related challenges are widely discussed in research, particularly in early studies and those conducted in rural areas or developing countries. For instance, Patterson, Carrillo and Salinas (2012) initially intended to utilise live video and audio feeds to enable discussions between students across countries. However, due to bandwidth limitations in some areas, this approach was found to be ineffective, which resulted in time loss. This consequently forced the researchers to identify alternative ways of establishing synchronous interaction.

Even when technology is stabilised, certain issues related to the specificity of the tools used in synchronous learning can still arise. For example, when discussing real-time instruction in a distance course that was delivered through videoconferencing software, Carlson (2011) indicated that when the students could simultaneously use their own microphones to talk to the instructor, they frequently talked over one another. At the same time, as Carlson infers, enabling and disabling the microphones when necessary was found to be very time consuming. Similar problems to this have also been encountered in other studies. Falck et al. (1997), for instance, observed a slow flow of events in children's communication mediated by technology.

Synchronous learning is commonly conceived of as being more interactive than asynchronous learning. Nevertheless, the distance between a learner and a physical classroom can still be hard to transcend in synchronous formats (Falck et al., 1997). Effective communication tends to depend on the capacity of a medium to transmit non-verbal signals, such as emotions and body language (Yenika-Agbaw, 2010). The technological restraints addressed earlier make building effective computer-mediated communication one of the biggest challenges in virtual learning environments (Walther, Anderson and Park, 1994; Morris, 2005; Lu, 2011).

Researchers have paid much attention to the importance of common digital literacy and to how prepared individual instructors are to deliver synchronous distance learning in virtual environments. Initial barriers can be significant, especially when instructors have "never imagined any other way of teaching besides face-to-face instruction" (Yenika-Agbaw, 2010: 112). Following from this, teachers require support and training to deliver effective lessons in a synchronous format (Mountain, 2009). Arguably, the same is true with regard to students, particularly children, although this issue has not been directly researched.

Synchronous distance teaching requires strategies and methods that are often different from those deemed acceptable in the traditional classroom (Hooper and Rieber, 1995; Conte, 1998; Byrom and Bingham, 2001; Goddard, 2002; Gillies, 2008). However, existing research on the subject does not give a comprehensive answer as to what these strategies should be. Instead, the majority of studies focus more on the general effects of synchronous distance learning (e.g. Roblyer et al., 2007; McBrien, Jones and Cheng, 2009; Parker and Martin, 2010). In turn, literature concerning strategies for distance instruction is either bound to a narrow context (e.g. Burns, Burniske and Dimock, 1999; Rao, 2007), or merely provides general recommendations (e.g. Mulrine, 2007; Mountain, 2009; Lavolette et al., 2010). The universality and applicability of these strategies remains doubtable. Therefore, online instructors, especially those dealing in children's education, are often left to rely on their own experience, which is developed through trial and error. According to Lonie and Andrews (2009), a lack of technical and pedagogical preparedness for teaching in the virtual classroom decreases the effectiveness of the learning experience for remote students.

Some other factors challenging synchronous distance learning that are not addressed directly in the literature are also identifiable. Firstly, distance learning tends to unite groups of students and

teachers who are unfamiliar with one another (e.g. Falck et al., 1997), which in synchronously delivered sessions can become a barrier to effective communication, especially in children's education. Indeed, as Falck et al. infer, familiarity between pupils may enhance the quality of a virtual classroom. Secondly, communication generated through video or audio channels at a distance raises ethical concerns. Even though the potential for a video session to be recorded is considered to be one of its more positive aspects (Clark and Kwinn, 2007), the fact that each participant in the virtual classroom is able to make recordings without others' knowledge calls in to question learners' and instructors' privacy. Finally, as extra time in front of the computer is required in the virtual classroom, specific health issues may arise that are not problematic for its face-to-face equivalent (Powers and Mitchell, 1997; National Heart, Lung, and Blood Institute, 2013).

2.3. The role of interaction

2.3.1. Definitions and characteristics of interactions

The notion of interaction underlies the key themes in research on synchronous instruction in virtual learning environments. However, despite being addressed by a substantial amount of research (Moore, 1983; Moore, 1993; Mahesh and Mclsaac, 1999; Powers, Davis and Torrence, 1999; Krieger, 2002; Gorsky and Caspi, 2005; Morris, 2005; Martin, Parker and Deale, 2012), the concept of interaction in distance learning is characterised by the absence of an unambiguous consensus on what it actually represents or involves.

Based on discussions at the centre of relatively early research (Boyd and Apps, 1980; Herring, 1987; Jonassen, 1988; Wagner, 1994), *interaction* can be defined as a process involving at least two interconnected events that occur in relation to two or more objects. Wagner (1994) distinguishes interaction from interactivity, suggesting that "interaction functions as an attribute of effective instruction while interactivity functions as an attribute of instructional delivery systems" (6). In other words, while interaction addresses processes that occur between objects in an environment, interactivity describes the environment in terms of the presence and nature of interactive events that may occur in it.

Depending on the objects involved, Moore (1989) identified three major types of interactions inherent in learning environments: learner-instructor, learner-learner, and learner-content. In addition to these three major types, Hillman, Willis and Gunawardena (1994) suggested a fourth dimension, termed learner-interface interactions, that they defined as "a process of manipulating tools to accomplish a task" (34). However, while Moore's classification has become dominant in subsequent research, there is inconsistency in the use of the fourth dimension.

In contrast to classifications of interactions based on Moore's approach, alternatives can also be found in the literature. Researchers also categorise interactions based on different groups of factors, such as explicitness, mediating technologies, or types of activities and events. Overall, an analysis of the literature addressing interaction directly or within certain theoretical frameworks (including *transactional distance* and *social presence*) revealed 65 terms indicative of interactions, which were systematised within 9 categories (Appendix B).

2.3.2. The significance of interactions

Interactivity is a key component of successful learning in virtual learning environments (Chou, 2002; Muirhead and Juwah, 2004). Research has identified (Kirschner et al., 2004; Yoon and Johnson, 2008) and verified (Wei, 2012) that student performance relies on learning interaction. It has also been found that as long as interactivity is at a high level, it supports deep and meaningful learning (Anderson, 2003).

Interactivity enables students to become active participants in learning and it thus enriches their social experience (Townes-Young and Ewing, 2005). Rich interactions enhance "socio-emotional and social processes related to group formation and group dynamics affecting affiliation, impression formation, developing affective relationships, and building social cohesiveness and community" (Kreijns et al., 2011: 1). In turn, as high interactivity promotes the presence of social actors, it "can enrich**…**children's learning experience and increase their motivation" (Tung and Deng, 2006: 251). Accordingly, when students are not actively engaged in the learning process, they tend to lose interest and become distracted (Fulford and Zhang, 1993).

Hence, in can be concluded that rich interaction has a positive influence on student academic achievements, satisfaction and motivation, as well as promoting collaborative learning and facilitating socio-emotional processes.

2.3.3. Interaction within theoretical frameworks

Physical separation between teacher and student can lead to "a psychological space of potential misunderstandings between the behaviours of instructors and those of the learners" (Moore and Kearsley, 1996: 200). This space determines *transactional distance*, which negatively influences the effectiveness of learning (Moore, 1993). According to Moore, to decrease students' and teacher's perceptions of transactional distance, it is important to optimise dialogue (the extent of communication constructiveness), structure (course organisation and its impact on student engagement), and learner autonomy (level of self-directed learning).

Transactional distance is a psychological rather than geographical concept, and it exists both in virtual and face-to-face environments (Moore, 1993). Therefore, it can be used to compare the communicative qualities of different educational settings. Transactional distance is generally perceived as a useful framework for understanding the processes involved in distance learning (Garrison, 2000; Jung, 2001). However, based on a review of six studies that tested Moore's framework, Gorsky and Caspi (2005) defined Moore's theory as tautological and reducible to a single variable of dialogue. As long as Moore (1993) considers dialogue to be a synonym for purposeful and constructive interactions, it can be inferred that interactivity in a learning environment determines the level of transactional distance.

Apart from transactional distance, the concept of *social presence* has also been found to directly relate to interaction. Short, Williams and Christie (1976) initially identified social presence as the "degree of salience of the other person in a mediated communication and the consequent salience of their interpersonal interactions" (65). However, as research continues to redefine social presence (Picciano, 2002) by considering it under different theoretical perspectives, a clear and unambiguous definition of the concept is yet to be achieved. At the same time, across various studies, social presence is broadly conceived of as a psychological term addressing individuals' perceptions of how they feel about interacting with others (Kim, 2011).

Despite disagreements in definitions, researchers have similar conclusions about the nature and effects of social presence in virtual environments. Studies have indicated the positive influence that social presence has on perceived learning outcomes (e.g. Gunawardena, 1995; Russo and Benson, 2005; Weinel et al., 2011). Social presence has also been found to enhance students' engagement with learning (Cobb, 2009) and satisfaction (Gunawardena, 1995; Gunawardena and Zittle, 1997; Richardson and Swan, 2003). Moreover, being a facilitator of collaboration (Cunawardena and Zittle, 1997; Ko, 2012), social presence is considered a vehicle for social learning (Tu, 2000).

Of special interest for this study is the relationship between social presence and interaction. Though this relationship is emphasised across research, its direction appears equivocal. For instance, Wei (2012) suggests that social presence enhances learning interactions in virtual environments. Contrary to this, other studies (e.g. Short, Williams and Christie, 1976; Tu and McIsaac, 2002; Levy and Stockwell, 2006; So and Brush, 2008) imply that interaction is a factor in, or indicator of, social presence. These points of view suggest that a high level of interactivity facilitates students' perceptions of social presence, which in turn increases the extent of their interactions.

2.3.4. Conditions for high interactivity

The dominant descriptive feature of interactive environments is the capacity to transmit both verbal and non-verbal signals between participants (Daft and Lengel, 1986; Cobb, 2009; Yanika-Agbaw, 2010), which enables rich communication (Short, Williams and Christie, 1976; Daft and Lengel, 1986). At the same time, according to Gunawardena (1995), even advanced synchronous forms of distance learning create interaction patterns that tend to be different from those occurring in face-to-face environments. Therefore, it can be argued that interactivity in the virtual classroom does not solely depend on the medium (Gunawardena, 1995); rather it is a complex function of learning and instruction (Wagner, 1994), defined by "a complex interplay of social, instructional, and technological variables" (Roblyer and Wiencke, 2003: 85).

Importantly, interactivity in an environment depends on the quality of interactions while having little connection with their quantity or frequency (Tu and Mclsaac, 2002; Lowenthal, 2010). According to Zhang and Fulford (1994), quality and usefulness, rather than number and

length of messages between participants, primarily determine the level of interactivity in virtual environments. Instructors can either enhance or decrease interactivity depending on how efficiently they manage communication processes (Roblyer and Wiencke, 2004) and whether they choose appropriate teaching techniques (Gunawardena, 1995). Therefore, high interactivity in virtual environments can only be achieved providing the communication medium is efficiently used.

In order to utilise asynchronous learning tools, "instructors need to move away from the popular lecture approach" (Mountain, 2009: 40); this means that they require training in methods and strategies that are relevant to the virtual classroom (Gillies, 2008). A range of studies have attempted to determine specific methods to enhance interaction (for instance, Norton, 2001; Palloff and Pratt, 2007; Martin, Parker and Deale, 2012). Nevertheless, it is arguable that their inferences remain impractical due to being either too broad or too context-bound.

2.4. Summary of the literature review

This literature review has revealed multiple pragmatic and educational reasons for implementing synchronous distance learning across a variety of learning and social contexts, indicating the importance of virtual environments with real time interaction in education. Nevertheless, synchronous distance learning is accompanied by a range of challenging factors, most of which impose limitations on establishing an effective social interplay between individuals in virtual learning environments. The interactivity was found to be the fundamental condition for increasing the educational potential of learning environments, facilitating learning process, and, consequently, increasing student motivation, satisfaction, and attainment.

While technology in virtual learning environments provides opportunities for arranging interaction, the instructor still plays a dominant role in establishing a sufficient level of interactivity. However, the existing body of relevant studies fails to provide instructors with thorough guidelines as to how to implement effective strategies in synchronous distance learning. While some research indicates specific principles of good practice, these were

found to be either vague or contextually narrow and, hence, hard to apply. Furthermore, the relevant literature focuses predominantly on higher education, making the appropriateness of most strategies for children's education questionable.

Resultantly, research which reveals interactivity-enhancing strategies for children's synchronous distance learning and examines the relationships between these strategies and specific contexts is warranted.

3. Methodology

3.1. Research aims and questions

Based on the knowledge obtained through the literature search and the gaps that this revealed in the literature, it was decided that this research project should aim to explore which strategies used by teachers in arranging children's synchronous learning in virtual environments are capable of enhancing interactivity and under what conditions. The study incorporated both theoretical and applied objectives: to extend the theoretical base for further research on synchronous distance learning, and to provide teachers involved in this form of learning with general guidance applicable to their professional practice.

In accordance with the study's key objectives, two questions drove the research:

1. Regarding synchronous learning in virtual environments, which strategies employed by teachers can best facilitate interactivity?

2. In what ways do specific learning conditions determine the effectiveness of interactivity-enhancing strategies for synchronous learning in virtual environments?

3.2. Research strategy and design

To answer the research questions, the study first reflected on a diverse array of individual teachers' experiences and then considered the multiplicity of strategies they utilised in synchronous distance learning. The project also explored a variety of conditions under which certain strategies have been found to be effective. Furthermore, emergent themes and conditions were correlated and systematised. Ultimately, the research findings were selectively examined based on their validity, transferability, and applicability.

Following this, two stages went on to mould the research project (Table 1). The *first stage*, which aimed to develop theoretical propositions from data and understand the relationships between facts, adhered to an inductive strategy which Blaikie (2000) defines as particularly

valuable in pursuing exploratory objectives and answering 'what' questions. According to Blaikie, inductive research starts with data accumulation and leads to "making generalisations about the patterns or regularities that exist in the data obtained" (103). To make theoretical generalisations in this study, it was necessary to accumulate data from multiple teachers' experiences, reveal any common strategies they used, and to correlate these strategies with the variety of conditions under which they had proven effective. In light of this, a cross-sectional, or social survey design was employed, which established a focus on the analysis of a variety of cases and the relationships between them (Blaikie, 2000; Bryman, 2008).

