Bogiannidis *et al.*
Smart Learning Environments (2023) 10:26
https://doi.org/10.1186/s40561-023-00246-w

Smart Learning Environments

RESEARCH Open Access

An exploration of the possible educational opportunities and the challenges at the intersection of the physical and digital worlds occupied by 10–14 year-old students

Nikolaos Bogiannidis*, Jane Southcott* and Maria Gindidis

*Correspondence: nikolaos.bogiannidis@monash.edu; jane.southcott@monash.edu

School of Education, Culture and Society, Faculty of Education, Monash University, Melbourne, Australia

Abstract

In developed countries, digital technologies are disrupting every facet of students' lives. It is no longer an option to turn off devices and disconnect from the outside world at the school gate. Educators are struggling with the number of technologies being introduced and how to safely and effectively integrate these tools in classrooms that have no boundaries. In an era where it seems that each child takes central place on the world stage; always connecting, learning, creating and sharing, it is timely to investigate the experiences of technology-rich 10–14 years old Australian students' experiences with technology in everyday life, and reflect on the persisting challenges and the new possibilities being created by the myriad choices of technological tools and their uses. The purposive selection of the participants was based on the volunteers' daily access to personal devices and frequent use of applications and various online platforms. This inductive qualitative study used concept mapping as a tool for conducting research and thematic analysis to identify and explore patterns in the data. Our findings reveal the formation of a fluid and hybrid digital rhizomatic non-hierarchical and multiplicitous network that allows students to connect, think, act, interact, access ideas and resources in ways that may assist educators in closing the gap between formal learning and informal learning whilst living in a rich technology world.

Keywords: Connectivism, New learning spaces, Digital playgrounds, Virtual more knowledgeable others, Adaptive learning

Introduction

The disruptive nature of new technologies and the challenges associated with these tools continue to be a concern for educators in 1:1 classroom environments where each student has a device (Luo & Murray, 2018). There is a recognition that technology has a vital role in the education of students for a technology-rich world, but fluency with these tools and, at times, students' choice to use the devices in inappropriate ways often become obstacles to harnessing its full potential (Filipe et al., 2019; Gane et al., 2018; Lemoine et al., 2020). Today, students' devices are small, mobile, smart and powerful, allowing

users to access a vast network of people, services, communication tools, information and entertainment systems at the touch of the screen (Chaudron et al., 2018). Such features make these devices the ideal tool for the twenty first-century classroom, but this comes with challenges that require discipline, critical thinking and sensible decision making. In a rapidly evolving digital world, there is often a lag in understanding existing and emerging tools and how students use them to support their learning at schools and at home. This include the impact of technology on their academic performance and well-being, and the variations of technology use across different student populations within this age group in specific contexts (Hällgren & Björk, 2023). Moreover, there is limited research beyond technology integration in the classroom and the impact of technology use at home on student learning. This research gap is critical to address students' voices and understand their ways of thinking which can provide valuable insights into how educators reframe and transform education and provide more innovative personalized and relevant learning experiences in blended educational environments (Fischer et al., 2023). Hence, it is timely to explore how these adolescent students use digital technology in their daily activities. This age group of pupils was born in a technologically advanced period and has been constantly exposed to various digital tools throughout their lives. From an educational standpoint, it is critical to have a more profound knowledge of how the research participants utilise technology in order to create a more comprehensive map of the influence it has on their progress and well-being. In addition, studying how young people between the ages of 10 and 14 engage with various types of technology might provide vital insights into its potential benefits and drawbacks. This understanding may give insight into how new and emerging technologies may be used to revolutionise the delivery and reception of educational content. This enquiry may also aid in developing a better knowledge of how this age group of students utilise digital technologies, allowing successful instructional technology techniques to be designed and modified. More significantly, children of this age group will continue to utilise technology, and their current experiences will influence the extent and how they use it in the future. Investigating the lessons that may be drawn from the purposively selected group of students in the specific location, time, and conditions may provide substantial insights into how technology will evolve and be employed in the future.

Through this inductive study, we sought a snapshot view of the students' daily activities involving technologies and to explore the possible educational opportunities and challenges at the intersection of the physical and the digital world, hoping that 10 to 14-year-old students can offer us insights into best practices and possible alternative teaching and learning practices.

The questions guiding this study are:

- What technologies do 10–14 year-old students use in everyday life, and for what purposes?
- What are the challenges and opportunities for educators, if any, afforded by the technologies used by the students?

As school settings are very complex, we employed qualitative research to investigate the above questions. This research approach can best address the multiple realities

(Merriam, 1998). of the participants' use of digital technologies in the classroom and at home because it allows for a comprehensive examination of the experiences, perceptions, and perspectives of the individuals involved in their context at a particular time (Merriam, 2019). It also allows for the collection of rich, detailed data through observations, documents and mind maps, which can provide a deeper understanding of the subject matter (Merriam, 1998).

Another critical strength we considered when selecting qualitative research was the ability to capture the multiple realities of the purposively selected sample of students, which can provide better opportunities to make sense (Merriam, 1998) of the use of digital technologies by the students in the classroom and at home.

In summary, the choice of qualitative research allowed the researchers to explore and make sense of the context in which digital technologies were being used in the classroom and at home and understand the factors that shaped the use and the impact of digital technologies on students' lives. This type of qualitative research approach helped us better understand how digital technologies are used in these specific settings by this group of students at a particular time.

Literature review

Digital technologies in education

There is a significant body of studies related to the use of digital technologies in all levels of education and everyday life (Beckman et al., 2014; Palaiologou, 2016; Selwyn et al., 2017). For some time, researchers have agreed that technology is neither good nor bad. What technology, why, how, and frequency of use can positively or negatively impact any outcome (Greenhow & Askari, 2017; Inal & Cagiltay, 2007; Olds et al., 2006). In education, effective implementations of new technologies have the potential to transform the way teachers teach and how students engage in learning through the use of smart devices (McKnight et al., 2016). Curriculum and pedagogy should determine the choice of technology in teaching and learning (McKnight et al., 2016; Taber, 2017). Technology can support students to construct knowledge, develop skills and to become self-regulated learners. There is, however, a danger that with ever-increasing layers of technology, classrooms could become messy and ineffectual spaces for engagement and, as Phillips (2015, p. 326) cautions, underpinning this, "there is no consensus or definitive explanation of what technology integration looks like in a classroom, or how it can be achieved". Often there is little consistency in the use of digital technologies between schools or even classes within schools.

Technological fads should not drive educational decisions. There is a need to move beyond technology integration to technology-enabled learning where the focus is "on the content-based pedagogy of teachers' lessons, followed by a consideration of all the tools teachers might use to implement it, in order to affect student learning" (Brantley-Dias & Ertmer, 2013, p. 120). There is a complex relationship between curriculum, pedagogy and digital technologies. The curriculum should inform the choice of pedagogy, underpinned by the learning theory, followed by the technology tool that will best address the specific task and need (Taber, 2017).

Two recent educational theories relevant to this study, connectivism and rhizomatic learning, highlight the value of social relationships and networks for knowledge

acquisition. The two theories share a common understanding of learning as a process of establishing and maintaining relationships rather than accumulating factual knowledge.

Connectivism is an approach to learning and information organisation that places premium on learning residing in networks, the role of specialized nodes, diversity and flexibility (Siemens, 2004). It recognizes the existence of several pedagogical approaches and informational channels and advocates that learning occurs when a person makes associations between disparate pieces of knowledge.

The rhizome is the inspiration for rhizomatic learning (Cormier, 2008); it is a plant with a horizontal stem that sends out roots and branches in all directions. Reality, according to the rhizomatic worldview, is a structure that has no beginning nor end and is always moving, linking, and morphing into something new (Deleuze & Guattari, 1987). Based on this concept, rhizomatic learning is an approach to education that favours the development of interconnected networks of knowledge above the traditional method of memorising facts to learn (Cronje, 2018). Students are encouraged to draw parallels between what they're learning and what they already know, as well as to reflect on the relevance of their own experiences to the material they're studying.

