

ORIGINAL ARTICLE

Transforming a doctoral summer school to an online experience: A response to the COVID-19 pandemic

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Abstract

For the last 28 years, one of the leading international science education organisations has regularly provided a week-long summer school experience for doctoral students. In summer 2020, the COVID-19 pandemic prevented international travel and close-contact interactions between scholars. This required the transformation and relocation of learning interactions between mentors and doctoral students online through a virtual week-long summer school. All doctoral participants, from across the five continents, were invited to reflectively comment on their educational experience after the online event. This paper consequently presents the perspectives of these science education PhD students who engaged with the transformed virtual summer school to consider how the range of varied online interactions maintained the learning opportunities for them and enabled their introduction to an established research community. The study indicates how the digital activities facilitated and maintained high-quality learning exchanges through a varied array of intellectual activities involving both experienced and novice scholars.

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The findings demonstrate how successful academic outcomes can be achieved remotely while minimising international travel and significantly reducing financial outlay. This was achieved through creatively structuring a week-long virtual experience and combining a series of synchronous and asynchronous learning opportunities for different groupings of participants within the international summer school community.

KEYWORDS

community, digital transformation, doctoral education, science education research, summer school education

Practitioner notes

What is already known about this topic

- Doctoral students often feel that studying for their research degree is a very solitary experience.
- Supporting doctoral students to discuss their research with peers and more experienced others can address the feelings of isolation.
- The pandemic restricting face-to-face interaction constrains how learning can unfold in online contexts.
- It is possible to provide doctoral support through online means, however, the exact nature of such is not clearly defined.

What this paper adds

- Clear evidence that doctoral learning communities [involving university students and tutors] can be successfully developed through online virtual environments.
- That online working can afford and extend doctoral learning, develop beginning researcher identities and provide students the opportunity to become part of an international research community whatever their geographical setting and prior socio-cultural experiences.
- Clarity about the nature of online activities that ensure an appropriate blend of the kind of synchronous and asynchronous interactions that effectively support virtual online doctoral learning.
- The Community of Practice COP theoretical framework can offer a useful way of looking at different dimensions of higher degree learning.

Implications for practice and/or policy

- This paper provides advice for those who would like to develop their own virtual learning networks that bring together learners from universities and wider organisations to develop a community of learning.
- That an appropriate blend of synchronous and asynchronous interactions can mediate and support doctoral students, aiding them to effectively become more knowledgeable members of an international research community within a short space of time.
- That international virtual events can successfully achieve learning outcomes while also minimising overseas travel, significantly reducing financial expenditure and individual carbon footprints.

INTRODUCTION

Completing a doctorate can sometimes be a long and lonely journey (Daniel, 2020; Cantor, 2020). Therefore, opportunities for research students to exchange ideas, ask questions or clarify understandings with others in a similar context is limited. Social isolation and the lack of a supportive network that provides a sense of belonging (van Rooij et al., 2021) can make a difference to the success that individual research students achieve. Providing opportunities for individual research students to engage with communities that work in their intellectual field is one crucial part of their learning journey (Whisker et al., 2010). Other influences affecting doctoral students' success include supporting ways of supervisors and peers discussing, questioning and critiquing research (ibid.). Studies also indicate how small seminar groups can support research students' development through dialogic interactions (van de Pol et al., 2019) focused on common areas of concern, such as reading or writing (Parker, 2009). These can also support researcher professional development, nurture collegiate relationships and transform a potentially solitary experience into a more social experience (Olszewska & Lock, 2016). Consequently, supporting research students to engage in and with these kinds of intellectual activities, at a time when Covid-19 restrictions limited personal interactions, through a virtual summer school became an aspiration of the Oxford organising committee. This paper, therefore, reports upon the pragmatics and impact of such an ambition. Eliciting how newly practicing science education research students were successfully supported to extend their doctoral learning through a virtual summer school is consequently described and explained in this study.

Previous summer schools run by the science education research organisation were designed to provide a range of research related activities. These included seminars for small groups of doctoral researchers, referred to herein as Beginning Researchers (BRs). The range of ways that each student was encouraged to socially interact with peers and mentors involved BRs thinking about, discussing and critiquing theirs and others' doctoral projects, as well as science education research generally, in a variety of ways. The varied methods of communication between BRs and experienced researchers (ERs), encouraged throughout the week-long summer school, transcended the traditional doctoral dyadic approach to supervision. This enabled isolated doctoral researchers to meet with other like-minded researchers. The multiple interactions and conversations promoted between ERs and BRs therefore extended and enhanced the one-to-one student/supervisor relationship usually recognised as the core of the doctoral learning process (Parker, 2009). The summer school discussed in this study embraced a view of learning as a 'community of practice' (Wenger, 1998; Wenger et al., 2011). Activities were aligned with social constructivist approaches (Staarman & Mercer, 2010) to encourage dialogic exchanges, in-depth discussions, reflections and consequently intellectual development. This promoted alternate ways of thinking about, interpreting and reaching conclusions for and about all attendees' doctoral research projects. Furthermore, this joint meeting of the minds 'endowed experience with meaning' (Bruner, 2006, p. 191) and also introduced the doctoral students to important research being carried out by experienced science educationalists.