Table 1 – Stages of the research project

Stage	**Aim**	**Design**	**Strategy / Data**	**Sampling**	**Data collection**
1	Theory generation	Cross-sectional (social survey)	Inductive / Qualitative	Maximum variation, multiple cases	Questionnaire
2	Theory verification	Quasi-experimental	Deductive / Qualitative	Maximum variation, one case	Questionnaire, observation, interviews

According to Breakwell (2000), in the early inductive phase of research, cross-sectional designs benefit from qualitative data treatment. In this study, gathering qualitative data from multiple teachers was vital for disclosing as many strategies as possible without limiting the respondents with pre-specified categories (Patton, 2004). Furthermore, this approach allowed rich descriptive information to be obtained about unique contexts where specific strategies had been spotted. In order to gather rich qualitative data, a self-completion questionnaire was chosen as the primary instrument for data collection. This approach was adopted for a number of reasons. First, it allowed data obtained from different participants' perspectives to be aggregated (Patton, 2004; Bryman, 2008), which consequently informed the study about the distribution of characteristics and allowed for varieties between them to be determined (Marshall and Rossman, 2006). Secondly, by collecting personal, factual data based on a pre-determined set of options, the questionnaire established initial, broad categories for comparing the respondents' experiences. Finally, this approach was beneficial as it reached a sufficiently large number of participants, thus enhancing ultimate generalisations, for it is known that the

"plausibility of any general law is proportional to the number of instances of it that have been observed" (Harre, 1972: 42, in Blaikie, 2000: 103).

The questionnaire was designed to employ both closed and open-ended questions in order to increase the amount of collected data. This, however, raised the issue of a reasonable sample's size and composition, which is common in research directed towards theory development (Blaikie, 2000). Since the study was focused on individuals' experiences as bounded cases, it was important to justifiably maximise the number of participants with experiences acquired in unique contexts. At the same time, in order to avoid unmanageable data redundancy (Lincoln and Guba, 1985), the number of cases had to be limited "based on expected reasonable coverage of the phenomenon given the purpose of the study" (Patton, 2004: 246). With this in mind, a purposive sampling strategy was chosen to determine a minimum set of cases that could comprehensively illustrate the studied process of synchronous distance learning (Denzin and Lincoln 2000; Silverman, 2005). In particular, the maximum variation logic of purposive sampling was followed, as this approach reveals "central themes which cut across a great deal of variation" (Ritchie and Lewis, 2003: 79). Necessary variation was achieved through identifying a set of key factors from the literature review and determining a variety of settings where synchronous distance learning typically occurs (Patton, 2004). These factors were then utilised to distinguish and select unique cases that met the inclusion criteria.

The first, inductive stage of the study was designed to produce theoretical propositions able to "provide clear enough categories and hypotheses so that crucial ones can be verified" (Glaser and Strauss, 1967: 3). Taking into account that knowledge obtained via inductive strategies is considered subject to further examination (Blaikie, 2000), the *second stage* of this study adopted a deductive logical approach in order to examine the theoretical propositions that were produced (Kelle, 1995). According to Blaikie (2000), a deductive study begins with the proposal and testing of hypotheses, which are then matched with the data collected through observations or experiments. With this in mind, it was first hypothesised that the strategies revealed by the above approach could increase interactivity in virtual learning environments, provided they were applied within similar contexts to those where they had initially been found effective. To test this proposition, it was necessary to examine the strategies with in-depth qualitative analysis of each case in which a strategy had been identified. In light of this, a crucial-case study appeared to be the most appropriate design, as it is capable of challenging

hypotheses by finding and analysing one or a few cases that most closely fit a theory (Eckstein, 1975). As Yin (1989: 38) puts it, crucial-case studies aim to support hypotheses by analytic generalisation "in which a previously developed theory serves as a template to compare empirical studies". Yin suggests that provided at least two cases support the same theory, replication can be justifiably claimed. Since the conclusions made at the first stage of this research were supported by at least one case, obtaining confirmation in just one additional case would sufficiently increase the validity of the study's results. However, finding an appropriate crucial-case appeared to be impossible due to the fact that this theory, which needed verification, had been developed within the same project. To cope with this issue, elements of experimental design were utilised to emulate a crucial-case study approach.

Experimental design is considered especially useful in qualitative studies when there is a need to reach confidence in the validity of casual findings (Bryman, 2008). Experiments involve testing cause-effect relationships through collecting evidence that demonstrates the influence of one variable on another (Breakwell, Hammond and Fife-Schaw, 2000). At the second stage of this study, the influence of specific strategies (dependent variables or causes) on the interactivity of learning in a virtual environment (independent variable or effect) was examined. The need to examine multiple combinations of different causes indicated the appropriateness of a factorial experimental design and that multiple experimental groups needed to be established (Blaikie, 2000). However, a qualitative approach to data processing allowed for more valuable data to be obtained in a single-group design which, despite being uncommon for quantitative research, was found to be particularly useful in this study.

Although approaching only one group was beneficial in terms of establishing in-depth qualitative analysis, it did not allow for all the strategies found at the first stage of this study to be examined. In order to increase the number of strategies tested, a purposive sampling strategy was used. Specifically, maximum variation logic was followed: out of all the available cases, only those whose unique characteristics were relevant to the widest possible range of the strategies were selected. Consequently, since participants were not randomly selected and only one group was used, the design of the second stage of this study should be considered as quasi-experimental, rather than true-experimental (Robson, 2002).

Once a case was selected for the experimental study, it was necessary to determine which of the strategies appropriate to this case had not been used in the participants' group before and, therefore, could be examined in terms of its effects on the experimental group. To do so, prior to the intervention session, a short checklist was completed by the participating teacher and a systematic observation of a recent distance learning session from the participants' group was conducted. Only strategies that were neither indicated by the teacher nor noted in the observation were advised to be implemented in the experimental stage. The observation procedure was also applied to the intervention session in order to detect which of these strategies had been utilised and could be accountable for changes in the environment's level of interactivity.

Qualitative methods of data gathering made it possible to follow a post-test only approach, which revealed the effects caused by the implementation of new strategies in the virtual learning environment. In order to gain a sufficient amount of data whilst only approaching participants once, a focus was placed on the teacher and students' perceptions of any changes that happened in the environment during the intervention session. This made interviews a particularly appropriate instrument of data collection: according to Patton (2004), as a method of data gathering, interviews enable participants to describe perceived changes in the environment without being tied or cued by standardised categories. The interviews in this study had a semi-structured design and were administered to the teacher and children after the experimental session finished. The children were interviewed in a group in order to encourage rich discussion and to promote the expression of different views with respect to the changes that occurred (Patton, 2004) through the establishment of a supportive environment in a more natural atmosphere (Marshall and Rossman, 2004).

3.3. Instruments of data collection

3.3.1. Questionnaires

At the first stage of this study, a self-completion questionnaire was used to gather data (Appendix C). The questionnaire consisted of two parts. The first, context-related part included a set of categorical, close-ended questions retrieving background information about

the contexts in which the respondents had gained their experiences of teaching in virtual environments with synchronous modes of learning. The quantity and composition of these questions were prompted by examples of virtual learning environments found in relevant literature. The context-related questions were intended to enhance the comparability of the data retrieved from the participants who completed the questionnaire (Breakwell, Hammond and Fife-Schaw, 2000). The first part of the questionnaire was conducted within sampling procedures, so it was sent out prior to the subsequent questions.

The second part of the questionnaire contained three questions, all of which were open-ended and which therefore enabled respondents to give answers "in their own terms…[in order to] allow unusual responses to be derived…[that could be] useful for exploring new areas" (Bryman, 2012: 247). One question was used to gather additional, detailed information about the settings and conditions of the respondent's work in virtual learning environments. The other two were designed to obtain data about strategies that teachers perceived of as enhancing the interactivity of virtual learning environments. However, pilot results indicated that the term *interactivity* was likely to be misinterpreted by the respondents, so the strategy-related questions were redesigned to ask the teachers about general methods which they found to contribute to any aspects of learning in virtual environments. The researcher, in turn, had to filter the responses during data analysis to determine those strategies that were relevant to interactivity.

3.3.2. Checklist and observation

In order to collect data from teachers regarding the strategies that had been followed in the participant's academic group prior to the experimental session, a checklist was used (Appendix D). This was designed in the form of a questionnaire, with each item standing for one specific strategy. The list of strategies was based on the findings of the first stage of the study.

Despite being important for further enquiry, the data drawn from the checklist had limited reliability as it was based on individual, subjective perspectives (Breakwell, Hammond and Fife-Schaw, 2000). In order to maximise the degree of accuracy in determining strategies not previously applied within the participant's learning group, each teacher's response was

correlated with an observation of one recent regular learning session conducted in the intervention group. According to Bryman (2008), systematic observations can be helpful in recognising teaching styles and understanding what actually happens in lessons. Given that the themes for the observation had been identified and described beforehand, the observation protocol was also designed in the form of a checklist (Appendix E). This allowed for "the existence or non-existence of the behaviours" to be noted (Breakwell, Hammond and Fife-Schaw, 2000: 235).

The experimental session was observed and analysed, based on its screen recording. This enabled more flexibility in the observation procedure and allowed for analysis at a level of reliability and detail not possible in a direct observation (Breakwell, Hammond and Fife-Schaw, 2000). Once the observation was completed, the protocol was matched with the teacher's checklist: if either the researcher or the teacher detected a strategy, the session was considered to have been previously used in the environment and was not considered to be a factor that could be accountable for changes in the level of interactivity. Afterwards, the observation was replicated in the intervention session, in order to reveal the range of strategies that had been utilised by the teacher.

3.3.3. Interviews

According to Fontana and Frey (1994: 361), the "understanding of an individual or a group perspective" can be particularly aided by the use of interviews. With this in mind, two interviews – one with the teacher and one with the group of children – were conducted after the intervention session, in order to determine the extent to which the new strategies affected participants' perceived level of interactivity in the virtual learning environment. The interview with the teacher was also intended to garner her understanding of the specific effects of each new strategy that she had applied in the session.

A partially-structured interview design was chosen to establish a sufficiently focused yet in-depth discussion: only a brief list of themes guided the interviewer, ensuring that all key points were covered (Appendix F). Such an approach proved particularly efficient in the children's group interview: first, it allowed the interviewer to establish a more natural and comfortable atmosphere for discussion (Marshall and Rossman, 2004); besides this, maintaining focused

interactions kept responses short, which maximised the number of information-rich answers (Breakwell, Hammond and Fife-Schaw, 2000). Both interviews were audiotaped and transcribed before analysis. The teacher's interview was piloted and the children's interview was discussed with their class teacher prior to being administered. Based on the results of piloting procedures, minor changes were made to the sequence of addressed topics.

3.4. Sampling and data gathering

For the purposes of the first stage of the study, the sample population was drawn by means of a purposeful sampling strategy from a commercial online database of schoolteachers (N=64,502), representing predominantly Eastern European countries (98%). Firstly, an electronic message was sent out with a description of the study, requesting teachers' voluntary informed consent to participate in the survey and providing a link to the contextual part of the teacher questionnaire. The contextual questions identified the teachers who had experience of working in virtual environments with synchronous learning (i.e. teachers who met the inclusion criteria), and determined the contextual conditions under which they had gained this experience. Overall, 743 teachers (1% of the sample population) met the inclusion criteria and gave their consent to participate in the survey. In order to establish a more in-depth investigation while still maintaining across-cases variation, the number of participants was minimised. This was achieved by only including unique cases in the final sample (Patton, 2004) which were in turn identified through analysis of the answers to the contextual questions. When the analysis revealed two contextually identical cases, the teacher who reported longer instructional experience was chosen for the final sample. Ultimately, the final sample encompassed 52 participants, of which 48 (Appendix G) completed the follow-up experiential part of the questionnaire. This resulted in a response rate of 92%; replacements with the same characteristics were found for the eight individuals who declined invitations to complete the follow-up questionnaire.

Although small samples are common in qualitative research (Miles and Huberman, 1994; Ritchie and Lewis, 2003), a large number of participants in a qualitative study can be particularly helpful to explore a phenomenon, provided the study's research aims are met and that this approach can be reconciled with the time and resources available (Patton, 2004).

In this study, a reasonably large quantity of participants was considered essential to reveal the variety of strategies used in synchronous distance learning and, thus, to sufficiently saturate the data. The specificity of the sample at the first stage of the study was balanced by the questionnaire design and data analysis methods, with the major focus of in-depth analysis being deliberately moved from single cases to common themes within the entire data set.

Unlike the first stage of this research project, the second stage was aimed at in-depth analysis of single rather than multiple cases. Since a small sample size was accompanied by the goal of testing the multiplicity of hypotheses, a purposive sampling strategy was found to be beneficial, as this approach aims to access the cases where the processes being explored are most likely to occur (Denzin and Lincoln, 2000). To select an information-rich sample that could contribute to this study, the sampling process followed two steps and employed a combination of strategies. Firstly, the researcher employed a snowball sampling approach by contacting a range of head teachers using email addressed published on school websites and asking them to recommend teachers that they knew to have practiced instruction in virtual environments with synchronous forms of learning over a prolonged period. Such a strategy allowed for the accumulation of information-rich and accessible cases that fitted with the purposes of the study (Patton, 2004). Secondly, to examine as many theoretical propositions as possible, maximum variation sampling was employed: out of 24 available cases, 1 was selected the learning conditions of which were relevant to the greatest number of strategies under examination. Overall, 13 of 154 strategies (20%) were found to be relevant to the chosen case.

Ultimately, a group of nine participants represented the final sample: a female Belarusian language teacher aged 27, and her 8 students aged 10 to 12 (Table 2). The experimental study was conducted in a school in Minsk, Belarus, after voluntary informed consent was obtained from the head teacher, participating teacher, children and their parents. In advance of the intervention session, the checklist form was completed by the teacher and one recent distance session was videotaped and observed. Following the intervention session, the interview was conducted with the teacher, while the children were interviewed the following day. The intervention session was screen recorded for the purposes of further observation.

Table 2 – Participants of the experimental stage

Participant	Gender	Age	Data collection
Teacher (2T1)	F	27	Questionnaire, Interview
Student 1 (2S1)	F	10	Group interview
Student 2 (2S2)	F	12	
Student 3 (2S3)	F	11	
Student 4 (2S4)	M	10	
Student 5 (2S5)	M	12	
Student 6 (2S6)	M	11	
Student 7 (2S7)	M	11	
Student 8 (2S8)	M	12	

3.5. Data analysis

Analysis of the data gathered at the first stage of this study was initiated by coding it, based on a pre-specified set of descriptive categories. According to Miles and Huberman (1994), the use of descriptive codes allows segments of data to be summarised, while the use of a pre-defined coding framework enables the researcher to tie data with research questions and establish grounds for further cross-case analysis. In light of this, three master codes were originally identified, namely 'context', 'strategy', and 'interaction'. During analysis, the first two codes were expanded upon with descriptive sub-codes that were formed by the growing body of data (Punch, 2009). In contrast, the 'interaction' item was kept constant in order to unambiguously identify the pieces of data related to the interactivity concept; it consisted of 65 sub-codes, standing for interactivity indicators that had emerged from the literature analysis (Appendix B). Ultimately, the descriptive, first-level coding allowed contextual characteristics and interactivity-related strategies inherent in each particular case to be identified. Furthermore, this coding device promoted subsequent cross-case analysis through systemising data from different cases within a unified scheme of categories.