Both connectivism and rhizomatic learning have been related to the emergence of digital technologies that enable students to construct learning ecologies through networking with one another, gaining access to varied knowledge resources, producing and sharing insights in a non-linear fashion.

Digital technologies at home

Outside the boundaries of the school environment, there is a complex but seemingly orderly technology-rich connected world where individuals make choices as to when and what tools to use for learning, socialising and entertainment. In the absence of adult supervision, students may engage in multitasking where the elements of learning, socialising, and entertainment are present simultaneously. Outside school hours, students choose to connect through the use of social media and video games as "when students are at home, they not only use social media more actively but they use more diverse forms of social media than when they are at school" (Lu et al., 2016, p. 56). An OECD study by Pedró (2012, p. 56) found that connectedness is a normal part of children's lives as "they remain connected for more time, increasingly using portable devices; and more importantly, the range of activities they carry out is spreading". One of these activities includes video gaming, which can have cognitive, motivational, emotional and social benefits for players as they can immerse themselves in games, learn how to socialise, and deal with more challenging situations (Granic et al., 2014). Video games allow social interaction in previously unconsidered ways, and "increasingly, players are gaming online, with friends, family, and complete strangers, crossing vast geographical distances" (Granic et al., 2014, p. 76).

Methodology

The setting

Boulevard College (pseudonym) is an affluent, co-educational, highly academic private P-12 school located in a large city in Australia. It has a student population of about a thousand students. The students in the Preparatory to Year Four classes (aged five to ten

years) use school managed and owned iPads. The students in the Middle School (aged eleven to fourteen) bring their own iPads, populated with school mandated educational apps and students' apps that the school does not oversee. The curriculum is primarily delivered as separate subjects, and students use iPads to access resources such as electronic texts, class notes and assignments. A learning management system (LMS) supports student learning, distributes resources and keeps parents up-to-date with the school's educational programs and activities. The curriculum is written and controlled by subject coordinators. All students receive the same curriculum simultaneously, and the same assessments and progress reports are sent to parents every four weeks. There is no deviation from the curriculum, but teachers choose how they deliver lessons and are held accountable for students' performance. iPads are used in all subjects.

The participants

After university ethical approval, students in the Middle Years of schooling (aged 10–14 years) were invited to participate in this study. The school has an enrolment of 55 per cent boys and 45 per cent girls, which is constant across the year levels. The students are Australian, with close to 30 per cent of them having a non-English language background. Most of the non-English background students migrated with their families from Asian countries and India. Most families are considered wealthy and able to pay annual fees, varying from $28,000 Australian dollars to $35,000, depending on the year level. Both the school and its community have very high expectations for academic results. At the time of the data collection, the Year 5 and 6 students had one year of experience in managing their iPads for learning and other purposes outside school hours, including but not limited to communication, socialisation, and entertainment. The remainder of the students had two or more years of experience in managing their devices. All students had to take their iPads to every class charged, connected to the school's network, and use the devices as instructed by the teacher. Although not desired by the school, it is not uncommon for students to have apps running in the background allowing notifications and messages from other users to pop up on their screens. Most students at Boulevard College live in the surrounding suburbs some distance from each other and use technology as a tool to connect and stay in touch after school hours. For these students, the traditional neighbourhood has been replaced with the 'digital' neighbourhood where they hang around in cyberspace to chat, play, learn and exchange ideas.

Data collection

Our qualitative exploration used rhizomatic mind maps to capture the students' engagement with digital technologies. In this process, "each learner has an individual map and that one learner cannot trace another's map … It makes sense to use a map that shows connections when one deals with a connected environment" (Cronje, 2018, p. 5). We use the terms 'rhizomatic' and 'mind' interchangeably. Students were asked to develop mind maps starting with the prompt: 'technologies I use in everyday life at school and home'. We selected rhizomatic mapping as such graphical tools offer helpful ways to organise and represent knowledge. In this approach, concepts are "usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts" (Novak & Cañas, 2008, p. 1). Such participant-generated graphic

representations "allow for the identification of concepts and connections based on how the participant frames their experience" (Wheeldon & Ahlberg, 2017, p. 9). Using the rhizomatic maps as data allows us to record participant understandings and leads to "new opportunities to study the process of learning and new knowledge creation" (Novak & Cañas, 2008, p. 11). In qualitative research, "maps offer a means of gathering more unsolicited reflections, providing a visual *snapshot* of experience from which to ground theory within data" (Wheeldon & Faubert, 2009, p. 79). Mapping permitted the participants to clarify their use of technologies in everyday life and the researchers to further organise the data into specific categories, "connecting and observing patterns of movement, force and affect across very diverse formal and disciplinary divides" (Schumack & Tuckwell, 2010, p. 5). In a technology-rich world, mapping acts as a bridge between the physical and the virtual world, allowing us to:

> *make the complex accessible, the hidden visible, the unmappable mappable. As we struggle to steer through the torrent of data unleashed by the Internet, and to situate ourselves in a world in which commerce and community have been redefined in terms of networks, mapping has become a way of making sense of things … mapping is an increasingly vital activity, one that undergirds diverse disciplines and transcends the supposed physical/digital divide. (Abrams & Hall 2006, p. 12)*

We adopted a similar approach to bring to the surface the unmapped activities carried out by students in Years 5, 6, 7, and Year 8 students through the use of digital technologies. After obtaining parental consent and students' assent, the Home Room teachers asked the thirty-four volunteers (9 boys and 25 girls) to develop a mind map outlining their everyday use of technologies at school and home on their iPads using the SimpleMind+ App, designed to facilitate the building of mind maps. The mind mapping activity took place during the morning homeroom sessions over two periods of fifteen minutes (thirty minutes in total). The anonymous mind maps were then collected by their teachers, using the method of airdropping, and passed on to the researchers. The files are electronically stored in a secured Dropbox folder, accessible only to the researchers.

Data analysis

We employed thematic analysis as the method to interrogate and sort our data. After familiarising ourselves with the data, we transferred the thirty-two mind maps into one table, listing all elements reported by each participant in order to analyse and to identify similarities, differences, and patterns "across all data set[s]" (Braun & Clarke, 2012, p. 57). We filtered what we considered important information and adopted an inductive approach to coding the data relevant to our research questions. Next, we organised the data into three overarching themes: education, entertainment, and social use. Then, we constructed an overall mind map combining the students' input data under the three abovementioned headings. The mind map depicts the digital tools used by the students, the purpose and the main features of each tool. Thus, giving us a snapshot of the current technology use and each tool's main features, allowing us to reflect and speculate on the new possibilities hidden in the evolving, and at times, overlapping digital rhizomes related to education, entertainment, and socialisation. Applying the term rhizome is apt as we did not find a hierarchical or sequential engagement with digital tools, but rather

a "multiplicity of inseparable components … [that was] always already overlapping other concepts, becoming a non-totalising project of thinking differently" (Sellers, 2015, p. 7).

Findings

A close examination of the participants' contribution to this study offered us a glimpse of a complex digital space ecosystem that expands physical boundaries and makes it possible for students to connect, learn, socialise, and be entertained in ways not possible without the use of digital technologies. We have represented this ecosystem as a rhizome that constantly changes due to students' decisions, interactions, and new technological developments. The three nodes in Fig. 1 represent the overarching themes that emerged from the data provided by the volunteers. At the end of each node, the plus sign (+) indicates that the rhizome has more branches, which will be revealed and discussed in other sections of this article. The three nodes appear to expand towards a specific direction, but they may join together during a typical day as students may use digital technologies to socialise, have fun and learn simultaneously. This idea may have implications on formal learning as it poses teaching and learning challenges related to classroom management, student engagement, learning pace and curriculum content. Similarly, this ecosystem may be viewed as problematic, especially when students must complete educational tasks independently, outside school hours.