In endeavouring to provide an online summer school despite the onset of the COVID-19 pandemic, it was hoped that the ER applicants (from various countries worldwide) would still benefit from a virtual experience. An overriding aspiration was to mitigate feelings of isolation and insecurity that doctoral work can ordinarily evoke (Starke-Meyerring, 2014), which was exacerbated by the constraints on social interaction that the pandemic brought about. Therefore, promoting similar kinds of learning interactions previously evident in the face-to-face summer school, between BRs and ERs, through distanced digital means became the key aim of the organisers. The week-long screen-to-screen digital experience for the doctoral students (and ERs) became known as the virtual doctoral network (VDN). The

specific activities promoted within the VDN, detailed later in the paper, utilised synchronous videoconferencing to support small seminar groups focused on constructive critique of individuals' research projects, smaller and whole group social events, writing and theorising workshops, plenary E-lectures (with extended discussions), alongside a dedicated VDN webpage to host asynchronous program material including a virtual research-poster gallery.

This paper, consequently, presents participants' perspectives, about the affordances and constraints, presented by the digital transformation of a planned face-to-face summer-school. BRs' reflections on their experiences were collated after the VDN via both questionnaires and interviews. The BRs identified both affordances and missed opportunities that the digitally transformed activities facilitated. Further, we include how the BRs describe success of the VDN in supporting their introduction into a research community of practice (CoP) and science education research globally.

The implications for organising future summer schools, virtual or otherwise, are also considered.

THE CONCEPTUAL FRAMEWORK: COMMUNITIES OF PRACTICE

Wenger's CoP was adopted as the theoretical framing for this study, as it enabled a focused discussion on the extent to which the VDN met the overarching aim of introducing doctoral students to an established community (Wenger, 1998; Wenger et al., 2011), which was comprised of international science education researchers. Applying this framework to interpret and synthesize the impact of relocating doctoral student learning onto an online platform has been advocated by other educational researchers (Alexander, 2006; Waycott et al., 2017). Within this international summer school community, it was intended that there would be many ways that the BRs could engage in discussion and exchange of perspectives with other ERs already extensively involved in science education.



FIGURE 1 The nature of different processes and dimensions of learning that afford induction into a community of practice (from Wenger, 1998, p. 5)

It was assumed that the varied dialogic interactions taking place between ERs and BRs engaged individuals in making meaning. This would extend their horizons (Farnsworth et al., 2016; Wenger, 1998; Wenger et al., 2002) regarding different aspects of science education research. These interactions held the potential to mediate the developing identity (Wenger et al., 2002) of BRs new to the global science education research scene. The various online interactions and discussions provided opportunities to engage in dialectic exchanges of varied forms to develop learning along the following four trajectories: Learning as doing; learning as belonging; learning as experience and learning as becoming. These are depicted in Figure 1, adopted from Wenger (1998, p. 5), to illustrate key components of his theory of learning, through participating in a CoP, that relates to the VDN.

These processes of learning and induction as defined by Wenger, which frame the activities of the VDN, are as follows:

Practice: Learning as doing

A way of talking about shared historical and social resources, frameworks and perspectives that can sustain mutual engagement in action. (Wenger, 1998, p. 5)

Meaning: Learning as experience

A way of talking about our (changing) ability—individually and collectively—to experience our life and the world as meaningful. (Wenger, 1998, p. 5)

Identity: Learning as becoming

a way of talking about how learning changes who we are and creates personal histories of becoming in the context of our communities. (Wenger, 1998, p. 5)

Community: Learning as belonging

A way of talking about the social configurations in which our enterprises are defined as worth pursuing, and our participation is recognizable as competence. (Wenger, 1998, p. 5)

THE VIRTUAL DOCTORAL NETWORK: AN OUTLINE

The summer school experience, designed to maximize ER and BR learning interactions, is outlined in Table 1. In December 2019, prospective doctoral students submitted a five-page synopsis of their PhD research. Each synopsis was reviewed by two experienced ERs. From almost 100 applications, 49 were accepted and invited to participate in the summer school.