At the next level of coding, the data assigned to each of the categories were analysed and broken down into smaller, more meaningful units (Punch, 2009). This process can be identified as the pattern (Miles and Huberman, 1994), inferential (Punch, 2009), or analytical coding

phase (Richards, 2009). Finding patterns in data was specifically useful in this study due to the large number of cases involved (Miles and Huberman, 1994): specifically, through a cross-case data review, common patterns were found which described the typical strategies used by teachers and which distinguished the characteristics of virtual learning environments where these strategies had proven effective.

To guide the analysis of correlations between the disclosed strategies and contexts of virtual learning environments, a variable-by-variable matrix was constructed. Miles and Huberman (1994) infer that variable-by-variable analytical displays allow variable-oriented and case-oriented strategies to be combined. Thus, utilising this type of analytical tool in the present study enabled the researcher to overview cross-case commonalities while keeping data linked with specific cases. To produce theoretical propositions and refine conclusions, the set of data was recursively analysed by means of multiple strategies: clustering, variable partitioning, and factoring (Miles and Huberman, 1994).

Data collected at the second stage of the study from the teacher's and children's interviews were combined and simultaneously coded with a pre-specified set of categories. These categories were identified as 'effect', 'interaction', and 'strategy'. The 'effect' category was used to identify changes caused by the implementation of new strategies in the virtual learning environment; this category was extended with new thematic sub-codes during the review of the transcripts. The 'interaction' category had the same structure as it did in the first stage of the study, containing a range of pre-defined sub-codes designed to extract data relevant to the concept of interactivity. The 'strategy' category was also pre-specified and was kept constant during the analysis; it was used to distinguish data linked to specific strategies.

To facilitate the analysis of cross-category data relationships, an effect matrix was designed. According to Miles and Huberman (1994: 137), effect matrices are capable of indicating "what changes a particular treatment brought about in its target population" by displaying data concerning outcomes associated with a projection on a set of dependent variables. In the constructed matrix, the variety of strategies stood for the dependent variables and established the rows of the matrix, while the columns were used to indicate outcomes that were summarised as 'positive', 'no effect', and 'negative'.

Apart from the methods described above, memoing was used throughout the analysis as a method allowing the analysis to: conceptualise empirical data; refine and expand codes; produce key categories and describe those categories' relationships; and shift towards a more comprehensive understanding of data (Miles and Huberman, 1994).

3.6. Quality of findings

3.6.1. Reliability

Throughout the study, measures were taken to ensure the reliability of data and findings. The initial choice of data collection strategies were methodologically justified in accordance with the research aim and questions. Efforts were made to ensure that the dependability of the utilised methods was met: the structure of the observation protocol and the teacher's checklist were coherent with previous research findings drawn from the literature analysis; the questionnaire and the teacher's interview were piloted before administration, and the children's interview had a preliminary stage which was reviewed and refined by their teacher. The transcripts of the interviews were revised by an external assistant, which maximised their completeness and precision (Silverman, 2000; Gibbs, 2007). The coding of the collected data was crosschecked with another coder to reach an 'inter-coder agreement' (Creswell, 2009); after clarification of disagreements in coding, the inter-coder reliability was calculated to be 92%, using Miles and Huberman's (1994) formula. The data was partly check-coded by the researcher to evaluate the internal consistency of coding, which reached a level of 94%. Both intra and inter-coder agreements succeeded the recommended minimum level of 90% (Miles and Huberman, 1994).

3.6.2. Validity and generalisation

Triangulation was used as the key strategy to ensure internal validity and increase the findings' credibility (Patton, 2000; Creswell, 2009). According to Miles and Huberman (1994), the validity of findings increases when they are confirmed by several independent sources of data. Silverman (2000) emphasises that in order to maximise validity, it is important to not only try

and confirm findings, but also attempt to test and refute them by using multiple data sources. In his paper, Silverman also questions the appropriateness of triangulation as a strategy for validation; nonetheless, three of the four alternative strategies he suggests appear to imply similar logic to that of triangulation. Creswell (2009) argues that in qualitative research, data can be triangulated when it is collected either from multiple participants' perspectives or by means of different methods of data collection. Analogically, Denzin (1970) distinguished two forms of triangulation – within-method and between-method – both of which were implied in this study.

The majority of the findings in this study emerged from analysing data that was retrieved from several sources. The questionnaire contained at least two different questions addressing the same phenomenon, and the internal consistency of answers was crosschecked for each case (Patton, 2000). Most of the themes that emerged from the questionnaire responses reflected on the perspectives of several respondents and, therefore, added to their validity (Creswell, 2009). Determining common patterns across participants during data analysis helped to identify deviant cases and allowed further analysis to confirm or refute findings (Silverman, 2010); this entailed the refinement of a number of conclusions that had been made beforehand. The findings based on the questionnaire data were further verified by the field experiment which also employed a set of triangulated methods: the teacher's and children's interviews were used to collect data on the same phenomenon, and the teacher's response to the checklist was validated by the results of the observation.

Care was also taken to safeguard the external validity of findings, a process also referred to in qualitative research as transferability, theoretical validity (Maxwell, 1992), or generalizability (Miles and Huberman, 1994). Although findings in qualitative studies cannot be generalised in the probabilistic sense, they can be transferred across settings (Marshall and Rossman, 2006) and be made generalizable to a broader theory (Yin, 2003). In this study, external validity was enhanced by methodological decisions, sampling procedures, and reporting strategies. Thus, cross-case analysis undertaken at the first stage of the research project provided grounds for the transferability of findings across similar contexts (Miles and Huberman, 1994). The variation of these contexts was maximised through adherence to purposive sampling procedures. Further to this, the characteristics of sample cases where specific themes arose were sufficiently reported (Punch, 2009). In the second stage of the study, the theoretical propositions produced by the first stage were analysed by projecting them on to alternative cases, constituting what

Yin (1989) termed ‘analytic generalisation’. Along with these approaches, the field experiment examined the applicability, or pragmatic validity, of findings by applying and challenging them, rather than looking at findings in similar contexts (Kvale, 1989).

3.7. Ethical considerations

3.7.1. Ethical approval

This study obtained approval from the University of Oxford Central University Research Ethics Committee (CUREC) prior to beginning data collection (Appendix H). Once permission for the project was granted, the accepted methodology was strictly followed at all stages of the study. In addition to following CUREC protocols, the researcher ensured that the study was consistent with the British Educational Research Association’s Ethical Guidance for Educational Research (BERA, 2011) and the Social Research Association’s Ethical Guidelines (SRA, 2003).

3.7.2. Voluntary informed consent

Since the study required access to a school selected by the researcher, it was essential to gain and maintain the consent of the school’s head teacher throughout the research process. In light of this, a formal letter was sent to the head teacher, which included a comprehensive explanation of the study to ensure that consent was an informed choice. The head teacher was asked to sign and return a consent form enclosed with the formal letter.

Once a teacher and group of children were selected to take part in the study, voluntary informed consent was also obtained from participants to ensure that they understood what was being asked of them and agreed to participate without duress (BERA, 2011). Considering that the children involved were regarded as ‘people whose ability to give free and informed consent is in question’ (BPS, 2010), informed consent had to be sought on their behalf from parents or guardians (BERA, 2011). Therefore, the teacher, parents, and guardians were provided with consent forms to sign, which were enclosed with formal letters explaining the study’s aims, participants’ role in the study, data collection and processing procedures, confidentiality and

anonymity guarantees, the voluntary nature of participation, and the procedure for opting-out (SRA, 2003; Bryman, 2008; CUREC, 2009, 2010).

Although formal consent was obtained from parents, the children were also informed of their right to withdraw at any time with no adverse consequences. The children's assent to participate was continuously assessed during data collection through sensitive attention to their verbal and non-verbal signals (BPS, 2010). Prior to starting data collection, the children received a leaflet providing key information about the study and explaining their role and rights. Hence, voluntary informed consent was obtained from the children "by means appropriate to their age and competence level" (BPS, 2010: 16).

Regarding the online questionnaire, the responding teachers were provided with an online information sheet, attached to the email containing the link to the questionnaire form. Before submitting the form, the teachers had to tick a checkbox to confirm their informed and voluntary consent to participate.

3.7.3. Participant respect and welfare

Throughout the study, the researcher prioritised participants' welfare, aiming to prevent any possible intrusion, stress or distress, physical or psychological discomfort, or any other harm (SRA, 2004; Bryman, 2008). Study-related activities and meetings were scheduled at a time and place convenient for the participants, who were treated "fairly, sensitively, with dignity, and within an ethic of respect" (BERA, 2011: 5). Data collection methods excluded any deception or touching on sensitive information. Given the cross-national, multilingual context of the study, verbal and written interactions with the participants were held in the language of their preference.

The researcher took special care to protect the children's interests (SRA, 2004), conducting the study in accordance with the United Nations Convention on the Rights of the Child (BERA, 2011). The children were interviewed in groups to minimise any possible psychological discomfort. No tests were utilised in the study, and the children's regular academic work was not disrupted. The researcher maintained a professional and sensitive attitude to the children and their activities at all times.

3.7.4. Treatment of data

The researcher treated participants' data confidentially and anonymously (BERA, 2011). In accordance with the Data Protection Act (1998), only relevant and adequate personal information was collected by the methods described above, which was then kept up-to-date and processed according to the researcher's rights. The data subjects were informed about, and provided with the right to access and alter, their personal information upon request or to object to it being stored or processed (SRA, 2004). To ensure privacy, unique codes were used instead of the participants' names to label data. All the data were fairly and lawfully processed, and no participant was made identifiable in the research summary (Bryman, 2008), neither directly nor by means of 'deductive disclosure' (Tracy, 2010: 847). Research data were securely stored and made available only to the researcher and his supervisor (BERA, 2011). The list matching participant codes with the names of subjects was located separately from other research materials (SRA, 2004). No hard copies of the data were kept, and all the electronic files were encrypted and stored in a computer with locked access. Once the data were no longer necessary for the purposes of this study, they were destroyed.

4. Findings

4.1. Data variation

To obtain the information-rich data necessary for determining strategies for increasing the interactivity of synchronous learning in virtual environments, it was vital to achieve variation in the characteristics of the survey's cases. This variation was established by means of a purposive sampling strategy: the maximum number of unique cases was selected from those available. Characteristics of the cases were primarily drawn from the teachers' answers to close-ended questions addressing the contexts in which they had gained their experience of working in virtual environments with a synchronous mode of instruction. Minor amendments to the description of 14 (29%) cases were made based on the teachers' detailed narratives of their work. The comparative characteristics of all 48 survey cases are presented in Appendix G.

The sampling strategy allowed for saturated data to be collected and analysed. As a result, with a single case indicating 2 to 26 single strategies, overall, 154 interactivity-related strategies were identified in this study. Out of these, 145 strategies (94%) came from at least two cases, which allowed for the within-method triangulation of data (Denzin, 1970).

Although the teachers were generally keen to describe their practices and methods in detail, a few respondents (AT08, AT13, AT24, AT32, AT35, AT41) stated that they used no specific strategies in online work. Nevertheless, the subsequent description of their approaches led to the identification of a range of interactivity-related strategies with the exemption of case AT41. For example, teacher AT13 began with stating:

> Well, I would not say I use any specific strategies. I just try to do only what works best for me. (AT13)

However, further on she reported:

> I found it specifically important to introduce short (not too long) breaks during sessions as they prevent tiredness and stimulate children's engagement in what is happening in the classroom. (AT13)

At the same time, not all teachers provided enough data from which interactivity-related strategies could be identified (AT19, AT41). In two cases (AT42, AT47), the teachers gave no descriptions of their approaches to teaching in the virtual learning environment whatsoever.

4.2. Issues surrounding interactivity

4.2.1. Identifying interactive events

To determine the connection between the strategies being discovered and the interactivity of synchronous learning in a virtual environment, the chart of interactive events' characteristics produced in the literature review was used. A strategy was identified as interactivity-related provided it had a connection with at least one item in one or more sections of the chart. This allowed interactivity-related strategies to be determined from the whole range of instructional methods used by the teachers. For example, teacher AT10 suggested:

> …peer-evaluation is definitely a good way to make children participate in discussing a topic, and it also establishes a sort of relationship between them. (AT10)

Although the teacher did not explicitly consider peer-evaluation to be an interactional strategy, the indicated effects were found to be connected to interactivity. This was due to their connection with one indicator of interactivity (connectedness), two characteristics of interactive events (learner-learner direction and visual or audio channels), and two types of interactive actions (evaluation procedure, commenting and peer-evaluation activities).

It was also found that some strategies may have an implicit, delayed effect on interactivity. For instance, teacher AT18 stated:

> I can deliver far less information when teaching online, so it is crucial for me to properly estimate how much I can do in one session. Otherwise, you easily run out of time and often have to rush from one activity to another or just skip some part of the lesson…[Rushing] interferes with the initial plans and changes the focus from managing online learning to dealing with time and organisational issues. (AT18)

According to this statement, whilst an objective assessment of the amount of content that can be delivered in one session does not directly increase the interactivity of learning;

not following this strategy can ultimately break the lesson's structure, decrease the level of the instructor's engagement, and consequently entail a loss of control over the interactive processes.

Due to the aforementioned issues, the majority of strategies indicated by the survey's respondents were found to have at the very least, an implicit influence on interactivity, which explains the relatively large number of strategies ultimately found.