Education

Digital technologies permeate both formal and informal learning spaces and allow students to create, access, share, and communicate with peers and significant others. Figure 2 maps out the tools students use daily for educational purposes. These tools appear to cover students' needs in terms of productivity, communication and access to resources.

Figure 3 is an expanded map of all the nodes associated with the tools students use for educational purposes and how. Tools such as Microsoft Word, PowerPoint, iMovie and Sketchbook Pro allow users to create and edit multimedia texts that can be shared and accessed through the LMS, email, and the Internet.

Students use tools such as PDF Expert and the Notes App to capture information in text, image, audio and video formats. Such documents can be used to support students' learning in an asynchronous self-paced mode without the presence of a significant other.

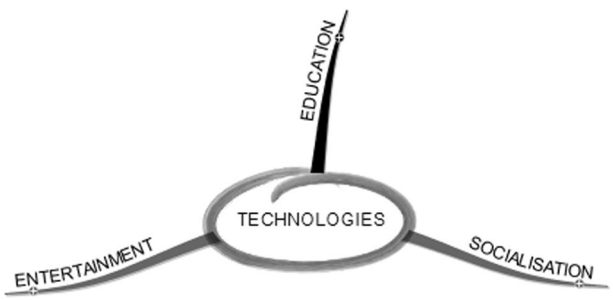

Fig. 1 Students' use of technology in everyday life for educational, entertainment and social interaction

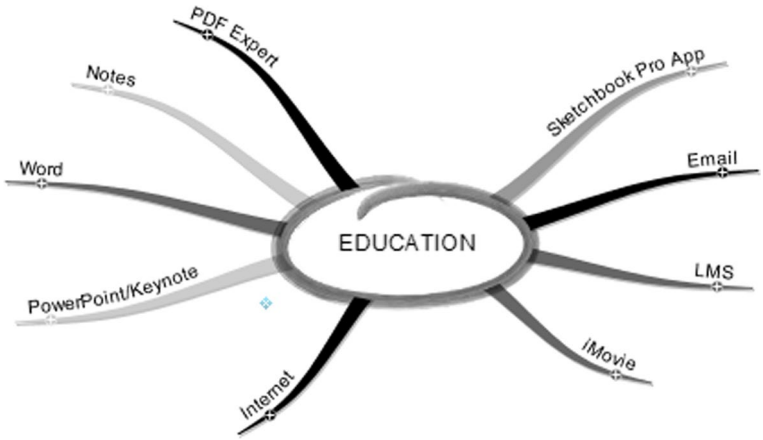

Fig. 2 The tools students use for educational purposes

Teaching is complemented by the information stored on portable devices controlled by the students.

Email is widely used for more formal communication with teachers and sending and receiving school work. However, productivity tools such as Keynote, PowerPoint, Word and Note have new features that allow users to share and co-create texts. These features complement the LMS that the students use to learn as a constructive social activity. Despite the integration of an interactive video platform, the use of the LMS appears to be limited to finding out about new projects and accessing assessment results.

As documented in Table 1, the Internet acts as one of the most powerful platforms for students to support their learning through interactive multimedia resources and collaborative tools. They access educational websites to gather information for their projects, consume video tutorials and digital texts and test their knowledge using quizzes and online tests. The power of the Internet depends on how students access and use the web of networks, including social media platforms, people, educational resources and services. The users control what to access, when and how. The web does not adjust to the needs of the individuals; the students have the power to determine the path that will best support their learning.

Social interaction

Social interaction, through the use of digital technologies, is deeply embedded in young students' lives. The volunteers indicated their preferences for several social media tools shown in Fig. 4, including Facetime, YouTube, Snap chat, House Party, iMessage, Pinterest and Instagram. These tools have similar features that allow them to stay connected with friends and others in different physical spaces. As we will discuss in the next section of this paper, each tool affords students the choice of when and how to connect with friends and others to communicate and share using multimodal texts. There was no preference for one tool over the other; selection appeared to be linked to the task at hand.

The social media tools used by the volunteer students offer powerful ways to learn, communicate, to share ideas and resources using text, images, audio and video. Students appear to select different tools for different reasons when crossing the

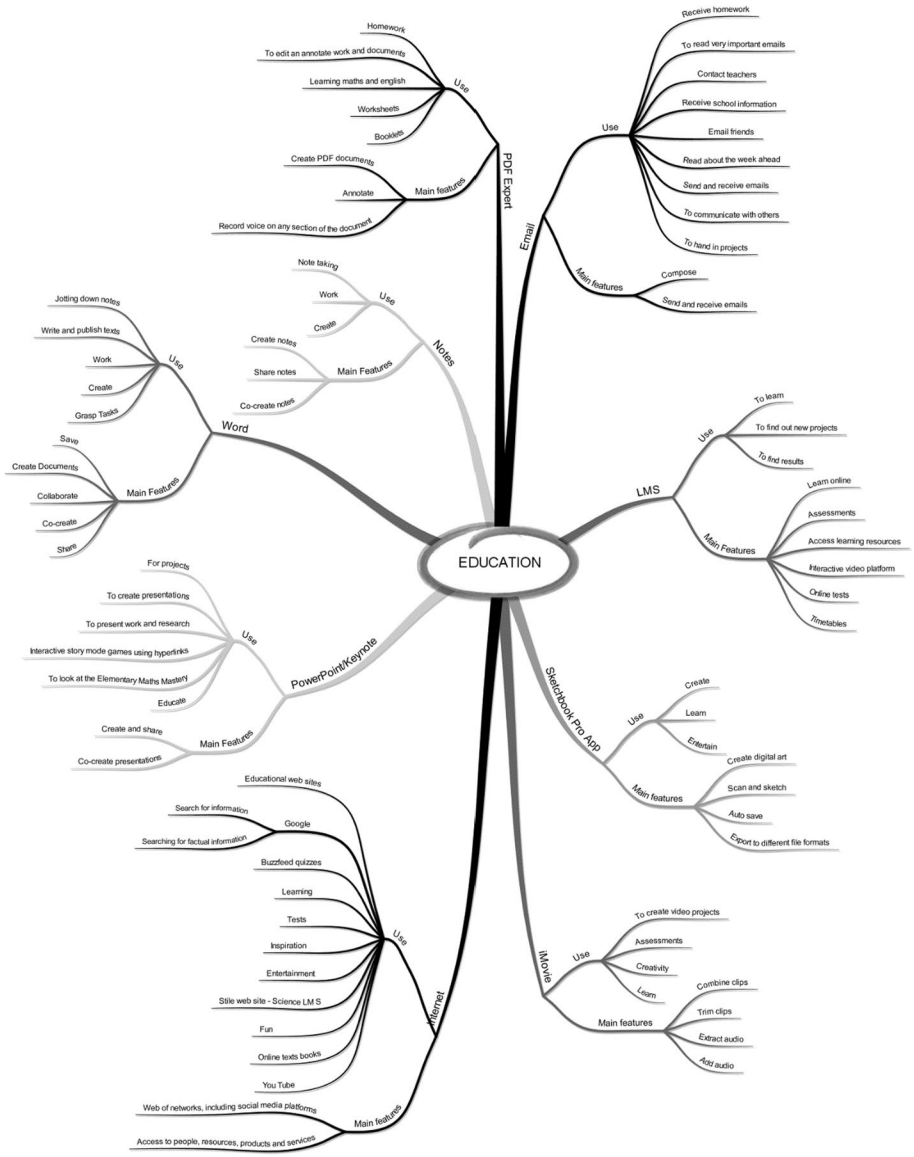

Fig. 3 Students' use of technology for educational purposes

boundaries between physical and digital spaces to engage with others. The students' use of technology for social interaction, as outlined in Fig. 5, is orderly and complex. Users appear to intelligently match their choice of tool for accomplishing a particular task depending on specific objectives, the devices available, the time and place where the connection is taking place, and the number of people required. Hence, students use the YouTube platform for entertainment purposes and visually learn from video clips posted by other users.