Ten different kinds of structured activities outlined in Table 1 provided the students with opportunities to be dialectically engaged in participation and interaction with others in the VDN. These interactions often included a screen-to-screen interface [usually via zoom], but they could also be promoted through Microsoft Teams or even via written comments on a shared google document. These digital platforms enabled processes of learning and induction within a community, as proposed by Wenger (1998) and illustrated in Figure 1. The nature of interactions (see Table 1) ranged from individual BR oral presentations centred on their individual research project to small group discussions about each-others' projects, to plenary lectures and interactive workshops given by eminent and experienced presenters.

TABLE 1 Overview of activities supporting the development of a community of practice at the virtual doctoral network (VDN)

Activity	Types of interactions and dialogic exchanges experienced during VDN
Research synopses submitted by BRs for scrutiny by ERs	ERs critique and assess quality of synopses to decide BRs allocation of a place at the summer school
Review of synopsis fed back to each BR	Two ERs score and provide review comments on the research synopsis for each BR
Plenary lectures given by ERs	ERs presenting ideas from research for BRs to consider
Post-lecture question and answer session	Dialogic exchanges between BRs and ER lecturer
Seven seminars (in small groups, ideally, of 7 BRs and 2 ERs)	In turn, BRs present their doctoral projects. Peers ask questions. ERs guide and facilitate discussions
BR poster presentations of their research projects	BRs summarise their research as A0 size poster, displayed in a virtual gallery
Post-poster presentation discussion	BRs respond to questions (from ERs and other BRs) through google docs
Early career researchers (ECRs) presentation	Former BRs, now ECRs, present summary of personal career journey
Early career researchers' discussion	BRs question ECRs about becoming ERs
VDN participants' final reflections	ERs and BRs reflect upon their experiences and participation within the summer school

To ensure that the small group seminars worked affectively, a ‘Code of conduct’ (Mason, 2018) was established for online small group seminars that involved a democratic and equitable approach to rotations in presenting, listening, clarifying, questioning, discussing and providing ‘the final word’.

The authors formed part of the local organisation committee, and as such, they were adamant that some form of the summer school had to go ahead as they wanted to provide support for the BRs despite Covid-19 restrictions. Prior to, and during, the VDN each of the authors assumed various roles. One author led the bid to hold the summer school in Oxford and held a leadership role maintaining oversight of all the running of the VDN. Another author assumed the role of a mentor to a group of BRs. Three authors assumed the role of videoconferencing technicians to ensure the smooth running of the virtual platform, help solve troubleshooting issues, collate questions for keynote speakers and help support the body of people at the event when needed. They also formed the early career research panel, which was highly rated as valuable to the BRs’ learning about potential career directions and possible academic pathways.

Table 2 summarises the affordances (or opportunities) for learning offered through the VDN programme. It also indicates how the interactions afforded different dimensions of engagement between the BRs and ERs to further develop their collegiate exchanges within the research CoP. Facilitating opportunities to engage in learning through ‘doing’, ‘experiencing’, ‘becoming’ and ‘belonging’ as the VDN week progressed enabled newcomers to ‘increase in participation in the community of practice’ (Lave & Wenger, 1991, p. 49).

Figure 2 provides more information about the chronology of activities the VDN offered.

The seminar groups that were typically comprised of seven BRs and two ERs had some flexibility to adjust their meeting times dependent on their local time zones and family responsibilities. The local time zones of participants ranged from the USA (United States of America) and Brazil to South Korea.

TABLE 2 Affordances (seen as opportunities) extended by the VDN CoP activities

VDN community of practice activity (typology of the interactions within the CoP)	Opportunity for learning as doing	Opportunity for learning as experience	Opportunity for learning as becoming	Opportunity for learning as belonging
Research synopses submitted by BRs for scrutiny by ERs	✓	✓	✓	✓
Review of synopsis fed back to each BR		✓	✓	
Plenary lectures given by ERs			✓	
Post-lecture question and answer session		✓	✓	✓
Seven seminars (in small groups, ideally, of 7 BRs and 2 ERs)	✓	✓	✓	✓
BR poster presentations of their research projects	✓		✓	✓
Post-poster presentation discussion		✓	✓	✓
Early career researchers (ECRs) presentation			✓	
Early career researchers' discussion		✓	✓	✓
VDN participants' final reflections		✓		✓

	Day 1	Day 2	Day 3	Day 4	Day 5	Online virtual gallery of all the BRs posters of their research projects
Morning	Mentoring seminar groups with 7 BRs and 2 ERs					
Lunchtime	Opening plenary lecture	Second plenary lecture	Social event – mentor group presentations	Third plenary lecture	Early Career Panel discussion	
Afternoon		Workshop		Workshop		
Evening	Mentoring seminar groups with 7 BRs and 2 ERs					

FIGURE 2 Indicative arrangements of the digitally transformed VDN Summer School

Each seminar involved one BR presenting their research for 30 min to the rest of their group using videoconferencing tools. They would then leave the group meeting with an ER to extend the individualised feedback, while the remaining peers discussed their work, facilitated by the other ER. This discussion would take approximately 30 min, after which the BR who presented returned to the seminar group and re-engaged in further reflective and constructive dialogue with his/her peers.