4.2.2. Types of interactions by directions

In projecting data collected on the chart of interactive events' characteristics, no evidence of interactions occurring in the learner-interface direction was found. The teachers do not seem to perceive a technological medium itself as a source or target of interactive events; instead, they view the technological element of virtual environments as a mediator for establishing interaction between the participants and the content:

> Enabling text chat is usually a good idea. It enables discussions to continue in those moments when the connection's quality suddenly weakens, limiting video or audio accessibility…If children have access to text chat most of the time, they can ask for clarification, as well as report on any technical problems if they arise. (AT18)

Besides, contrary to the reviewed literature, some teachers indicated that not only learners but also instructors take part in interacting with the content:

> I try to plan sessions flexibly and think about alternative scenarios for each session. Depending on how well students deal with the materials and activities, I modify the sequence of the lesson's activities or the composition of its content. (AT25)

A few respondents also indicated that pieces of content are capable of interacting as well:

> [S]o sometimes, I create quizzes using PowerPoint and set the presentation to show students specific web pages with some media content, depending on the kids' answers. (AT06)

It was found that interactive events may occur between more than two subjects:

> Developing an online discussion is definitely much easier with one student…and it is even more complex when there is more than one instructor involved. (AT23)

> I find it necessary to minimise the amount of content covered and tools used simultaneously in either individual or group work. (AT18)

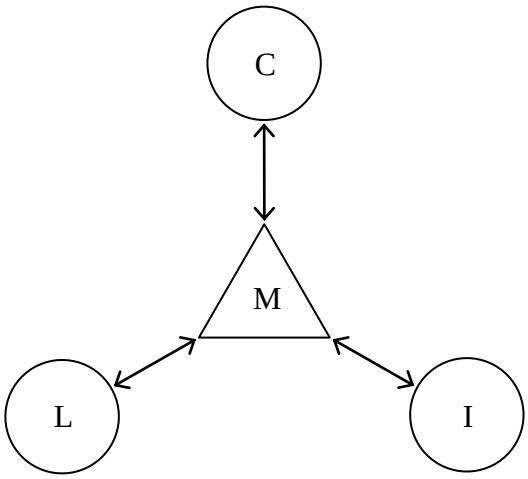
Generally, teachers tend to perceive a technological medium as an analogue or substitute for the traditional classroom medium:

> Technology enables me to emulate the standard classroom and establish learning activities that are familiar to the children. (AT14)

> I do not use any special methods or strategies when teaching via the internet, mostly relying on my experience in the traditional classroom. When the connection is good and stable…there is actually no big difference [between traditional and virtual teaching]. (AT15)

Hence, in accordance with the view of the survey's respondents, it can be summarised that interactions in learning environments occur between a varied number of learners, instructors, and pieces of content in any direction through a mediating interface, such as the virtual or traditional classroom (Figure 1). This advancement led to an alteration of the list of items in the chart of interactive events' characteristics: specifically, the items in the category of interaction directions were changed to Learner ↔ Content, Learner ↔ Instructor, Learner ↔ Learner, Instructor ↔ Content, Instructor ↔ Instructor, and Content ↔ Content. As long as the interactivity of learning environments was determined to be dependent on the use of a medium, for a disclosed strategy to be regarded as interactivity-related, enhancing the quality of that medium or increasing the efficiency of its use were considered sufficient.

Figure 1 – A directional pyramid of interactions in the learning environment



L – learner(s)
I – instructor(s)
C – piece(s) of content
M – medium

4.2.3. The synchronicity of interactive events

Analysis of the teachers' descriptions of their practices led to the assumption that a chain of interactive events should not necessarily be considered as being either a synchronous or asynchronous type. Rather, interactive events can dynamically vary between synchronous and asynchronous formats. Therefore, the boundary between the synchronous and asynchronous is often vague, and interactions of contrasting types may occur in a parallel ways on different levels of a discussion. For example, teacher AT39 explained:

> When explaining something new, I encourage my students to text their questions. First of all, it precludes possible disruptions. Doing this, I try to combine similar questions and answer these at once, which also saves some time for the session. Although my answers become delayed in this case, I find this approach helpful in keeping the overall discussion in the virtual class more organised. (AT39)

As follows, one strategy may have effects on both synchronous and asynchronous interactions in the same environment. In light of this, in looking for interactive-related strategies, it was deemed reasonable to assess their *ultimate* interactive effects, rather than local or temporary influences.

4.2.4. Increasing interactivity: strategies versus conditions

On being asked about ways of increasing the effectiveness of learning in virtual environments, not only did teachers suggest specific strategies but they also demonstrated a preference for certain learning conditions. The distinction between strategies and conditions is not always clear-cut, as both are determinants of the environment's interactivity and can be often described in similar terms. The principal difference, though, is that strategies are actions a teacher can deliberately choose, while conditions are the initial, pre-existing characteristics of an environment.

Once a strategy is identified and examined, it can point to relevant learning conditions, and vice versa. For instance, based on the survey's responses, it was found that minimising the number of students in the virtual class can lead to an increase in the interactivity of learning (AT01, AT02, AT08, AT13, AT18, AT25, AT36, AT38). This strategy, in turn, implies that working in small classes is potentially more interactive than working in large ones. In cases where a teacher does not have the opportunity to change the composition of the class,

the number of students can be considered as one of the initial learning conditions. Although in these cases the potential level of interactivity still depends on the pre-specified class size, the teacher has no direct control over this factor.

Conditions and strategies can have mutual connections, and it is sensible to analyse pre-existing learning conditions when choosing which strategies to apply in the virtual environment. Thus, not all teachers defined a large class size as limiting the level of interactivity. From a few of the responses (AT14, AT24, AT32), it followed that large classes can actually be more interactive than small ones under specific complementary learning conditions, such as a high quality network connection (AT32). Similarly, some strategies were found to work better under specific learning conditions, thusly revealing the interactivity potential of these conditions. For instance, splitting students into small groups was found to be particularly effective in large-sized classes (AT13, AT14, AT25, AT40).

In this study, each strategy that emerged from the survey's responses was analysed for its relevance to learning conditions common to the cases where it had been found. Appendix I contains the list of all revealed strategies and indicates relevant and limiting learning conditions. The table also provides links from all the strategies to the cases from which they have emerged. The list of strategies is ordered according to the number of evidencing cases.

4.3. Strategies for increasing interactivity

Ultimately, 154 strategies were identified from the survey's responses. These were split into four logical categories: preparation and training, structure and management, interplay and communication, and evaluation.

4.3.1. Preparation and training

Forty-one of the discovered strategies were characterised as preparatory. Being applied prior to learning sessions, they have a deferred influence on the interactivity of synchronous learning in a virtual environment.

Part of these strategies is associated with a proper configuration of the medium and network connection. Teacher AT08 addressed this issue in detail:

> You do not want to configure the software during the session (even though sometimes you need to change some settings based on what is going on in the classroom). This is why you need to be aware of technical conditions and the limitations of your students before the lesson begins. It enables you to set the software and quality of data more or less accurately…Sometimes you have to lower the quality of data significantly because of a single student who has lower connection. (AT08)

These assertions alongside other participants' opinions suggest that in order to prevent unexpected disruptions in the course of the actual session, the environment's configuration related to the signal transition of the learning environment instruments should be set up and tested in advance (AT08, AT17, AT25). In determining the appropriate level of data quality, it is logical to refer to the characteristics and capabilities of the least technologically advanced participants in the virtual class (AT08, AT17). Accordingly, the level of the weakest network connection in the group should set the bar for the class (AT17, AT32).

As well as being dependant on a strong and stable connection, the interactivity of synchronous distance learning relies on the quality of the virtual environment's graphical, audio, and video features. The teachers indicated that avoiding small details or patterns on the screen enhances the understanding of content (AT09, AT28). The implementation of a large screen may have the same effect, and it also positively influences the interactivity of interplay between learners and instructors (AT01, AT20, AT22, AT33). Apart from this, while customising the theme of the interface according to the subject or topic may facilitate students' motivation and participation (AT21), designs with destructive elements should be avoided as they conduce the loss of students' attention and involvement (AT30). Overall, as eight of the respondents indicated, there is a need for the interface design to be accessible and usable by all members of the virtual classroom, including guests or parents who may assist the children. A clear, intuitive learning interface was reported to increase learners' involvement and support the smooth running of the session, particularly for small children (AT13, AT26).

When audio is the key channel of interactions in the virtual learning environment, the quality of sounds must be prioritised and maximised in order to enhance the clarity of the information being transmitted (AT18, AT21, AT30). Apart from using quality audio recording and

producing devices (AT06, AT39), audio can be enhanced by the proper configuration of the technological medium:

> [It is important to] be very careful when configuring the quality of audio. If you set a high quality, there could be…a delay before the others hear what you have said. When lots of people are connected, any communication can be ruined. On the other hand, when audio is of a poor quality, there is a high risk of misunderstanding what is said. So, some kind of balance is required. (AT21)

As was stated by five of the respondents, while using the microphone, the members of the learning environments should reduce any background noises they possibly can. Amongst other methods, the use of headphones must be also encouraged to prevent the transition of the sound from speakers into the microphone:

> …it is impossible to speak using microphones if someone does not use headphones, because if you say something and it is transmitted to that person, the sound goes back through the microphone, then it is transmitted to this person again, and so on. If there are two students who do not have microphones, a lot of background noise is created. (AT06)

There are more preparatory strategies to consider when the audio component of the environment is accompanied by the use of video. The respondents noted the importance of enhancing the quality of participants' on-screen pictures when video is utilised in the environment. With this in mind, not only should high quality video devices be implemented if possible (AT01), but also the ways in which the cameras are utilised and the image is displayed need to be optimised. In particular, maximising the size of the image on the screen may increase interactivity, because it allows for more non-verbal signals to be transferred and properly recognised by children and instructors (AT04). Similar results are promoted by arranging proper lighting, as it can significantly enhance the picture quality (AT01) even in environments with a poor network connection (AT20). In addition, it was found that it is effective to place the camera right in front of the face close to the monitor, as it creates "the illusion…that the person in the screen is looking into your eyes, which increases a sense of reality" (AT22), and "makes children watch and listen" (AT31). Using the camera zoom with the device placed at a distance may also enhance the realistic effect because of the minimisation of the picture's possible distortions (AT01).

Regardless of how well the medium seems to be set up, contingency plans must be made in case of the loss of connection. Even the teachers who worked in technologically advanced environments noted the importance of being prepared for an unexpected disconnection:

> I try to have a task prepared that does not require a strong connection or even any connection at all to complete. A short quiz or writing exercise may give enough time to solve occasional technical issues. (AT28)

Importantly, the children must be prepared for unplanned disconnections as well, and be aware of what alternative actions to take in case of emergencies. The teachers should provide means of communication that can be used if a child loses connection:

> I also found it useful to have a set of commands that the children know they MUST follow. When I write in the chat – "SILENCE", they must stop talking. They usually do. We also have "NO WEBCAM", "NO CHAT", "BREAK 5", and so on. (AT33)

> The children have my phone number, so they can call me in case they are experiencing any problems…but more often it is me who makes the call. (AT12)

When the online session involves using any supplementary materials, these should be given to all the children in advance (AT06, AT15, AT24, AT34). A high quality and reliability of the materials must be ensured to prevent disruptions during the virtual lesson (AT15, AT34). In light of this, some of the respondents (AT15, AT31, AT37, AT44) found it beneficial to use existing and proven materials when acceptable. It was also emphasised that materials of any kind have to be reconciled with the technological and physical settings in which the students work (AT08, AT27, AT25, AT29).

Preparation for children's synchronous distance learning sessions should involve the delivery of sufficient training to the classrooms' members. Proper training ensures that all members have the necessary technical skills that are vital in achieving effective interplay. In the training sessions, it is a good idea to describe the technical limitations of the environment (e.g. possible signal delays) and to ensure the class members know how to deal with them. Five respondents deemed it important to introduce new technologies, methods, and tools gradually, as the children may require time to get used to them. Specifically, when a new environment is going to be brought into use, one or a few introductory sessions held in advance can be used for practicing the necessary technical and communicational skills by children in a relaxed atmosphere (AT03, AT08, AT17).

Both training and introductory sessions can be used for establishing and reviewing the classroom rules, which, according to five respondents, may help the instructor gain better control over interactive processes that occur in the virtual classroom. At the same time, for some children (e.g. the younger ones), the effects of training can be limited, so the additional support of adults may be necessary during the course of the session.

4.3.2. Structure, content, and management

Structure and content

To deliver the same amount of content, the virtual learning environment requires at least as much time as is required in a traditional classroom. As running out of a session's time inevitably leads to the disruption of the instructor's plans, the amount of content covered within one session should be objectively estimated and, if possible, minimised (AT14, AT18, AT26). To retain control of the thread of events in the classroom and to establish a logical connection between them, the respondents deem it reasonable to leave up to 30% of the sessions' time free of any compulsory activity (AT14, AT18, AT25, AT31).

For compulsory activities, it was found to be practical to set flexible time boundaries, as this enables the instructors to configure the session around the students' progress and link together the different parts of the lesson:

> For many activities, it makes no sense predicting the exact time they will take. You must be prepared to establish an activity's length during the session in order to ensure it yields the expected results and is linked to the subsequent activities. What is reasonable is…estimating the maximum time the activity may take and determining which of its components can be excluded if necessary…You need to know where you can get more time from if you need it. (AT18)

Once carefully planned, the session plan and structure should be strictly adhered to (AT44, AT30, AT17, AT11). Teacher AT11 indicated that keeping the session focused facilitates interplay, increases the productivity of learning activities, and stimulates student engagement. The teacher also clarified certain points throughout the lesson:

> I try to hold the children focused on the lesson and avoid distractions. Time after time, I ask simple questions, remind them what we have done, explain what we are going to do next, call students by their names, and so on. (AT11)

Explicitly marking the start of sessions was found to increase learner engagement and connectedness, as well as to gain the children's attention (AT03, AT27, AT48, AT22). According to five respondents, the teacher must also ensure the instruction pace meets the progress of all the students and fits in with any technical limitations. To retain the children's productivity in learning activities, it was found that limiting each piece of work to 10−15 minutes and introducing short breaks throughout the sessions was effective (AT08, AT21). Teacher AT08 stated:

> The lesson might seem very dynamic, but you must remember the students are sitting still at their computers lacking physical activity, which in the end leads to a fall in interest, motivation, engagement and productivity in whatever they do. (AT08)

It was indicated by some of the respondents that students' motivation and productivity can be raised if they can see their progress during the session (AT11, AT35, AT45) and "do not feel as if there were stuck in one spot" (AT09). During individual or group activities, time reminders of any kind are of special help, for they can both stimulate concentration on a task and ensure adherence to the session's timetable. Once the session is finished, the teacher may find it provident to allow the children to stay in the virtual classroom (AT01, AT33, AT44):

> When the lesson is completed, my students are allowed to stay in the classroom and have some hang-out time. First of all, through this, they indirectly improve their technical skills. Besides…it develops in them a better attitude to the virtual environment in general. It also makes them feel that the virtual environment is a social space, so they are more willing to work collaboratively in the subsequent sessions…[They] then spend less time in off-task conversations during the sessions itself. (AT01)

Ten of the survey cases showed that the interactivity of synchronous distance learning benefits from a flexible and dynamic choice of methods and tools used in the virtual session. Although, as was posed previously, the introduction of new approaches to online instruction should be gradual as introducing "even minor novelties in children's learning…[may] stimulate their interest and participation" (AT08). Specifically, the respondents reported positive interactivity-related effects in the occasional conduction of virtual field trips (AT07, AT08, AT32), periodic change to the lesson component's sequence (AT01), alterations in the amount of time dedicated

to learning activities (AT02, AT15), and invited remote guests (AT05, AT14, AT20, AT38). When guests participate, it is necessary for the teacher to assist them in working with the children:

> It is important to understand that professionals in some fields are not necessarily prepared or know how to interact with children. Actually, many people get embarrassed when talking to children and need support [from the teacher]. (AT14)

Assigning children to the role of presenter was found to be another way of stimulating their engagement and knowledge sharing (AT11, AT25, AT28). The teacher may also be wise to adhere to a facilitative approach rather than to a purely instructional approach, moving from lecture to communication and discussion (AT11). This is particularly apt in distance education, given that the boundary between the roles of the instructor and learner is more blurred compared to that of traditional classrooms (AT09, AT11, AT28). At the same time, regardless of this difference, fundamental strategies of the traditional classroom still appear to be appropriate for the practice of synchronous distance learning, as long as there is evidence of positive effects (AT09, AT14, AT27). This is also the case with the different types of activities employed:

> As well as in the [traditional] classroom sessions, I take advantage of such forms of work as experimenting, observation, or presentation, which make it more interesting and easier for the students to deal with and learn new content. (AT14)

Management

It is advisable for teachers in virtual environments, using a synchronous form of instruction, to establish ways of contacting any student, at any time during any activity (AT09, AT13, AT29, AT33). As teacher AT09 stated:

> One of the worst things that can happen is not having a way of getting in touch with one or a few students in the class…[which] is often equivalent to the students' disconnection. (AT09)

When monitoring the progress of the class, it is important to pay particular attention to the achievements of the students making the least progress (AT30, AT09, AT14, AT32). Non-verbal activities (such as eye or body movements and facial expressions) can be used for discerning the students' attitudes and motivation levels (AT06, AT40, AT38). Similarly,

when monitored, off-task text chat messages can indicate or predict deviant, unwanted behaviour that may lead to breaks in the flow of interactive events (AT04, AT14).