The FaceTime application is used as a substitute to face-to-face communication by using audio and video channels whilst students are in different geographical spaces. Similarly, students use iMessage to connect with others using mainly text messages. This app allows the parties involved to reply immediately or when convenient.

Table 1 An overview of the digital technologies the students use at school and the reasons

Tools	Multimedia	Interactive	Collaboration	Reasons students use social media
LMS	Yes	Yes	Yes	To learn To research new projects To find results
Internet	Yes	Yes	Yes	Educational websites Search for information Quizzes Learning Tests Inspiration Entertainment Science Fun Online textbooks YouTube
Word	Yes	No	Yes	Notes Write and publish texts Work Create Grasp tasks
Notes	Yes	No	Yes	Note taking Work Create
PDF Expert	Yes	No	Yes	Homework To edit and annotate Learning in Maths and English Worksheets Booklets
PowerPoint	Yes	Yes	Yes	Educate For projects To create presentations To present work and research Interactive story mode To look at elementary maths mastery
iMovie	Yes	No	No	Visually learn from videos Entertainment To watch other people's lives
Email	Yes	No	No	To hand in projects To receive homework To read very important emails To contact teachers Receive school information Email Friends Read about the week ahead To communicate with others
SketchBook Pro	Yes	No	No	Learn Create Entertain

Students choose to use Snapchat when they want to add extra multimedia and entertainment elements. Special effects filters allow the users to incorporate funny images on photographs, and the files disappear after a certain period. The students indicated their preference for HouseParty, a relatively new application when they wanted to communicate with two or more people in video and text conversations in private digital rooms. When students wanted to connect to share life stories or learn about the latest news, they employed Instagram. Pinterest appears to be more popular with students who are interested in the ideas of others and keeping up with the latest trends. Looking at Table 2, it is evident that the multimedia features and the ability for group

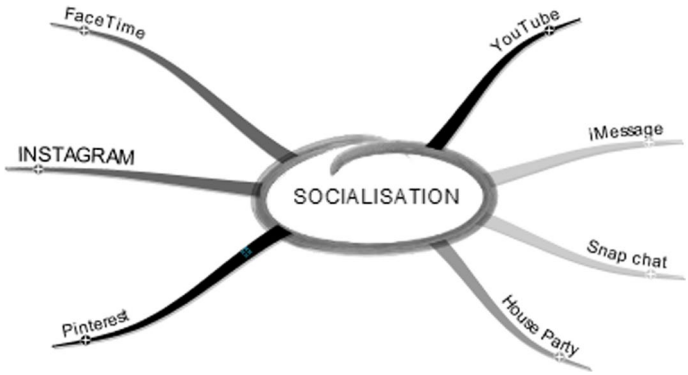

Fig. 4 The tools students use for social interaction

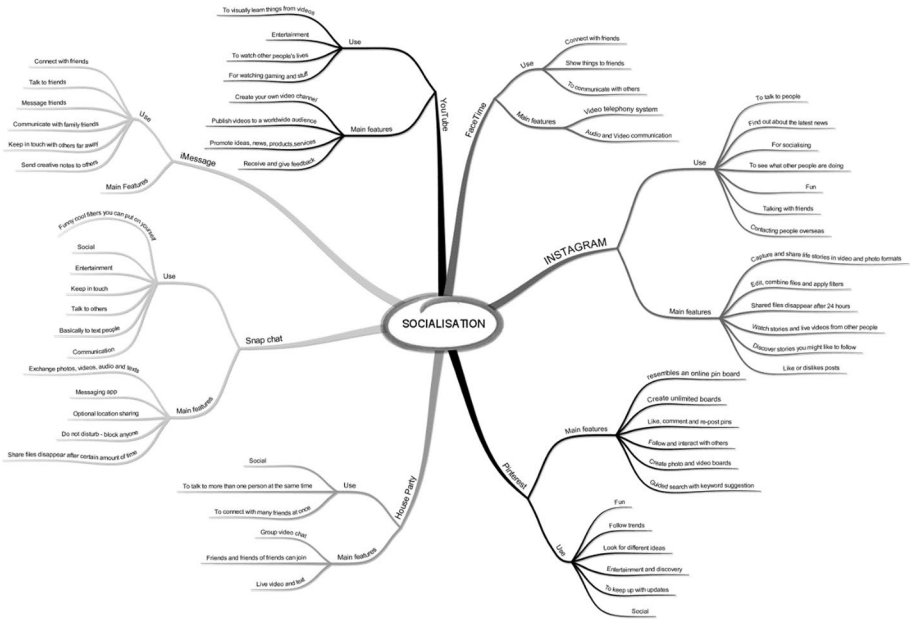

Fig. 5 Students' use of technology for social interaction

participation in social interaction from different geographical locations can create new opportunities for communities to connect, communicate, and advance their knowledge.

Entertainment

The participants in this study have indicated that they use several sophisticated digital games as part of their daily entertainment activities. As evident in Fig. 6, which has been created from the students' responses, these games range from a simple block and race game to high quality immersive 3D environments. At least six of the games mentioned allow players to take control of the digital setting, the plot, the characters and enable users to create and solve the challenges in a non-linear way, collaboratively or alone. These features and other common gamification elements such as reward systems, challenges, scoring and social interactions make games more attractive to youngsters.

Table 2 An overview of the social media tools the students use and the reasons

Tools	One to one	Group	Text only	Multimedia	Reasons students use social media
House party	Yes	Yes	No	Yes	Socialise Connect with more than one person
Instagram	Yes	Yes	No	Yes	Socialise Find out the latest news See what other people are doing Contact people overseas Fun
FaceTime	Yes	No	No	Yes	Connect with friends Show things to friends Communicate with others
Pinterest	No	No	No	Yes	Socialise Fun Follow trends Look for different ideas To keep up with updates
Snapchat	Yes	Yes	No	Yes	Socialise Funny filters you can put on yourself Text people
iMessage	Yes	Yes	No	Yes	Connect with friends Send creative notes to others Keep in touch with others far away
YouTube	Yes	Yes	No	Yes	Visually learn from videos Entertainment To watch other people's lives

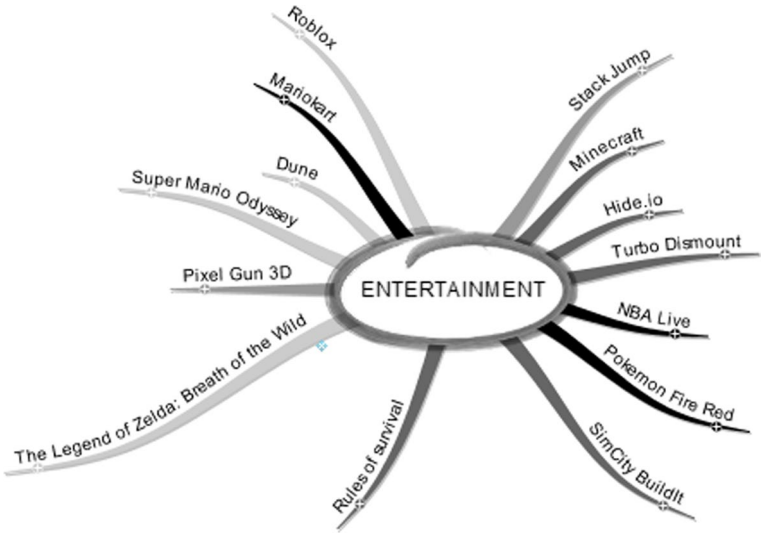

Fig. 6 The video games students play as part of their entertainment

Table 3 provides an overview of the games students play and their reasons for their choices. Two of the essential building blocks of most of the games mentioned by the volunteers include immersive, high-quality graphical representations and the option to play alone or in groups at different physical spaces. The combination of these games acts as a digital playground where friends meet in simulated environments to play with or against each other, explore, create, problem-solve, and overcome the challenges posed. Students justify their choices for these games in terms of the challenges provided, the