Interplay and communication

The overall interactivity of the session benefits from interactions being stimulated from the very beginning of the lesson:

> How you start the session is how it will continue…to get children engaged and participating throughout the session, I give them a simple task to complete in groups, or an individual task with the subsequent sharing of results. This is a good impetus for further effective group work. (AT02)

To promote interactivity, it is important to establish and maintain a constant logical connection between the episodes of interplay between learners, instructors, and content. In doing so, it was found that ensuring each raised question is dealt with is important (AT35, AT11, AT07, AT11). To save instructional time and prevent disruptions in delivering content, the respondents recommend inducting and addressing several relevant questions at once (AT45, AT39, AT34).

Three of the respondents (AT28, AT26, AT09) underlined the necessity of taking children's attention away from the technology in order to establish a sense of realness of the interactions occurring. Thus, teacher AT09 inferred:

> When children are completely engaged in a specific activity or task, they seem to forget they are interacting via technology. (AT09)

In order to maintain the level of interactivity already established, teachers, as facilitators of online learning, should minimise time spent away from the virtual classroom during the session (AT13, AT17, AT26, AT27). This is of particular importance when young children or large groups of students are involved, which in itself makes effective interplay more difficult to achieve (AT26, AT27). At the same time, it was found that, while keeping the children within easy reach, providing them with time away from the teacher when they are working on a task either individually or in groups can increase interactivity by promoting self-disclosure and mutual attention among the students (AT06).

Participation

To promote students' engagement in synchronous distance learning, not only do equal opportunities for participation have to be provided for all children (AT09, AT12, AT13, AT27), but the teacher also needs to actively encourage the participation of each class member. One of the difficulties the teacher is likely to encounter, especially in large classes, is the necessity of managing students with different levels of achievement. To cope with this, teachers are advised to assign different roles (e.g. expert and learner) to the children based on their achievements and assign relevant tasks (AT21). Specific tasks can be prepared for the high and low achievers (AT13, AT14). In cases where not all the children's questions have been answered within the session, the opportunity should be provided for the students to ask any remaining questions after the lesson is finished (AT01, AT09, AT23, AT31).

Group work

The strategy most frequently indicated by the survey's respondents was dividing the students into small groups:

> Managing a large number of students can be problematic. Therefore, you should always consider breaking the class into smaller groups. (AT02)

When arranging group work, combining children of different levels of motivation or achievement may help decrease academic and social gaps between them (AT14, AT21, AT28). Whatever the composition of the group, assigning a leader role to one of the students can help the teacher in managing group work (AT12, AT14, AT21). The leaders should be periodically changed, if possible, in order to provide equal participation opportunities for all the students (AT14, AT21). The groups' composition and size should also vary, as this may enhance student relationships (AT05, AT14); however, using fixed groups can occasionally be preferable:

> We have divided the children into two fixed groups based on their academic results. When group work is required, the children know what to do, so it takes little time to arrange this process…We designate different children as group leaders so they can explore different roles in collaborative activities. (AT21)

When local and more remote children are present at the same time, multiple interactive characteristics of the virtual learning environment can be enhanced by selecting the participants of groups, taking no account of their location and familiarity with each other (AT07, AT08, AT12, AT13):

> As in…[my] class, students often do not know each other, I try to combine local and distant students in one group as early on as possible to establish better relationships between the students and I supplement this with further class work. (AT08)

Once group work is finished, the teacher may wish to share each group's results with the others (AT01, AT17, AT24):

> Comparing groups' results entails an emulative effect and enhances group work efficiency. (AT01)
>
> It is helpful to discuss a group's work with the whole class in order to smooth the transition between group and whole-class activities. (AT17)

Medium and materials

To establish effective synchronous distance learning, the instructor should ensure that the children can manage any tools or materials that are employed (AT16, AT24, AT26). With this in mind, it seems sensible to simplify the technological component if possible.

To increase clarity in communication, the connection's stability should be prioritised over quality (AT13). Throughout the session, the connection quality needs constant checking (AT02, AT07):

> When something indicates that the connection has weakened, I stop the discussion and conduct a small connection test: the students activate their microphones and webcams, we keep silent for a few seconds, then I call each student by the name, and the students are required to raise a hand when they hear their names. (AT02)

If technical issues are identified on a student's side, they must be addressed sensitively to avoid distressing the student and, if possible, after the session (AT20, AT25, AT30):

> If a student can fix a technical problem quickly, it is best if the instructor tells them how. If not, then it is more effective to adapt activities to the student's technical setup. (AT20)

Once a technical feature is not used or is being used inappropriately, access to it should be denied to the children (AT14, AT18, AT25, AT27). At the same time, enabling text chat at all times was found by the respondents to be beneficial as it enables them to monitor off-task messages (AT04, AT14), to induct questions without disruption (AT39, AT45), to clarify messages distorted by other tools (AT05, AT18, AT32), and to report technical difficulties (AT05, AT09). Special care, however, should be taken with younger students who may have limitations in using text-based features (AT29). A few respondents pointed out that polls can often serve as a more interactive, appealing, and manageable alternative to text-based questions, especially when teaching in large groups of students (AT09, AT14).

A few respondents found it helpful to record sessions for the purposes of subsequent analysis and self-reflection (AT02, AT18), extracting valuable pieces of the lesson and referring to them in further sessions (AT02, AT32), and providing students with the opportunity to find or recall any piece of information covered in the session (AT02, AT18).

4.3.3. Interplay and communication

Communication and feedback

According to six of the respondents, in order to ensure the effectiveness of interactions, it is important to constantly check the children's understanding of the content. This goes in line with the suggestion that the interactivity of the learning environment is dependent on the efficacy of the questioning and listening by the teacher (AT03, AT17, AT38). One of the relevant tactics indicated by five respondents was to not quote students' messages in full, but only relevant passages, and refer explicitly to their senders when replying.

To make the most of a medium's interactive capabilities, the teacher should be accessible to the children (AT03, AT07, AT31). In particular, the students need opportunities to ask questions (AT07, AT09, AT31, AT32), and the teacher should encourage this by emphasising his or her readiness to provide any necessary support, within reason (AT03, AT07, AT31). Once questions arise, it is vital that the instructor responds. According to teacher AT07,

> Ignoring children and avoiding their questions decreases their interest, motivation, and willingness to ask questions afterwards. If I cannot answer a question immediately, I at least try to indicate that I have heard or read it and will cover it later. (AT07)

Children's attitudes and how much they learn in a virtual learning environment are positively affected by a teacher's reflection on their achievements. This reflection can be established by providing students with summative reports (AT01, AT15), in which not only academic results, but also their participation is assessed:

> What can also positively influence the children's work is preparing individual reports. It is time consuming, but it can produce positive results. First of all, in the virtual class, when a child receives such a report, they realise that their individual activity is important. (AT15)

> It is useful to evaluate the student's progress in participation, dealing with specific tasks, and individual and group work. Not least important, however, is to provide them with some comments on what they can improve or change in subsequent sessions. (AT01)

Either in reports or on-going comments, it is better to describe and offer solutions rather than just criticise the negative aspects of a child's work (AT10, AT18).

Six of the respondents indicated that taking account of non-verbal messages promotes a better awareness of students' understanding or attitudes and may thus help the teacher in building more effective interaction. At the same time, non-verbal information can be distorted by a technological medium, so it should only be relied upon when the teacher can be sure of an accurate interpretation.

The teachers find it helpful to make children explicitly aware of the existence of feelings in the virtual environment and to promote emotional expression. Those teachers working in text-based environments consider emoticons especially valuable in supplementing communication with an emotional component when an unambiguous interpretation is ensured (AT02, AT12, AT20, AT33). At the same time, the teachers should clarify ethical issues to the children:

> [The students] feel less responsible for what they say in a virtual environment…they use offensive language more readily. The teacher should explain that virtual words have real effects. (AT11)

Medium

Simultaneous talking was found as having a high potential of disrupting interactions (AT06, AT13, AT17, AT20). At the same time, while six of the respondents – five of whom regularly work in groups of nine and more children – deem it feasible to encourage students to turn off microphones when not talking, two teachers – teaching in classes of two to sixteen students – indicate the opposite (AT04, AT06). Thus, teacher AT04 explained:

> I used to limit the use of the microphones as well, but it did not always work well. Often students forgot to activate the microphone before starting to talk and vice versa. (AT04)

Teacher AT06 outlines the advantages of leaving the microphone on from a different perspective:

> As in traditional classrooms, students need to be allowed to speak any time they want to. It makes sense to ensure that the microphones are on at all times. The teacher…must take measures to ensure their proper use (as well as in the traditional classroom, children may be required to ask for permission or raise their hand before interrupting the teacher). At the same time, it's easier to set a good standard of discipline in the virtual environment, as the teacher can block any channels of communication whenever necessary. (AT06)

Four teachers pointed out the importance for the speaker to be identifiable at all times (AT06, AT13, AT38, AT40), which can be vital in large-sized groups of children (AT13).

Supplementing discussion with text chat was found helpful in obtaining alternative opinions, which students may not wish to express by other means (AT08, AT14):

> I noticed that some children can be reluctant to enter into video or audio-based discussions…However, the same students may be quite active participants when text chat is used. I try to encourage everyone to participate in discussions of any kind, but I also leave chat activated when possible. (AT08)

Presence

A few respondents emphasised that synchronous discussion in a virtual learning environment benefits from participants being perceived of as real people (AT20, AT37). For example, teacher AT20 suggested:

> [In the virtual classroom], although the whole group is present at the same time, everyone remains physically alone, and this inevitably diminishes the quality of the discussion and influences students' participation…To achieve a sense of reality, teachers can describe or show the settings where they are working or even make some of the surrounding sounds audible to the children. In other words, it is useful to create the illusion for the children that they are in the same room as the teacher. (AT20)

The participants need to be introduced to each other in advance or at the beginning of the first session: the teachers and class guests may be well-advised to present themselves to the children when they meet for the first time (AT11, AT12, AT31, AT43), as well as to introduce children who are unfamiliar with each other (AT07, AT37):

> If there is a new child in the class, I start by saying a few words about all the children and describe their positive qualities. Alternatively, I ask all the children to introduce themselves. This is important, because in an unfamiliar environment, children are not willing to participate in class work. (AT37)

It is a good idea for teachers in virtual environments to maximise the times when the children can see them, either by video or image. According to five of the respondents, this reminds the children of the teacher's presence. One respondent (AT05) reported that when there is a teacher's picture shown on the screen, children initiate discussions with the teacher more frequently. On the other hand, for some individual and group activities where the teacher's participation is not required, a higher level of student privacy can be beneficial (AT09).

Seven teachers indicated that referring to each other by name enhances student engagement, emotional expression, connectedness, intimacy, and mutual attention. For this reason, having instructors' and students' names on the screen, especially in newly established groups, is beneficial. Similar effects were indicated by a few respondents (AT05, AT07, AT13) in relation to establishing social and academic relationships between learners and instructors out of the virtual classroom.

Ethics and privacy

Ethics and privacy must be respected at all times with regards to children (AT15, AT21, AT33). Thus, while children may work from their homes, the teacher should analyse how comfortable it is for them to use microphones or cameras:

> On a few occasions I had to forbid the use of video in the [virtual] classroom, because students simply began to watch and discuss each other's rooms. This not only disrupted the lesson, but it also made some children uncomfortable. And some students just turned off their cameras themselves. (AT33)

Sensitive issues ought to be addressed in private so as not to adversely affect children's attitudes to the virtual environment (AT15, AT44, AT45). For the same reason, the teacher should only share privately obtained data with the children's permission (AT15).

4.3.4. Evaluation

To improve the efficiency of instruction in virtual environments, it may be prudent for teachers to analyse the most and the least successful sessions (AT09, AT14, AT17). This analysis can be supplemented by obtaining the children's feedback on the sessions (AT01, AT09, AT28):

> It is useful to review a recorded session and analyse what did and did not work. (AT09)

> The children should be asked for their opinion on the sessions, for they may provide useful data for analysis from their perspective. It may be vitally important to know what the students would like to change in the virtual classroom. As an option, the teacher may send an anonymous survey after a session or conduct a poll. (AT28)

The teachers should then determine and analyse the reasons for the children's disconnection or attrition, as these may be indicative of manageable shortcomings of a technical, instructional, or social nature in the environment (AT02, AT28).

4.4. Transferability of strategies

The following experimental case was presented by a teacher from Belarus who taught the national language and a group of eight of her students. The teacher had had experience of conducting after-class distance sessions in synchronous format to this group of children. By the time of the experiment, the children had been members of the same class for six years and knew each other well. The teacher had known the children for nine months. Previous virtual sessions had been delivered by the teacher using a piece of software that enabled, among other things, two-way video, audio, and text communication, screen sharing, file sending, polling, and session recording.

Based on the experimental case characteristics, 118 strategies were initially identified as relevant. These were drawn from survey cases with characteristics similar to the experimental case. Further, based on the teacher's checklist and observation data, 49 strategies were identified that had not previously been used in the environment. These strategies were recommended for use in the experimental session. Post-observation showed that 32 strategies were ultimately applied by the teacher in the experimental session.

From the teacher's interview data, it was concluded that 23 (71%) of the strategies had had a positive effect on the environment's interactivity, 8 (25%) had a neutral effect on interactivity, and 1 (4%) had a negative outcome (Appendix J). Overall, the teacher perceived the use of the strategies as improving the interactive qualities of learning:

> I could certainly see improvements during this session due to the new strategies, both in terms of the session's development and in terms of the children's work and interplay. And in my perception, this lesson was significantly closer to a lesson in the [traditional] classroom. (BT01)

The children's group interview indicated nine directions in which positive changes related to learning interactivity had occurred: attitude, clarity, content, emotions, interface, interplay, sense of authenticity, stability, and timing. Out of these directions, negatively perceived effects were only found in three areas: clarity, interface, and sense of authenticity. Appendix K provides a summary on the themes revealed in the children's interview data with reference to the most descriptive quotes.

Overall, according to the teacher's and students' interview responses, after the implementation of the new strategies the level of interactivity in the learning environment was raised. Although the experimental stage of the study allowed the examination of only 32 of 154 strategies, it justified the validity of the findings and demonstrated the transferability of the strategies found in similar cases.

5. Discussion and conclusions

5.1. Understanding and implying an active approach to increasing interactivity

5.1.1. Strategies for increasing the interactivity of synchronous distance learning

Interactivity is considered an essential element of successful learning in virtual environments (Chou, 2002; Muirhead and Juwah, 2004; Kobb, 2010). According to major theoretical schools, learning entails changes in either the behaviouristic (Skinner, 1975) or cognitive schemes (Illeris, 2002) of students. Similarly, in an educational context, interactive interplay leads to an alteration of one's actions (Burke, 1982) or challenges one's perceptions (Garrison, 1993). With this in mind, it is arguable that establishing interactive relationships between learners, instructors, and content promotes learning. Analogically, it can be hypothesised that an educationally effective learning environment could be characterised as interactive.

It follows that in order to enhance the effectiveness of synchronous online learning, teachers should take measures to increase its interactivity. However, a close connection between interactivity and learning makes the boundary between interactive and non-interactive effects vague. While some strategies have a relatively direct influence on the level of interactivity in the virtual environment, many lead to interactive effects indirectly or in a deferred manner. This phenomenon explains the existence of a wide range of strategies that can be justly viewed as connected to interactivity.

Roblyer and Wienke (2003) suggest that interactivity is determined by the interplay of social, instructional, and technological factors. Placing this proposition under a broader perspective with an emphasis placed on the concept of interactivity being fundamentally similar across physical and technological environments, the strategies for increasing interactivity can be categorised as instructional (influencing ways of arranging and performing instruction), contextual (affecting demographical and environmental elements of learning), and

environmental (influencing the choice and utilisation of a specific medium). Depending on its nature, one strategy may incorporate characteristics of only one or a few categories. Moreover, as long as interactivity is considered a function of instruction and learning (Wagner, 1994), strategies related to any of the categories may indicate both actions of the teacher or features of the medium, and specific behaviours of the learners.

Applying strategies to increase the interactivity of synchronous learning in virtual environments should begin in advance of the sessions. As soon as the initial learning conditions are known, appropriate preparatory strategies can be selected and followed. Consequently, having prepared and planned a learning session to promote interactivity, teachers may then uncover more of the environment's interactive potential by shifting from a 'subconscious' instruction towards deliberate teaching enhanced by proper strategic decisions. Achieving a sufficient level of interactivity promotes a lesson's fluency, which makes synchronous distance learning focused less on the environment and more on constructing a productive interplay between the class members.

Online learning by its fundamental educational principles is similar to traditional learning (Ally, 2007). In line with this assumption, the study showed that instead of relying on systematically chosen strategies, teachers dealing with synchronous distance learning can find it effective to rely on traditional instructional methods and to enhance them according to their personal experience and on-going adjustment to what works best. However, even seemingly effective synchronous learning benefits from adherence to a set of interactivity-enhancing strategies deliberately chosen in accordance with the environment's characteristics. Thus, the experiment conducted in this study proved this assumption by demonstrating that slight, yet appropriate changes in a teacher's approach to instruction may increase the interactive characteristics of virtual learning environments.

It follows that the effectiveness of learning can be enhanced if a teacher, moving from a traditional to a synchronous distance form of instruction, has access to training on the choice and application of strategies for increasing the interactive qualities of virtual learning environments. Furthermore, when interactivity involves both teaching and learning, proper training is essential for the children, too.

5.1.2. The role of learning conditions

Although applying specific strategies in a learning environment (either virtual or traditional) may lead to increasing its level of interactivity, reliable predictions about the extent of such effects can only be made provided the environment's learning conditions are taken into account. While there are universal strategies for increasing interactivity, others are only effective under specific learning conditions. These conditions determine a potential, maximum level of interactivity in the environment, which can be reached provided appropriate strategies are carefully selected and efficiently followed.

Obviously, learning environments exist under a multiplicity of learning conditions, and teachers may apply more than one strategy at a time. Interactivity is, in turn, dependent on the interplay of the entire set of factors influencing the environment (Roblyer and Wiencke, 2004). The ultimate level of interactivity, therefore, is not simply a sum of separate values; rather it is a characteristic constituted of complex combinations of learning conditions and sets of strategies.

In the 'ideal' environment in interactivity terms, the combination of learning conditions maximises the highest possible level of interactivity, and the instructor's strategies fit these learning conditions perfectly. In this case, changing a 'perfect' set of strategies leads to diminishing the actual interactivity level without lowering the environment's interactive potential. On the other hand, altering a combination of learning conditions may entail a decrease in the maximum interactivity level that can be achieved. Furthermore, contrary to the 'ideal' case, a zero level of interactivity can be noted if either no interactive learning conditions are present or no appropriate strategies are followed (e.g. no internet connection in a purely videoconference-based environment, or the teacher is using audio conferencing to deliver content to students who do not have audio devices).

It is clear that the implementation of certain strategies can, and often presupposes, subsequent changes to the environment's conditions. Thus, for instance, training students on how to work in the virtual classroom entails changing the learner's proficiency in using the medium and thus modifies the initial learning conditions of the environment. Once the conditions have been changed, to maintain or increase the level of interactivity, the teacher should reconsider the methods he or she employs. In order to maximise interactivity when applying new strategies in

a learning environment, it is necessary to recursively review the environment's learning conditions that are affected to ensure that any strategies are applied appropriately.

5.2. Study limitations and directions for further research

Despite the fact that the study's aims were achieved and research questions were comprehensively answered, the ultimate findings have a set of limitations that indicate directions for further research in the field.

Firstly, while a purposive sampling strategy allowed the disclosure of interactivity-related strategies from cases covering all the distinctive characteristics of virtual learning environments drawn from the literature analysis, the study did not cover every possible combination of these characteristics. This means that comprehensive as it is, the list of discovered strategies cannot be considered complete, for further strategies could be found in studies of alternative, less common cases of synchronous learning in virtual environments. Nevertheless, as the majority of the strategies (93%) that emerged from the survey's data were confirmed by at least two cases, it can be claimed that the necessary data saturation has been successfully achieved.

Secondly, this study did not aim to measure the extent of the influence that specific strategies used by teachers have on the interactivity of synchronous learning in virtual environments across a variety of learning conditions. Although the interactivity-related effects of each revealed strategy were confirmed by at least one case, using purposive sampling did not enable a justification of the relative importance of one strategy over another, or a likely difference in a strategy's effects across distinctive learning conditions. Therefore, in order to evaluate the relevant significance of the strategies, a comparative analysis is required.

Thirdly, while specific disclosed strategies were found most appropriate to certain learning conditions, their transferability to cases with different learning conditions was not examined. Consequently, the potential effects that the strategies may have on interactivity in synchronous learning environments with alternative learning conditions need to be further assessed.

Finally, aiming to actively examine the applicability of the strategies across cases with similar learning conditions by applying them to a case where they had not been previously implemented, the experimental study could not cover the whole range of the revealed strategies, as not all of them had been relevant to the settings of the experimental learning environment. Besides, given that the experimental data reflected on a single intervention session, the implemented strategies were examined only on their short-term effects. Hence, there is a need for further, detailed evaluation of both the short and long-term effects of the revealed strategies and their combinations on the interactivity of synchronous learning in virtual environments.

5.3. Conclusion

Interactivity is a key element of successful synchronous distance learning, influencing students' achievements, satisfaction and motivation. The level of interactivity is highly dependent on the initial learning conditions of an environment. At the same time, the interactive potential of learning environments may only be fully revealed by means of a pertinent choice and application of interaction-enhancing strategies. While some of these strategies can be universally applied across a variety of environments, others may only benefit interaction under specific learning conditions. Building interactivity is a prolonged process, so the application of strategies should begin prior to the learning sessions and should not stop as soon as the sessions finish.

Synchronous distance learning, in a way, can be compared to learning through a wall: the individuals are very close but are also separated; they all work in one common environment while staying on their own; their communication is live and synchronous but, at the same time, is mediated and restricted. This wall describes the technical mediums, the characteristics of which may significantly vary, thus determining the environment's interactivity limitations, as well as its potential. In order to increase learning interactivity and effectiveness, teachers need to adhere to strategies to overcome the medium's restrictions and reveal its interactive potential. Ultimately, children's learning experiences in the virtual environment can only be enhanced provided the technology, content, and class members support each other and co-exist in harmony.

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Appendices

A. The concept of the virtual classroom

Though a vast amount of research has addressed the notion of the virtual classroom, there is a distinct lack of clarity and inconsistency in its definition. Thus, some authors (e.g. Graziadei et al., 1997; Powers et al., 1999; Ashkeboussi, 2001; Aydin and Yuzer, 2006; Adewale, 2012) make no explicit distinction between the concepts of the virtual classroom and a virtual learning environment, or simply use these terms interchangeably. Others, when addressing the notion of the virtual classroom, do not give a clear definition to this concept, yet still regard it as being connected or equal to distance learning (Beem, 2010) or a virtual learning environment (Little, Titarenko and Bergelson, 2005; Taylor and McQuiggan, 2008; Stuber-McEwen, Wiseley and Hoggatt, 2009). Few authors associate the virtual classroom with predominantly asynchronous forms of distance learning, e.g. Imig, 2010.

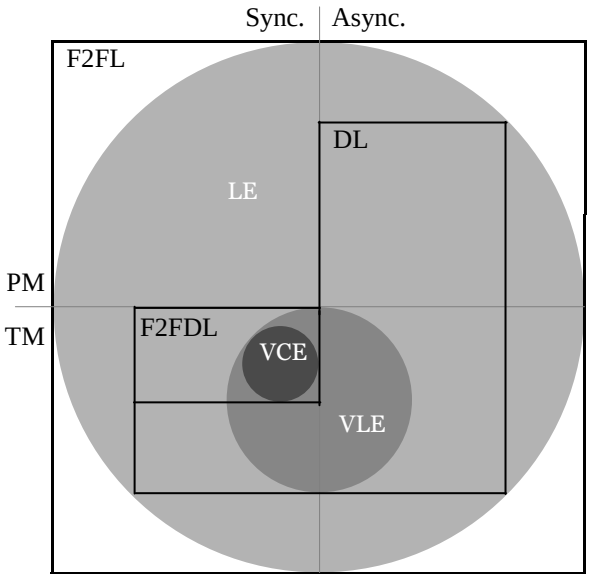
Accroding to Rajasingham (1996: 33), "a classroom is a communication system that makes it possible for a group of people to come together with the intention of learning something" (in Falck et al., 1997: 216). This means that the traditional classroom can be viewed as a medium that allows for instruction to be delivered through lecturing and participants' interactions (Ashkeboussi, 2001). In the virtual classroom, the computer takes the mediating role, providing access to learning and teaching practices available in the traditional classroom (Hiltz, 1986; Hsu, Marques, Khalid Hamza and Alhalabi, 1999). Falck et al. (1997: 216) infer that the virtual aspect suggests "the environment creates for us an illusion as if we were in the real world…and the virtual classroom 'feels and works like a real classroom' in effect".

Clark and Kwinn (2007) point out two key similarities between face-to-face learning and distance learning in virtual classrooms. The first is that an instructor is present in the environment at the same time as the students. Another similarity is the high level of social presence in the classroom, compared to levels of sociality in asynchronous forms of learning. Clark and Kwinn define social presence as "the extent to which the learning environment offers opportunities for social interactions, including hand shaking, eye contact, smiles, puzzled

looks, verbal exchanges, and so forth" (9). They also mention that despite the similarities mentioned, the virtual classroom is void of the body language available in face-to-face environments; however, this statement will be challenged in the discussion below on technology's capacity to transmit non-verbal signals. At the same time, physical interaction, which is inherent in the traditional classroom (Kreijns et al., 2011), has not yet been established in virtual settings, so the virtual classroom can only partly reconstruct the traditional classroom environment, which approaches but does not achieve the highest level of social presence.

It can be summarised that the virtual classroom is a form of virtual learning environment that allows real-time interactions to be established at a level closely approaching the standard of interactions available in face-to-face settings. Consequently, it is arguable that virtual classrooms take the intermediate place between face-to-face and distance environments, allowing for the notion of *'face-to-face' distance learning* (Figure 2).

Figure 2 – Forms of learning and types of learning environments



Sync. – synchronous learning
Async. – asynchronous learning
PM – learning through physical medium
TM – learning through technological medium
F2FL – face-to-face learning
DL – distance learning
F2FDL – 'face-to-face' distance learning
LE – learning environment
VLE – virtual learning environment
VCE – virtual classroom environment

The fact that both the instructor and the students meet in the virtual classroom at a designated time (Parker, Grace and Martin, 2010) highlights the synchronous nature of the environment. However, due to inconsistencies surrounding the definition of this term, it seems to be good practice to explicitly specify which form of instruction is involved before the term is used. Some authors (Graziadei et al., 1997; Aydin and Yuzer, 2006; Roblyer et al., 2007; Lonie and Andrews, 2009; Martin et al., 2012) do this by distinguishing between 'synchronous' and 'asynchronous' virtual classrooms or virtual learning environments. At the same time, instruction, rather than the environment, can be defined as synchronous or asynchronous (Clark and Gibb, 2006; Lu, 2011). Therefore, when specifying what kind of learning is meant when the concept of the virtual classroom is used, the term 'interactivity' should characterise the type of *learning*, rather than the type of *environment*.

Based on the analysis of relevant literature, this study views the virtual classroom as a form of virtual learning environment in which a synchronous form of learning is implemented.