Table 3 An overview of the games the students play and the reasons

Games	One player	Multiplayer	Immersive/3D	Strategy/ problem	Reasons
Roblox	Yes	Yes	Yes	Yes	Fun, friends
Mariokart	Yes	Yes	Yes	Yes	Racing
Dune	Yes	N	N	Yes	Entertainment
Super Mario Odyssey	Yes	Yes	Yes	Yes	Exploration
Pixel Gun 3D	Yes	Yes	Yes	No	Entertainment
The Legend of Zelda: Breath of the Wild	Yes	No	Yes	Yes	Exploration
Rules of survival	No	Yes	Yes	No	Compete, friends
Stack jump	Yes	No	Yes	Yes	Challenges, entertainment
Minecraft	Yes	Yes	Yes	Yes	Create, fun
Hide.io	Yes	Yes	Yes	Yes	Fun
Turbo dismount	Yes	Yes	Yes	No	Injure avatar
NBA Live	Yes	Yes	Yes	Yes	Build, Compete
Pokemon fire red	Yes	Yes	Yes	Yes	Fun
SimCity BuildIt	Yes	No	Yes	Yes	Build
Sims	Yes	No	Yes	Yes	No reason offered

fun they experience, the opportunities to explore and create, and the social and competitive aspects of games. These justifications may help us unpack the hidden elements that drive students' engagement with new and emerging technologies.

As we look at the students' responses concerning the main features of each game, it is evident that individuals are involved in social gaming, requiring strategic thinking, problem-solving and decision making. In Fig. 7: Students' use of technology for entertainment, it is evident that some of the games listed contain violent themes, which can be of concern to parents and educators and should be addressed in any discussion related to designing and leveraging games for educational purposes.

Discussion

In our inductive, exploratory study, we did not begin with pre-conceived notions concerning how students engaged with technology. The data provided by the students in the form of rhizomatic maps offered us a glimpse of a rich and complex technology world where students routinely use digital tools in everyday life to accomplish various tasks related to education, social interactions and entertainment. In this section, we discuss each of these three concepts concerning previous research in the field.

Education

Both at school and home, access to technologies appears not to be an issue for our participants. Still, there seems to be a growing gap between the types of digital tools the students access and use at school compared with the technologies employed outside school hours and how they use these technologies. For schools, accessing technology must precede "the digital conversion of school systems; however, for the conversion to be successful, it is critical to move the focus beyond the technology itself, to how technology enables teaching and learning" (McKnight et al., 2016, p.

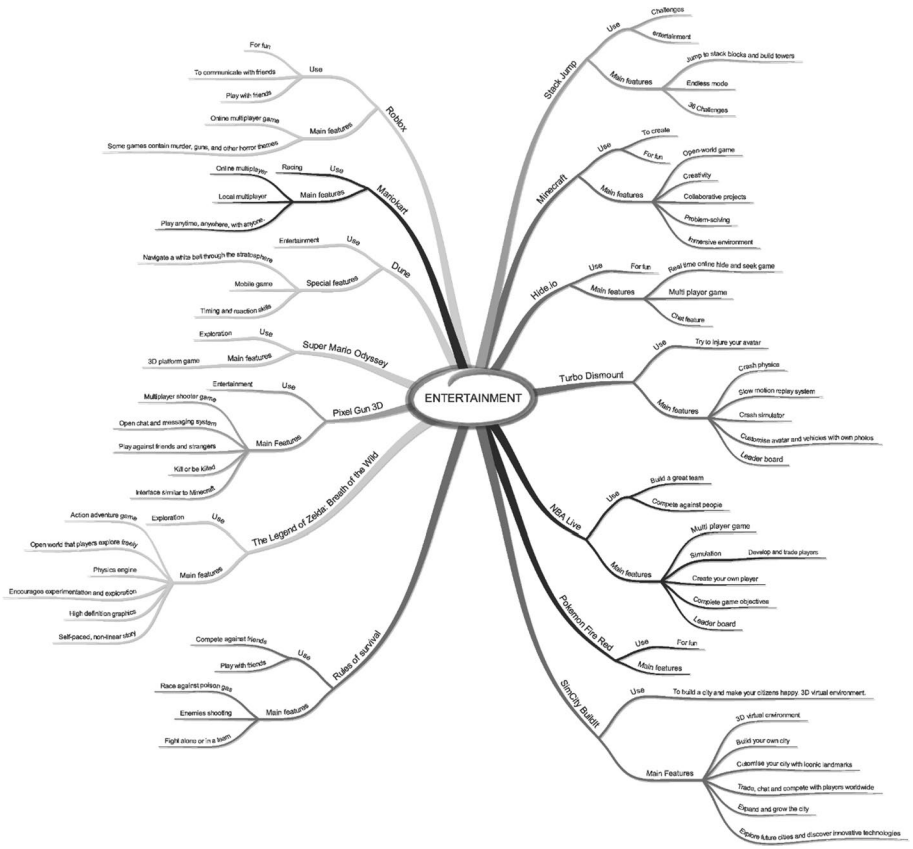

Fig. 7 Students' use of technology for entertainment

194). While students may use various tools to create digital texts, communicate with others, and learn independently, they rarely have choices over the curriculum and the learning processes. Technology within the school boundaries is mainly used as a substitute for existing practices, including accessing online textbooks, doing online tests, searching for information, creating and delivering presentations, taking notes and communicating through email. The educational value of this approach is not an objective for investigation in this study. Nevertheless, Brown and Mbati (2015) warn that technology implementation does not automatically translate into deep learning, but effective pedagogical practices must accompany it. Educators can take advantage of new features embedded in software packages and learning platforms. These features allow users to share files, collaborate on tasks, interact, and have timely access to essential resources, resulting in more flexible learning opportunities for students.

Learning is no longer confined to traditional classrooms and limited sources of information. According to Greenhow and Lewin (2016, p. 13), new technologies have the "potential to disrupt the boundaries between sites where learning takes place. [These tools] can empower learners through a greater agency, opportunities to participate in networked communities and access to a wide range of resources to support knowledge building and collaboration". The integration of existing digital technologies at this particular setting could be enhanced using a paradigm-based constructivism, which

> *assumes that learners are not empty vessels to be filled with knowledge. Instead, learners are actively attempting to create meaning. Learners often select and pursue their own learning. Constructivist principles acknowledge that real-life learning is messy and complex. Classrooms which emulate the 'fuzziness' of this learning will be more effective in preparing learners for life-long learning. (Siemens, 2004, p. 3)*

The data indicated that teachers have access to tools that can be utilised to construct a safe learning digital ecosystem and encourage students to self-direct their learning anywhere, anytime. This approach may lead to experiences where "home study tasks need no longer be seen as intended as solitary activities but can become interactive even when students are not easily able to meet physically outside the timetabled class" (Taber, 2017, p. 409). The physical environment, where traditionally formal learning takes place, can be supported by digital learning ecosystems, brings education closer to an evolving framework of physical and digital connected communities, giving rise to debates about learning theories, including connectivism and navigationism. However, embracing these theories and using new tools in transformative ways in education continues to be a challenge. For some time, the use of connectivism has highlighted the fact that there are "tectonic shifts in society where learning is no longer an internal, individualistic activity [and] how people work and function is altered when new tools are utilised" (2004, p. 7). New digital tools can transform learning environments and give students choices on how they want to advance their knowledge.

The data also showed that students navigate the Internet searching for information to complete educational projects. One of the most popular destinations is the YouTube platform that students access to learn visually. Brown and Mbati (2015), define the process of searching and identifying resources as navigationism, "a learning paradigm in which learners find, identify, manipulate and evaluate information and knowledge. This knowledge is integrated in their world of work and life to solve problems and to communicate this knowledge to others" (p. 124).