B. Characteristics of interactive events

Characteristics of interactive events	
Direction*	Learner-Content [1][3][4]** Learner-Instructor [1][3][4] Learner-Learner [1][3][4] Learner-Interface [2][3][4]
Nature	Socio-Emotional/Social [4] Technical [5] On-Task/Off-task [4][5] Explicit/Implicit [31]
Channels	Body language/facial expressions/other visual cues [19][24][25] (visual) Vocal intonations/cues [19][24] (audial) Physical contact [26] (physical) Smell [26] (olfactory)
Role	Procedural [6][7] Expository [6][7] Explanatory [6[[7] Cognitive [6][7]
Criteria	Rate/Duration [31] Lag time/Timely response/Immediacy [4][9][17][24][25] Coherence (perceived instructional value)/Productivity [8][9] Relevance [5][12] Flexibility [12] Accessibility [20] Understanding [16] Complexity [17] Privacy [23][21] Quality [5]
Indicators of interactive events	
Indicators	Learner engagement / Participation [4][5][8][28] Instructor engagement [4][8] Understanding/Clarity [5][11] Intimacy [14][15] Emotional expression [16][17][19] Efficiency of group work [16] Co-presence/Connectedness/Sense of community [5][16][21][22][27] Mutual attention [16] Realism [18] Self-disclosure [5][19]

	Continuing a thread/Quoting/Referring [19] Asking questions [5][19] Expressing views about others' messages [19] Building on previous learning experience [29] Co-encouragement [5]
Interactive actions	
Procedures	Evaluation [10] Management [10][30] Resource support [10] Ethics [10][30]
Activities	Presentation/Individual activities [5][12] Reflection/Clarification/Inference/Judgement [5][12][31][32] Experimenting [12] Informative feedback/Commenting [12][24][31][32] Self-assessment [12] Peer-evaluation [12] Observation and imitation [13] Collectiveness/Group work/Discussion/Debate [5][16][32] Scaffolding [32] Sharing [32] Individual and group responses/Using names [5]
Events	Gaining attention (reception) [29] Informing learners of the objective (expectancy) [29] Stimulating recall of prior learning (retrieval) [29] Presenting the stimulus (selective perception) [29] Providing learning guidance (semantic encoding) [29] Eliciting performance (responding) [29] Providing feedback (reinforcement) [29] Assessing performance (retrieval) [29] Enhancing retention and transfer (generalization) [29]

* The category was altered during data analysis and ultimately included the following items: Learner ↔ Content, Learner ↔ Instructor, Learner ↔ Learner, Instructor ↔ Content, Instructor ↔ Instructor, and Content ↔ Content.

** Sources:
[1] Moore, 1993
[2] Hillman, Wills and Gunawardena, 1994
[3] McBrien, Jones and Cheng, 2009
[4] Chou, 2002
[5] Schullo, 2005
[6] Offir and Lev, 2000

[7] Wei, 2002
[8] Roblyer and Wiencke, 2004
[9] Yacci, 2000
[10] Kahn, 2001
[11] Giossos et al., 2009
[12] Sahin, 2008
[13] Bandura, 1986
[14] Short, Williams and Christie, 1976
[15] Argyle and Dean, 1965
[16] Kim, 2011
[17] Tu and Mclsaac, 2002
[18] Tung and Deng, 2006
[19] Rourke et al., 1999
[20] Biocca and Harms, 2002
[21] Henninger and Viswanathan, 2004
[22] Swan and Shih, 2005
[23] Tu, 2001
[24] Wei, 2012
[25] Ko, 2012
[26] Kreijns et al., 2011
[27] Parker and Martin, 2010
[28] Rose, 1999
[29] Kahveci, 2007
[30] Wagner, 1994
[31] Henri, 1992
[32] Zhu, 1996.

C. Teachers' questionnaire

[Part 1]

Do you have experience of distance teaching and technology that allows you and your students to be present in the virtual classroom at the same time?*
[ ] No [ ] Yes, irregular / a few sessions [ ] Yes, regular / many sessions

* i.e. you deliver lessons distantly, communicating with multiple students all interacting at the same time by means of computer, webcam, and microphone through the Internet or other computer network.

Are these technologies used in your regular distance sessions?

Video:	( ) yes, by the teacher	( ) yes, by both the teacher and students	( ) no
Audio:	( ) yes, by the teacher	( ) yes, by both the teacher and students	( ) no
Text:	( ) yes, by the teacher	( ) yes, by both the teacher and students	( ) no
Screen demonstration:	( ) yes, by the teacher	( ) yes, by both the teacher and students	( ) no

What is the average quality of the internet connection in your distance sessions?
( ) High ( ) Low ( ) Changeable

How many students are usually in your distance session groups?
[ ] 1 [ ] 2 to 8 [ ] 9 to 16 [ ] more than 16

To children of what educational level do you usually deliver distance sessions?
[ ] Pre-school [ ] Primary school [ ] Secondary school

How well do you and the students in your distance learning groups know each other?
[ ] The children and I know each other well
[ ] The children know each other well, but I do not
[ ] The children do not know each other, but I know most of them
[ ] None of us know each other well

[Part 2]

Please describe one of your typical distance lessons in your own words.
(Use as many words as you wish. You might like to include aims, contexts, conditions, arrangement issues, length, technologies and software used, etc.)

Which strategies (methods) do you think improve your lessons and in what way?

Which strategies (methods) do you think interfere with your lessons and why?

D. Teacher’s checklist template

Please tick all strategies that you follow in your practice of teaching in virtual environments with a synchronous mode of learning.

Strategy	**Comments**
[ ] Strategy 1	
[ ] Strategy …	
[ ] Strategy 154	

E. Observation protocol template

Strategy	**Evidence observed (time)**	**Observer comments**
[ ] Strategy 1		
[ ] Strategy …		
[ ] Strategy 154		

F. Interview schedule

Teacher’s interview: opening question:

What do you think has changed since the implementation of the new strategies?

[Discuss the effects of each observed strategy separately.]

Children’s interview: guiding questions

What changes have you noticed in this lesson compared to your previous lessons?

What was better in this session compared to previous sessions?

What was worse in this session compared to previous sessions?

G. Comparative description of the survey cases

Case IDs	Way of data transmission				Connection quality			Number of children			Participant familiarity in the sessions					Level of education			Specific features		
	Screen	Video	Audio	Text	High qual. connection	Low qual. connection	1 child	2 to 8 children	9 to 16 children	More than 16 children	Everyone knows each other	Children know each other	Teacher know the children	No one knows each other	Mixed or varied groups	Preschool	Primary school	Secondary school	Guest participation	Intercultural participants	Local and remote children
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
AT01	V	V	V	V	V	V	V	V	V		V							V			
AT02	V	V	V	V	V	V	V	V			V	V	V	V	V		V	V			
AT03	V	V	V	V	V	V	V	V			V						V				
AT04	V	V	V	V	V	V	V	V			V							V			
AT05	V	V	V	V	V	V		V	V		V							V	V		V
AT06	V	V	V	V	V	V		V	V		V						V	V			
AT07	V	V	V	V	V	V		V	V				V					V	V		V
AT08	V	V	V	**?**	V	V		V	V						V		V	V	V		V
AT09	V	V	V	V	V	V		V	V						V			V		V	
AT10	V	V	V	V	V	V		V			V							V			
AT11	V	V	V	V	V	V		V				V						V			
AT12	V	V	V	V	V	V		V							V			V	V	V	V
AT13	V	V	**V**	V	V	V			V	V					V		V		V		V
AT14	V	V	V	V	V	V			V		V							V	V		
AT15	V	V	V	V	V		V	V			V							V			
AT16	V	V	V	V	V		V				V							V			
AT17	V	V	V	V	V				V		V							V			
AT18	V	V	V	V		V	V	V			V						V	V			
AT19*	V	V	**?**	**?**		V	V				V							V	**?**	**?**	**?**
AT20	V	V	V	V		V		V			V							V	V		
AT21	V	V	V		V	V		V			V						V				
AT22	V	V	V		V		V				V						V				
AT23	V	Vt	Vt	V	V	V	V	V							V			V			
AT24	V	Vt	Vt	V	V	V		V	V		V						V		V		
AT25	V	Vt	Vt	V	V	V				V	V							V			
AT26	V	Vt	Vt		V	V	V	V			V	V		V	V	V	V				

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
AT27	V	Vt	V		V	V	V				V			V		V					
AT28	V		V		V		V	V			V						V				
AT29	Vt	Vt	V	V	V	V		V			V						V		V		
AT30	Vt	Vt	V			V	V				V						V				
AT31	Vt	Vt	Vt	V	?	?		V						V	V		V	V		V	
AT32	Vt	Vt	Vt	V	V	V	V	V	V	V	?	?	?	?	?		V			V	
AT33		V	V	V	V	V		V			V							V	V		
AT34		V	V	V	V		V				V							V			
AT35		V	V		V		V				V							V			
AT36			V	V	V	V	V	V	V		**V**	**V**	**V**	**V**	**V**			V	**V**	**V**	**V**
AT37			V	V	V	V	V	V			V		V		V			V			
AT38			V	V	V	V		V	V		V							V	V		
AT39			V	V	V	V		V			V						V				
AT40			V	V	V	V				V	V							V	V		
AT41*			V	V	V		V				V							V			
AT42*			V		V			V			V							V			
AT43			V			V	V				V			V			V				
AT44			Vt	V	V		V	V			V							V			
AT45				V	?	?		V	V	V	V							V	**V**	**V**	**V**
AT46*				V	V	V	V				V							V			
AT47*				V	V	V		V			V							V			
AT48				V		V		V	V						V		V			V	

V – the characteristic is present in the case with relevance to both students and teacher

Vt – the characteristic is present in the case with relevance to the teacher only

* – no strategies were indicated by these cases.

H. CUREC approval email

17 May 2013 10:05
Subject: **Approval: CUREC Ivan Katlianik**
From: **Catherine Walter** <[redacted]@education.ox.ac.uk>
To: **Ivan Katlianik** <[redacted]@education.ox.ac.uk>
Cc: **Chris Davies** <[redacted]@education.ox.ac.uk>,
Education Research Office <[redacted]@education.ox.ac.uk>

Dear Ivan,

Application Approval

Title: The characteristics of synchronous interaction between children and teacher in virtual learning environments

The above application, as per the attached documents, has been considered on behalf of the Departmental Research Ethics Committee (DREC) in accordance with the procedures laid down by the University for ethical approval of all research involving human participants.

I am pleased to inform you that, on the basis of the information provided to DREC, the proposed research has been judged as meeting appropriate ethical standards, and accordingly, approval has been granted.

If your research involves participants whose ability to give free and informed consent is in question (this includes those under 18 and vulnerable adults), then it is advisable to read the following NSPCC professional reporting requirements for cases of suspected abuse

http://www.nspcc.org.uk/Inform/research/questions/reporting_child_abuse_wda74908.html

NB Please check with the Research Office that the Belarusian translations in these documents are all readable; some of them are apparently not in unicode and may not survive emailing between different computer systems. It is your responsibility to make sure that a readable version is deposited with the Research Office.

Should there be any subsequent changes to the project which raise ethical issues not covered in the original application you should submit details to research.office@education.ox.ac.uk for consideration.

Good luck with your research study.

Yours sincerely,
Catherine Walter
Member of DREC

I. List of strategies for enhancing the interactivity of synchronous distance learning

Strategy		Relevant / irrelevant conditions	Supporting cases	Contra-dictory cases
1		2	3	4
Preparation and training				
1	minimise the class size	*Irrelevant conditions:* one-way communication *and/or* text-based environment	AT01, AT02, AT08, AT13, AT18, AT25, AT36, AT38	AT14, AT24, AT32
2	ensure interface accessibility and usability		AT02, AT06, AT13, AT21, AT22, AT26, AT27, AT45	
3	arrange adult's technical assistance for children	*Relevant condition:* younger children	AT13, AT16, AT22, AT25, AT26, AT27, AT30, AT32	
4	be aware of technological conditions for all children		AT08, AT09, AT13, AT17, AT25, AT27, AT29	
5	ensure all children have their own supplementary materials	*Relevant condition:* using supplementary materials	AT06, AT15, AT24, AT28, AT34, AT48	
6	turn on and set up the medium 10-15 minutes prior to the session		AT03, AT12, AT14, AT31, AT33, AT44	
7	maximise the image of the teacher's face	*Relevant condition:* using video	AT01, AT04, AT22, AT24, AT31, AT32	
8	check the correctness and quality of all supplementary materials	*Relevant condition:* using supplementary materials	AT01, AT06, AT15, AT24, AT34	
9	reduce background noises	*Relevant conditions:* poor connection *and/or* poor audio recording devices	AT01, AT06, AT20, AT22, AT30	
10	reduce external distractive factors		AT01, AT06, AT20, AT22, AT30	
11	leave teacher’s contact information for all children		AT01, AT09, AT12, AT25, AT34	
12	introduce new technologies, tools, and methods gradually		AT01, AT13, AT17, AT27, AT33	

1		2	3	4
13	establish clear rules for virtual classes		AT03, AT04, AT18, AT21, AT33	
14	be prepared for disconnection	*Relevant condition:* poor connection	AT08, AT09, AT18, AT20, AT32	
15	encourage the use of large screens		AT01, AT20, AT22, AT31	
16	set up proper lighting	*Relevant condition:* using video	AT01, AT20, AT22, AT31	
17	discuss the environment's limitations with children		AT02, AT05, AT09, AT45	
18	upload supplementary materials in advance	*Relevant condition:* using supplementary materials	AT06, AT15, AT24, AT34	
19	ensure the quality of guests' connections are sufficient	*Relevant condition:* remote presenter	AT08, AT22, AT29, AT36	
20	be aware of the limitations of children's physical settings		AT08, AT25, AT27, AT29	
21	have emergency tasks prepared		AT09, AT24, AT26, AT28	
22	ensure all class members have the necessary technical skills		AT13, AT16, AT24, AT26	
23	use existing and proven teaching materials		AT15, AT31, AT37, AT44	
24	avoid distractive medium designs and interface elements		AT01, AT22, AT30	
25	place camera in front of the face	*Relevant condition:* using video	AT01, AT22, AT31	
26	encourage children to maintain an appropriate work environment		AT02, AT06, AT22	
27	establish a set of emergency commands that must be followed		AT03, AT04, AT33	
28	conduct at least one introductory virtual session		AT03, AT08, AT17	
29	promote using sound-isolating headphones	*Relevant condition:* using audio	AT06, AT30, AT39	
30	agree with guests on the session’s schedule	*Relevant conditions:* remote presenter	AT07, AT14, AT24	

1		2	3	4
31	set and test signal transition parameters prior to learning sessions		AT08, AT17, AT25	
32	avoid small details and patterns on the screen	*Relevant conditions:* poor connection *and/or* small screens	AT09, AT25, AT28	
33	utilise large graphical elements		AT09, AT25, AT28	
34	use sound isolating headphones in a room with more than one student	*Relevant conditions:* using audio *and* student's allocation in one physical room	AT05, AT08, AT13	
35	establish mood with the design of the medium	*Relevant condition:* younger children	AT18, AT21, AT26	
36	use a high resolution camera	*Relevant condition:* using video	AT01, AT31	
37	use accessible forms of a medium		AT02, AT14	
38	use high quality audio recording device	*Relevant condition:* using audio	AT06, AT39	
39	set the medium's signal quality according to the technical characteristics of the less advanced computers in the class		AT08, AT17	
40	maximise the lowest quality of connection in the environment	*Relevant condition:* varied levels of connection	AT17, AT32	
41	deal with technological issues out of session		AT25, AT28	
42	place camera at a distance and use zoom	*Relevant condition:* using video	AT01	
Structure, content, and management				
43	employ group work	*Relevant conditions:* large-sized classes *and/or* local and remote students *and/or* newly introduced children	AT02, AT04, AT07, AT13, AT14, AT17, AT24, AT25, AT32, AT38, AT40, AT45, AT48	AT26

1		2	3	4
44	be adaptive and dynamic in choosing methods and tools		AT01, AT02, AT07, AT08, AT09, AT11, AT15, AT21, AT25, AT32	
45	encourage children to ask short questions in text	*Relevant condition:* availability of text messaging	AT07, AT13, AT17, AT29, AT39, AT40	AT29
46	objectively estimate the amount of content that can be delivered		AT14, AT18, AT25, AT26, AT31, AT39	
47	set flexible time boundaries in planning activities		AT18, AT25, AT30, AT33, AT35, AT44	
48	make ethical considerations		AT02, AT09, AT13, AT22, AT29	
49	plan and arrange post-session activities		AT03, AT12, AT31, AT33, AT44	
50	establish logical connections between pieces of information		AT07, AT11, AT11, AT32, AT35	
51	determine, and avoid exceeding, a reasonable level of instruction pace		AT09, AT13, AT17, AT32, AT33	
52	simplify technological components		AT26, AT27, AT28, AT39, AT44	
53	constantly check the quality of connection	*Relevant condition:* varied connection quality	AT02, AT07, AT20, AT25, AT32	
54	enable students to leave questions after the session		AT01, AT09, AT23, AT31	AT01
55	promote tasks that are interactive in nature		AT02, AT15, AT21, AT32	
56	make the beginning of the sessions clear		AT03, AT22, AT27, AT48	
57	invite guests to sessions		AT05, AT14, AT20, AT38	
58	combine familiar and unfamiliar children in one group	*Relevant conditions:* local and remote groups of students *and/or* unfamiliar children	AT07, AT08, AT12, AT13	
59	ensure each raised question is solved		AT07, AT11, AT11, AT35	
60	actively encourage all students to participate		AT08, AT09, AT13, AT21	

1		2	3	4
61	let students see the progress/structure of the lesson		AT09, AT11, AT35, AT45	
62	provide equal opportunities for participation to all children		AT09, AT12, AT13, AT27	
63	have ways of contacting any student at any time during activities		AT09, AT13, AT29, AT33	
64	control the progress of the least advanced students		AT09, AT14, AT30, AT32	
65	adhere to the session plan and structure		AT11, AT17, AT30, AT44	
66	keep the session focused		AT11, AT17, AT44	
67	assign presenter roles to children		AT11, AT25, AT28	
68	don’t leave the classroom	*Relevant conditions:* large-sized classes *and/or* younger children	AT13, AT17, AT26, AT27	
69	deny access to features not being used or being used inappropriately		AT14, AT18, AT25, AT27	
70	leave up to 30% of sessions time unreserved for any activity		AT14, AT18, AT25, AT31	
71	share and discuss the results of group work with the whole class		AT01, AT17, AT24	
72	allow children to stay in the virtual classroom after the session ends		AT01, AT33, AT44	
73	record all sessions and provide the students with access to them		AT02, AT18, AT32	
74	pay attention to children's non-verbal activities		AT02, AT37, AT38	
75	use text chat to clarify information	*Relevant conditions:* poor connection *and/or* poor audio recording devices	AT05, AT18, AT32	

1		2	3	4
76	imply various external tools		AT06, AT17, AT29	
77	utilise different types of supplementary materials	*Relevant condition:* using supplementary materials	AT06, AT17, AT29	
78	rely on traditional classroom strategies as long as they facilitate sessions		AT09, AT14, AT27	
79	take children's attention off technology		AT09, AT26, AT28	
80	assign group leaders		AT12, AT14, AT21	
81	minimise the amount of content		AT14, AT18, AT26	
82	combine motivated and unmotivated children in one group		AT14, AT21, AT28	
83	provide direct links to external tools and supplementary material	*Relevant condition:* using supplementary materials	AT14, AT22, AT48	
84	have a clock on the screen or use some other reminder for deadlines		AT15, AT24, AT25	
85	only assign tasks that can be completed by all children		AT16, AT24, AT26	
86	prioritise audio quality	*Relevant condition:* using audio	AT18, AT21, AT30	
87	be sensitive in addressing technical issues on a child's side		AT20, AT25, AT30	
88	encourage students not to run irrelevant software during sessions	*Relevant condition:* poor connection	AT20, AT40, AT43	
89	reply to a few messages at a time		AT34, AT39, AT45	
90	stimulate interactions at the beginning of lesson		AT02, AT20	
91	be attentive to off-task text chat messages		AT04, AT14	
92	enable children to use chat at all times where possible	*Relevant condition:* availability of text messaging	AT05, AT09	

1		2	3	4
93	change the composition of groups	*Irrelevant conditions:* purposive groups formation *or* difficulties in rearranging groups	AT05, AT14	AT21
94	limit one form of work to 10-15 minutes or break it into parts		AT08, AT21	
95	make short brakes during sessions	*Irrelevant conditions:* effective work is established, *and* large-sized classes *and/or* small children	AT08, AT21	AT13, AT26
96	replace questions with polls when possible	*Relevant condition:* availability of polling	AT09, AT14	
97	continuously ensure that children are focused on the session		AT11, AT45	
98	assign individual tasks to children going ahead or behind the plan		AT13, AT14	
99	help guests to work with children	*Relevant condition:* remote presenter	AT14, AT20	
100	change group leaders		AT14, AT21	
101	save chat history	*Relevant condition:* availability of text messaging	AT18, AT32	
102	make use of the phone when appropriate		AT20, AT24	
103	avoid external tools	*Relevant conditions:* younger students *and/or* poor connection	AT22, AT24	
104	devote equal time to distant and local children	*Relevant condition:* local and remote groups of students	AT05	
105	provide equal treatment to distant and local children	*Relevant condition:* local and remote groups of students	AT05	
106	give children time away from the teacher		AT06	AT27, AT21

1		2	3	4
107	adopt the facilitative approach over instructional		AT11	
108	prioritise connection stability over quality	*Relevant conditions:* poor connection *or* varied connection	AT13	
109	respond in text to save the message for future reference	*Relevant condition:* availability of text messaging	AT18	
110	assign expert and learner roles to children based on their achievements		AT21	
Interplay and communication				
111	call children by name		AT05, AT08, AT12, AT27, AT31, AT38, AT40	
112	be aware and make use of nonverbal messages	*Relevant conditions:* good connection, *and* good video devices *or* good audio devices	AT02, AT08, AT12, AT13, AT20, AT37	
113	be responsive		AT02, AT09, AT17, AT21, AT26, AT27	
114	children aware that feelings exist in virtual environments		AT02, AT08, AT12, AT20, AT26, AT37	
115	constantly check for understanding		AT03, AT13, AT18, AT27, AT38, AT48	
116	encourage turning off microphones when not speaking	*Relevant condition:* using audio	AT06, AT12, AT13, AT17, AT36, AT40	AT04, AT06
117	quote only relevant passages of students' messages and refer explicitly to the sender when replying		AT02, AT13, AT25, AT33, AT40	
118	make children see you or your picture		AT04, AT05, AT24, AT30, AT32	AT09
119	have names on the screen		AT05, AT08, AT12, AT31, AT40	
120	establish a reasonable level of intimacy		AT01, AT05, AT27, AT38	

1		2	3	4
121	use abbreviations and emoticons	*Relevant condition:* using text messaging	AT02, AT12, AT20, AT33	
122	look into camera when speaking	*Relevant condition:* using video	AT04, AT05, AT23, AT32	
123	reduce simultaneous talking	*Relevant condition:* using audio	AT06, AT13, AT17, AT20	AT04, AT45
124	ensure the speaker is identifiable at all times	*Relevant conditions:* using video *and/or* using audio *and/or* using text messaging	AT06, AT13, AT38, AT40	
125	enable students to ask questions		AT07, AT09, AT31, AT32	
126	maintain positive attitudes and relationships		AT08, AT17, AT18, AT20	
127	promote expressing feelings and emotions		AT08, AT20, AT26, AT37	
128	present yourself to the children	*Relevant condition:* a teacher unfamiliar to the students	AT11, AT12, AT31, AT43	
129	be accessible to the children		AT03, AT07, AT31	
130	Remind the children that you can support them		AT03, AT07, AT31	
131	imply effective questioning and listening		AT03, AT17, AT38	
132	establish social and academic relationships offline	*Relevant conditions:* long-term courses *and/or* one-way communication	AT05, AT07, AT13	
133	promote communication rather than discussion		AT07, AT10, AT35	
134	use private chat for discussion on sensitive issues	*Relevant condition:* availability of private messaging	AT15, AT44, AT45	
135	respect children's privacy		AT15, AT21, AT33	
136	express a positive attitude to the environment		AT18, AT20, AT30	
137	provide children with summative reports	*Relevant condition:* long-term courses	AT01, AT15	

1		2	3	4
138	provide a private messaging option	*Relevant condition:* availability of private messaging *Irrelevant condition:* learners are easily distracted	AT06, AT38	AT20, AT45
139	continuously analyse the class' attitude		AT07, AT10	
140	present unfamiliar children to each other prior to their first session	*Relevant conditions:* local and remote groups of students *or* unfamiliar children	AT07, AT37	
141	supplement discussion with a text chat to obtain alternative opinions	*Relevant condition:* availability of text messaging	AT08, AT14	
142	describe rather than criticise misbehaviour		AT10, AT18	
143	be a member rather than a teacher		AT12, AT38	
144	discuss off-session questions in the session		AT15, AT32	
145	enable students to use webcams in local groups	*Relevant condition:* local and remote groups of students	AT17, AT33	
146	keep verbal and visual communication short	*Relevant conditions:* poor connection, *or* poor video devices, *or* poor audio recording devices	AT18, AT20	
147	encourage students to view all participants as real people		AT20, AT37	
148	evaluate both academic results and children's participation		AT03	
149	employ peer-evaluation		AT10	
150	share privately obtained data only upon children's permission		AT15	

1		2	3	4
Evaluation				
151	control and analyse children's absence		AT03, AT28, AT32, AT36, AT47	
152	obtain children's feedback on sessions		AT01, AT09, AT28	
153	devote time to analysing the most and least successful sessions		AT09, AT14, AT17	
154	find out reasons for children's disconnection or attrition		AT02, AT28	

J. List of experimentally examined strategies and their effects

Strategy	Previous experience		Experiment		Interactivity effect	
	Reported	Observed	Examined	Observed	Nature	Comments
1	**2**	**3**	**4**	**5**	**6**	**7**
1						
2						
4	V					
5	V	V				
6			V	**V**	+	
7			V	**V**	=	
8	V					
9			V	**V**	+	
10	V					
11	V					
12			V			
13			V			
14			V	**V**	+	
15			V			
16			V			
17	V					
20			V	**V**	=	
21	V	V				
22	V	V				
23			V	**V**	+	
24		V				
25		V				
26			V			
27			V	**V**	+	
28	V					
29			V	**V**	+	
32	V	V				
33	V	V				

1	2	3	4	5	6	7
36			V	**V**	=	insufficient connection quality
37			V			
38		V				
41			V			
42			V			
43	V	V				
44	V	V				
45			V			
46	V					
47	V	V				
48	V					
49			V			
50	V	V				
51	V	V				
52			V	**V**	+	
53			V	**V**	+	
54			V	**V**	+	
55	V	V				
56	V					
57	V					
60	V	V				
62	V	V				
63	V	V				
65	V					
67	V	V				
69	V					
70			V	**V**	+	
71	V	V				
72	V	V				
73	V	V				
74	V					
75			V	**V**	+	
76	V					
79			V			
80	V	V				
81			V	**V**	+	to the detriment of the content depth
82			V			
84			V	**V**	+	

1	2	3	4	5	6	7
85	V					
86			V	**V**	+	
87	V					
88			V	**V**	=	difficult to monitor
89			V	**V**	=	scattering the teacher's attention
90			V			
91	V	V				
92	V	V				
94		V				
95	V	V				
100	V					
101		V				
102	V					
103			V	**V**	=	
106		V				
109			V			
110			V	**V**	=	
111	V	V				
112	V					
113	V	V				
114	V					
115	V					
116			V	**V**	–	children forget to turn the microphones on
117	V	V				
118	V	V				
119	V	V				
120	V					
121			V	**V**	+	
122		V				
123			V	**V**	+	
124	V	V				
126		V				
127			V			
129	V	V				
130	V	V				
131			V	**V**	+	
133		V				
135	V	V				

1	2	3	4	5	6	7
136		V				
139	V					
141			V			
142			V	**V**	+	
143			V			
144	V	V				
146			V	**V**	+	
147			V	**V**	=	
148			V	**V**	+	
149			V	**V**	+	
150			V	**V**	+	
151	V					
152			V	**V**	+	
154	V					

+ – positive effect
= – neutral effect
– – negative effect

K. Perceived interactivity-related changes that occurred in the experimental case

Theme	Positive quote example(s)	Negative quote example(s)
Attitude	"less tired at the end of the lesson" (BS02) "more interesting and fun" (BS04) "we used better headphones…, you hardly hear anything around you…, nothing distracts you" (BS07)	
Clarity	"could hear each other better" (BS07) "the voices were clearer" (BS01) "no echo this time" (BS03)	"everyone's voices sounded similar" (BS01)
Content	"understood the topic better" (BS08) "knew what to do each time" (BS04)	
Emotions	"was cool when [the teacher]…used smileys" (BS05)	
Interface	"the countdown…helped us…, we did it on time" (BS04) "liked that we did not have to leave the program" (BS02)	"having to turn on microphones…annoyed me" (BS07) "we had to press the button before speaking…[which] was distract" (BS08)
Interplay	"we talked more than usual" (BS04) "was cool…when we evaluated each other" (BS04) "in these head speakers you only hear what others say" (BS01) "easier to talk" (BS04)	
Sense of authenticity	"the teacher's picture was sometimes more realistic" (BS07) "felt more real" (BS07) "was more like a usual lesson" (BS02)	"[the voices] sometimes sounded as if it was a robot speaking" (BS01)
Stability	"fewer stops" (BS03) "it acted up less" (BS04)	
Timing	"finished on time" (BS02) "there was not such a fuss" (BS04)	
	Overall: 9	**Overall: 3**