At the intersection of constructivism, connectivism and navigationism, we observe the formation of the pillars of a relatively new and unpredictable learning model that has no beginning and no end, the rhizome. Consistent with Masny (2015), the main features of a rhizome are "connectivity, heterogeneity, multiplicity, rupture, unpredictability and mapping. A class, for example, can be considered a rhizome consisting of multiple, heterogeneous, non-hierarchical trajectories of experiences, some that rupture unpredictably and others that don't and, nevertheless, connect with each other" (p. 4). In view of the data provided by the participants in this study about how they use technology for learning, social interaction and entertainment, it is possible that "the rhizome can successfully challenge traditional authoritarian, hierarchical approaches to teaching and learning, freeing learners to follow their own learning paths and determine their own learning objectives" (Mackness et al., 2016, p. 89).

Moreover, as the volunteers' usage of digital devices at home is increasingly linked and collaborative, in accordance with connectivism and rhizomatic learning principles, there is neither a formula to follow nor a sequential method for the self-directed pupils to complete their selected tasks. They capably navigate digital spaces and accessing resources while switching between tasks, conversing, playing, creating and sharing. Students learn from each other, from information stored on networked platforms and give

and receive feedback through comments or symbols (thumbs up). Consequently, it is imperative that teachers know how to implement digital technologies to engage students (Bergdahl et al., 2018). High expectations for academic accomplishment in this setting, curricular constraints, and accountability measures may impede on the school's shift to a more relevant and engaging learning environment that corresponds to the students' experiences outside the school gates. The divide between the usage of digital technologies in society and in the school is expected to further expand. If educators do not act accordingly, their teaching methods may be regarded as obsolete by the students of the future (Bergdahl et al., 2018).

Social interaction

The participants have indicated that they use a range of devices and platforms to facilitate social interaction with friends outside school hours through text, images, sound, and video. This observation is not uncommon. Keengwe and Bhargava (2014) have found that this generation uses technology for "watching videos, accessing [the] Internet, chatting with one another, multitasking … and making the public spaces like their own private spaces with the use of these mobile technologies" (p. 740). Students' social media tools allow them to interact in both private or public digital spaces with one or more people for different purposes.

Students indicated that the primary reason for using social media is to connect with friends (Hogan & Strasburger, 2018). The participants in this study claim to have fun whilst socialising with friends, following trends, creating, sharing files, exploring ideas, and learning. These claims paint a picture of some of the desired features that formal education should be incorporating as part of the repertoire of strategies for engaging students, cultivating curiosity, developing independence and life-long learning skills. However, Greenhow and Lewin (2016, p. 18) claim that safety and privacy concerns are

> *inhibiting appropriation of these tools to support teacher-initiated learning. This drives some to adopt social media developed specifically for compulsory education; and with this comes a greater emphasis on formal learning attributes as teachers feel the need to exert greater control and put more rigid structures in place.*

In this study, the adoption of the LMS may emulate some of the ways students informally learn through the daily use of social media tools outside the school where "content creation and the personal publishing […] has become part of the daily lives of learners", (Brown & Mbati, 2015, p. 122). The data, however, indicate that the LMS at this school setting has the potential to accommodate varied learning activities and styles but is being used by students in very limited ways to access learning resources, tests and results. Pedró (2012), encourages educational systems to observe how "connectedness is changing the way learners acquire information and elaborate knowledge [and how] their identities are shaped by interacting with peers in an enlarged digital landscape of opportunities, including those for learning" (p. 153).

Entertainment

According to Olson (2010), gaming provides students with a common ground to develop friendships. Certain features related to the games mentioned by the students

appear to attract them to these digital spaces, including the ability to immerse themselves in high quality interactive virtual worlds, individually or with friends. Arbeau et al. (2020) note that "rich social environment of the online video game offers a multitude of social, identity, and experiential benefits" (p. 5). The participants also noted the elements of challenge and competition built in these games as justification for playing the games they listed. As Greenberg et al. (2010) highlight, "competition would seem to be the primary motive for playing most games, whether doing so with another person or against one's own standard. Nonetheless, that motive sets video gameplay apart from other media activities. Typically, we do not compete to see who can watch the most television or read the fastest" (p. 253). Data analysis also revealed that the games students play outside school hours are highly interactive and offer multiple challenges. These features allow students, regardless of their level of knowledge, expertise, and skills, to be in control and have a more personalised experience. Overall, outside school hours, students have indicated that they connect and interact through various advanced technologies, including video games. Students use these technologies routinely daily for learning, socialising and entertainment.

Challenges and opportunities

Students' frequent access to 1:1 devices, their use of social media and online presence may have implications for formal education as it poses teaching and learning challenges related to classroom management, student engagement, learning pace and curriculum content. Teachers may view an ecosystem that combines messaging apps, social media tools, games, and connectivity with the rest of the world as problematic, especially when students must complete educational tasks independently and unsupervised, both inside the classroom and beyond. For instance, students may use an App to communicate in a private room with others while simultaneously trying to complete an educational task. In addition, this generation, having been exposed to high quality immersive 3D environments and having participated in creating their own spaces, may be more difficult to be motivated, stay on task and follow linear instructions. Students who are disengaged with the learning content may use the devices to communicate with the outside world or play games to escape boredom. The core issue at hand is not the technology itself, but meaningful cognitive engagement with learning. These volunteers are used to shaping and navigating their own environments in a non-linear fashion rather than working in a physical space and accessing a learning resources prepared by the teacher in a specific sequence. Opportunities exist to involve students in negotiating aspects of the curriculum, the mode of study and types of assessments to evidence learning. Students may also be asked to create their own personal digital spaces on the school's learning platforms and to regulate their own learning within specified parameters. A range of passive, active, constructive and interactive activities with or without technologies may also increase challenge and engagement. We acknowledge that this initial study has been undertaken with one cohort in one particular social and educational setting. Future studies will explore other contexts.

Conclusion

From the mind maps drawn by our participants, we suggest that students' lives outside school resemble a rhizo-nomadic world where they are always connected, exploring, sharing, actively learning, changing, and "continually (re)negotiating boundless spaces of both thought and thinking towards creating a network of a-centred interconnections" (Sellers, 2015, p. 7). It appears that they can choose from a range of tools and follow multiple pathways that make it possible to accomplish tasks, individually or collaboratively. Our participants navigate, locate, identify, manipulate, connect, and evaluate information and knowledge via the use of technologies. We were fascinated to discover that they share their knowledge with others in ways envisaged but rarely enacted by their teachers beyond their classrooms. Given that students are employing technologies that facilitate the creation and remixing of content, we argue that students view themselves as creators of information products and, at the same time, as agents of learning in an interconnected digital ecosystem. In this process, students may be able to develop new knowledge and skills and evolve into self-directed, motivated individuals able to navigate through the ever-changing spaces around them whilst acting and interacting with different actors. Given the right opportunities, they can develop the skills required to operate as life-long rhizomatic learners who are constantly connected in pursuit of acquiring new knowledge whilst shaping their own identity and the identity of others. They develop a sense of identity and belonging in the physical world by using digital technologies to create rhizomatic spaces where they connect, socialise, learn, explore, create, share, and play (van Eldik et al., 2019). To bridge formal and informal teaching and learning approaches, we propose that educators closely examine how students employ digital technologies outside school hours to create environments that resemble the rhizomatic paradigm where they self-direct their learning in the absence of formal teaching and a specified curriculum (Jagušt et al., 2018; Pöntinen et al., 2017). We argue that a recipe for a school system that prepares students for an unknown future must include multiple learning paths. The activities must be fun and engaging. The students should engage with challenging tasks requiring novel solutions and have numerous choices while active learning in a connected space that functions as a global rhizomatic classroom. This model of education already exists outside the boundaries of formal educational spaces. As evidenced in this study, young learners occupy these spaces to learn, interact, and entertain. This is what it appears that the students in this study are doing, and this is what every school may need to embrace:

- A variety of digital learning tools to address students' specific needs (Murray et al., 2019);
- Students being involved in decision making (Mitra, 2018);
- Gamification elements to stimulate interest, curiosity and increase engagement (Sailer & Homner, 2020);
- Connectedness as a seamless teaching and learning strategy (Luo & Murray, 2018);
- More authentic opportunities for students to explore their connected world through digital technologies (McKnight et al., 2016);
- Video tutorials as an asynchronous visual learning strategy (Belt & Lowenthal, 2021);

- Quality simulated 3D environments to teach complex concepts and to develop problems solving skills (Ledger & Fischetti, 2020);
- Adaptive learning paths to sustain students' interest, provide the 'just' right level of difficulty and challenges to learners (De Smet et al., 2016; Liu et al., 2017); and,
- Failure as part of the learning process and a strategy for generating solutions to problems with or without digital technologies (Menéndez & Min, 2019).

As self-directed learners and members of a rhizo-nomadic global connected community, the volunteers in this study do things differently using digital technologies. They live a life connected to each other and routinely access digital tools for education, socialisation and entertainment. To engage and prepare this generation of students for a technology-rich future, educational solutions need to consider the new realities and respond accordingly. Otherwise, we risk providing students with an education that is no longer engaging, relevant and meaningful to a generation of learners born in an era where the physical and the digital worlds have no boundaries.

Future implications of this study

Students with limitless access to digital tools will continue to participate in connectivism and rhizomatic thinking and learning as the world becomes increasingly complex and heterogeneous. Connectivism and rhizomatic learning can be incorporated into current teaching strategies to bridge the gap between formal and casual learning. These developing approaches will assist students in learning how to study in a non-linear, open-ended manner, which would become more crucial in the industry. Connectivism and rhizomatic learning are anticipated to grow in significance as the amount of information available to us and the rate at which technology evolves increases. It will become increasingly crucial at school and in the workplace to be able to interact with people and obtain information from a variety of sources. This may be accomplished with the aid of digital technology, which can be organised to allow students to interact with one another and access resources from a variety of sources, as well as to provide them with innovative opportunities to study, collaborate, create, and share information. In short, this study points to a future of education that combines the ideas of connectivism and rhizomatic learning into existing practises, where students learn in a non-linear and open-ended manner and build connections between diverse elements.

Acknowledgements
We would like to acknowledge the students who kindly dedicated their time to sharing their technology use in everyday life with us.

Author contributions
NB: Conceptualisation; Data curation; Formal analysis; Investigation; Methodology; Visualisation; Writing original draft, review and editing. JS: Conceptualisation; Formal analysis; Methodology; Supervision; Writing original draft, review and editing. MG: Conceptualisation; Formal analysis; Methodology; Supervision; Writing original draft, review and editing. All authors read and approved the final manuscript.

Authors' information
Nikolaos Bogiannidis is an experienced teacher conducting research related to the impact of rich technology spaces on student learning as part of his Ph.D. studies at Monash University. His research areas of interest include teacher adoption of disruptive technologies, mobile learning, and technology's role in differentiating learning and teaching. Correspondence regarding this article can be addressed directly to: nikolaos.bogiannidis@monash.edu.
Jane Southcott is an Associate Professor in the Faculty of Education, Monash University. Her research foci are twofold. She explores community music, culture, ageing, and engagement in the arts, employing qualitative, phenomenological, and quantitative strategies. Her other research field is historical, particularly concerning the development of the music curriculum in Australia, America and Europe. She is a narrative historian, and much of her research is biographical. Correspondence regarding this article can also be addressed directly to: jane.southcott@monash.edu.

Maria Gindidis is a Senior Lecturer in Teacher Education at Monash University, where she leads and teaches core units in the Faculty's teaching degrees. Maria's current research interests include School Leadership and Early Childhood Languages using intergenerational spaces, school improvement and the agentive voices of marginalised school leaders.

Funding
Not applicable.

Availability of data and materials
The datasets generated during the current study are not publicly available for privacy reasons, but are available from the corresponding author on reasonable request.

Declarations

Competing interests
The authors declare no competing interests.

Received: 2 December 2021 Accepted: 6 March 2023
Published online: 19 March 2023

References

Abrams, J. & Hall, P. (Eds.) (2006) 'Whereabouts'. In *Else/Where: New cartographies of networks and territories* (pp. 1–19). Minneapolis: University of Minnesota Press.
Arbeau, K., Thorpe, C., Stinson, M., Budlong, B., & Wolff, J. (2020). The meaning of the experience of being an online video game player. *Computers in Human Behavior Reports, 2*, 1–5. https://doi.org/10.1016/j.adolescence.2012.02.013
Beckman, K., Bennett, S., & Lockyer, L. (2014). Understanding students' use and value of technology for learning. *Learning, Media and Technology, 39*(3), 346–367. https://doi.org/10.1080/17439884.2013.878353
Belt, E., & Lowenthal, P. R. (2021). Video use in online and blended courses: A qualitative synthesis. *Distance Education, 42*(3), 410–440. https://doi.org/10.1080/01587919.2021.1954882
Bergdahl, N., Fors, U., Hernwall, P., & Knutsson, O. (2018). The use of learning technologies and student engagement in learning activities. *Nordic Journal of Digital Literacy*, *13*(2), 113–130. https://doi.org/10.18261/issn.1891-943x-2018-02-04
Brantley-Dias, L., & Ertmer, P. A. (2013). Goldilocks and TPACK: Is the construct 'just right?' *Journal of Research on Technology in Education, 46*(2), 103–128. https://doi.org/10.1080/15391523.2013.10782615
Braun, V., & Clarke, V. (2012). Thematic analysis. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), *APA handbook of research methods in psychology, vol. 2. Research designs: Quantitative, qualitative, neuropsychological, and biological* (pp. 57–71). American Psychological Association.
Brown, T. H., & Mbati, L. S. (2015). Mobile learning: Moving past the myths and embracing the opportunities. *The International Review of Research in Open and Distributed Learning*. https://doi.org/10.19173/irrodl.v16i2.2071
Chaudron, S., Di Gioia, R., & Gemo, M. (2018). Young children (0–8) and digital technology, a qualitative study across Europe. *JRC Science for Policy Report*. https://doi.org/10.2760/294383
Cormier, D. (2008). Rhizomatic education: Community as curriculum. *Innovate: Journal of Online Education*. https://www.learntechlib.org/p/104239/
Cronje, J. C. (2018). Learning 3.0: Rhizomatic implications for blended learning. In K. Persichitte, A. Suparman, & M. Spector (Eds.), *Educational technology to improve quality and access on a global scale. Educational communications and technology: Issues and innovations*. Springer. https://doi.org/10.1007/978-3-319-66227-5_2
De Smet, C., Schellens, T., De Wever, B., Brandt-Pomares, P., & Valcke, M. (2016). The design and implementation of learning paths in a learning management system. *Interactive Learning Environments, 24*(6), 1076–1096. https://doi.org/10.1080/10494820.2014.951059
Deleuze, G., & Guattari, F. (1987). *A thousand plateaus: Capitalism and schizophrenia*. University of Minnesota Press.
Filipe Matos, J., Pedro, A., & Piedade, J. (2019). Integrating digital technology in the school curriculum. *International Journal of Emerging Technologies in Learning*. https://doi.org/10.3991/ijet.v14i21.10863
Fischer, G., Lundin, J., & Lindberg, O. J. (2023). The challenge for the digital age: making learning a part of life. *The International Journal of Information and Learning Technology, 40*(1), 1–16. https://doi.org/10.1108/IJILT-04-2022-0079/full/html
Gane, B. D., Zaidi, S. Z., & Pellegrino, J. W. (2018). Measuring what matters: Using technology to assess multidimensional learning. *European Journal of Education, 53*(2), 176–187. https://doi.org/10.1111/ejed.12269
Granic, I., Lobel, A., & Engels, R. C. (2014). The benefits of playing video games. *American Psychologist, 69*(1), 66–78. https://doi.org/10.1037/a0034857
Greenberg, B., Sherry, J., Lachlan, K., Lucas, K., & Holmstrom, A. (2010). Orientations to video games among gender and age groups. *Simulation & Gaming, 41*(2), 238–259. https://doi.org/10.1177/1046878108319930
Greenhow, C., & Askari, A. (2017). Learning and teaching with social network sites: A decade of research in K-12 related education. *Education and Information Technologies, 22*(2), 623–645. https://doi.org/10.1007/s10639-015-9446-9
Greenhow, C., & Lewin, C. (2016). Social media and education: Reconceptualising the boundaries of formal and informal learning. *Learning, Media and Technology, 41*(1), 6–30. https://doi.org/10.1080/17439884.2015.1064954
Hällgren, C., & Björk, Å. (2023). Young people's identities in digital worlds. *The International Journal of Information and Learning Technology, 40*(1), 49–61. https://doi.org/10.1108/IJILT-06-2022-0135
Hogan, M., & Strasburger, V. C. (2018). Social media and new technology: A primer. *Clinical Pediatrics, 57*(10), 1204–1215. https://doi.org/10.1177/0009922818769424

Inal, Y., & Cagiltay, K. (2007). Flow experiences of children in an interactive social game environment. *British Journal of Educational Technology, 38*(3), 455–464. https://doi.org/10.1111/j.1467-8535.2007.00709.x
Jagušt, T., Botički, I., & So, H.-J. (2018). A review of research on bridging the gap between formal and informal learning with technology in primary school contexts. *Journal of Computer Assisted Learning, 34*(4), 417–428. https://doi.org/10.1111/jcal.12252
Keengwe, J., & Bhargava, M. (2014). Mobile learning and integration of mobile technologies in education. *Education and Information Technologies, 19*(4), 737–746. https://doi.org/10.1007/s10639-013-9250-3
Ledger, S., & Fischetti, J. (2020). Micro-teaching 2.0: Technology as the classroom. *Australasian Journal of Educational Technology, 36*(1), 37–54. https://doi.org/10.14742/ajet.4561
Lemoine, P. A., Waller, R. E., Garretson, C. J., & Richardson, M. D. (2020). Examining technology for teaching and learning. *Journal of Education and Development, 4*(2), 80. https://doi.org/10.20849/jed.v4i2.781
Liu, M., Kang, J., Zou, W., Lee, H., Pan, Z., & Corliss, S. (2017). Using data to understand how to better design adaptive learning. *Technology, Knowledge and Learning, 22*(3), 271–298. https://doi.org/10.1007/s10758-017-9326-z
Lu, J., Hao, Q., & Jing, M. (2016). Consuming, sharing, and creating content: How young students use new social media in and outside school. *Computers in Human Behavior*, *64*, 55–64. https://doi.org/10.1016/j.chb.2016.06.019
Luo, T., & Murray, A. (2018). Connected education: Teachers' attitudes towards student learning in a 1:1 Technology middle school environment. *Journal of Online Learning Research, 4*(1), 87–116.
Mackness, J., Bell, F., & Funes, M. (2016). The rhizome: A problematic metaphor for teaching and learning in a MOOC. *Australasian Journal of Educational Technology, 32*(1), 78–91. https://doi.org/10.14742/ajet.2486
Masny, D. (2015). Problematizing qualitative educational research: Reading observations and interviews through rhizoanalysis and multiple literacies. *Reconceptualising Educational Research Methodology*. https://doi.org/10.7577/rerm.1422
McKnight, K., O'Malley, K., Ruzic, R., Horsley, M. K., Franey, J. J., & Bassett, K. (2016). Teaching in a digital age: How educators use technology to improve student learning. *Journal of Research on Technology in Education, 48*(3), 194–211. https://doi.org/10.1080/15391523.2016.1175856
Menéndez, A. F., & Min, H. (2019). Embracing creativity in K-12 engineering pedagogy. In Z. Babaci-Wilhite (Ed.), *Promoting language and STEAM as human rights in education* (pp. 141–149). Springer.
Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Jossey-Bass.
Merriam, S. B. (2019). *Qualitative research in practice: Examples for discussion and analysis*. Jossey-Banks.
Mitra, D. (2018). Student voice in secondary schools: The possibility for deeper change. *Journal of Educational Administration, 56*(5), 473–487. https://doi.org/10.1108/JEA-01-2018-0007
Murray, A., Luo, T., & Franklin, T. (2019). Embracing a technologically enhanced environment: Teachers' experience educating students in an always-on and connected BYOD classroom. *International Journal on E-Learning, 18*(1), 53–78.
Novak, J. D., & Cañas, A. J. (2008). The Theory Underlying Concept Maps and How to Construct and Use Them. Florida Institute for Human and Machine Cognition. https://cmap.ihmc.us/publications/researchpapers/theorycmaps/TheoryUnderlyingConceptMaps.bck-11-01-06.htm
Olds, T., Ridley, K., & Dollman, J. (2006). Screenieboppers and extreme screenies: The place of screen time in the time budgets of 10–13 year-old Australian children. *Australian and New Zealand Journal of Public Health, 30*(2), 137–142. https://doi.org/10.1111/j.1467-842X.2006.tb00106.x
Olson, C. K. (2010). Children's motivations for video game play in the context of normal development. *Review of General Psychology, 14*(2), 180–187. https://doi.org/10.1037/a0018984
Palaiologou, I. (2016). Children under five and digital technologies: Implications for early years pedagogy. *European Early Childhood Education Research Journal, 24*(1), 5–24. https://doi.org/10.1080/1350293X.2014.929876
Pedró, F. (2012). *Connected minds: Technology and today's learners*. OECD.
Phillips, M. (2015). Digital technology integration. In M. Henderson & G. Romeo (Eds.), *Teaching and digital technologies: Big issues and critical* (pp. 318–331). Cambridge University Press.
Pöntinen, S., Dillon, P., & Väisänen, P. (2017). Student teachers' discourse about digital technologies and transitions between formal and informal learning contexts. *Education and Information Technologies, 22*(1), 317–335. https://doi.org/10.1007/s10639-015-9450-0
Sailer, M., & Homner, L. (2020). The gamification of learning: a meta-analysis. *Educational Psychology Review, 32*, 77–112. https://doi.org/10.1007/s10648-019-09498-w
Schumack, K., & Tuckwell, J. (2010). Mapping as ASSEMBLAGE FOR CULTURAL RESEARCh. *Institute for Cultural and Society Occasional Paper Series*. https://doi.org/10.4225/35/57a95cd39a8d8
Sellers, M. (2015). … Working with (a) Rhizoanalysis… and… Working (with) a Rhizoanalysis…. *Complicity: An International Journal of Complexity and Education, 12*(1), 6–31. https://doi.org/10.29173/cmplct23166.
Selwyn, N., Nemorin, S., Bulfin, S., & Johnson, N. F. (2017). Left to their own devices: The everyday realities of one-to-one classrooms. *Oxford Review of Education, 43*(3), 289–310. https://doi.org/10.1080/03054985.2017.1305047
Siemens, G. (2004). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology & Distance Learning*. http://www.itdl.org/Journal/Jan_05/article01.htm
Taber, K. S. (2017). The role of new educational technology in teaching and learning: A constructivist perspective on digital learning. In A. Marcus-Quinn & T. Hourigan (Eds.), *Handbook on Digital learning for K-12 schools* (pp. 397–412). Springer.
van Eldik, A. K., Kneer, J., & Jansz, J. (2019). Urban & online: Social media use among adolescents and sense of belonging to a super-diverse city. *Media and Communication, 7*(2), 242–253. https://doi.org/10.17645/mac.v7i2.1879
Wheeldon, J., & Ahlberg, M. (2017). Mind maps in qualitative research. In P. Liamputtong (Ed.), *Handbook of research methods in health social sciences* (pp. 1113–1129). Springer.
Wheeldon, J., & Faubert, J. (2009). Framing experience: Concept maps, mind maps, and data collection in qualitative research. *International Journal of Qualitative Methods, 8*(3), 68–83. https://doi.org/10.1177/160940690900800307

Publisher's Note