BRs were each asked to produce an electronic poster (as a PDF file) of their PhD study prior to the VDN, which would be displayed during the week in a virtual gallery. The use of google docs enabled all attendees to view and comment on every poster during the VDN week.

Several other developmental activities also took place during the week, including three plenary talks, two workshops and two social events. The plenary lectures centred on *becoming an educational researcher, ways to research formative assessment and issues around researcher identity and the nature of science*. These were presented live, online. The workshops focused on academic forms of writing and structuring a research project informed by Toulmin's argumentation framework (Toulmin, 1958). They were repeated to ensure all BRs could attend both. There was also an Early Career Researcher panel discussion, which provided students with the opportunity to hear from academics in the next phase of their career. The two social events were informal videoconferencing sessions, but semi-structured, with facilitated group activities and discussions. The opening and closing ceremonies (not specifically identified in Tables 1 and 2 as interactive learning opportunities) served to introduce and synthesize for participants, the purpose, structure and opportunities offered by the VDN.

Exploring the impact of the digital transformation of a week-long summer school for doctoral students, informed the following research questions that framed our research:

- RQ1: What are the affordances and constraints of a digitally transformed doctoral summer school (referred to as the VDN)?
- RQ 2: What dimensions of learning appeared to be successful within and beyond the VDN?

METHODOLOGY

A multi-method approach was adopted (Creswell, 2015) using online questionnaires and interviews (that were audio recorded and transcribed) to gain breadth and depth of understanding about BR's experiences of the VDN. The data collection was consequently two phased (Creswell & Creswell, 2018, p. 222). In this sense, multimethods (Mik-Meyer, 2020) were adopted rather than a mixed method (Johnson & Onwuegbuzie, 2004; Teddlie & Tashakkori, 2009) approach. The questionnaire included Likert scale questions that served to substantiate the extent to which the VDN successfully achieved the objective of introducing the BRs to the well-established science education research community. The interviews,

conducted sequentially to the questionnaire, delved deeper to elicit more personalised narratives (Mannay, 2015).

Procedure and participants

Questionnaires were circulated to all participants on the final day of the VDN. At the end of the questionnaire, BRs were invited to opt into an interview. The interviews took place one to two weeks after the event so that memories of the event were fresh. This opt-in option, post-VDN, meant that the BRs could independently choose to verbally extend their written responses, if they wished to, rather than feel potentially coerced further via an email from the VDN committee. Of the 43 BRs who attended the summer school, 15 responded, representing a response rate of 35% and the research team conducted interviews with 8 BRs. All students who volunteered to continue to be part of the research were contacted via email to agree interview dates and times. Data from the interviews were transcribed verbatim, anonymised and triangulated with their questionnaire responses. Ethical approval for the study was sought and granted by the authors' institutional ethical review committee prior to all data collection procedures.

Research instruments

The questionnaire consisted of seven open and nine closed questions. These questions provided information about four key areas related to the online experience:

1. Expectations of the digitally transformed summer-school and the extent to which the aims were met.
2. Perceptions of the digital experience and learning about research.
3. The extent to which participants felt connected and included with other members of the community.
4. The perceived benefits, limitations and developmental potential of the digital experience.

Recognising the qualitative nature of data elicited through the instruments, the questionnaire was subjected to content validation following its initial construction by one of the authors (Andrew & Halcomb, 2009). Several rounds of refinement involved reviews by the co-authors and other experienced researchers to ensure that the content in relation to the goals of the study were appropriately aligned. The follow-up interviews consisted of 14 questions, which facilitated a semi-structured approach (Kvale, 2007). The questions allowed the interviewer to cover key concerns related to the research questions, but with the flexibility to explore emerging ideas proffered by the interviewees. All questions sought to elicit participants' views about different aspects of the virtual format of the VDN. Interviewees were also asked about their expectations prior to participating, their motivations for joining, the benefits and limitations of the VDN as well as how it impacted their research trajectory, which elicited emergent narratives regarding their personal and professional development.

Analysis

The corpus of qualitative data gathered through the interviews and questionnaires were first reviewed inductively, with two members of the team engaging in the initial phases of

thematic analysis (Braun & Clarke, 2006; Saldana, 2009). The team sought to understand the broad content of participants' perceptions through coding and summarising the available data. Throughout this process, the remaining members of the team acted as critical friends (Stieha, 2014) to check interpretations of the coded data. In this way, the categories were refined and definitions for all codes were produced. Broad themes were developed based on the content and consideration of the research questions. These initially inductively derived themes included 'benefits', 'local' and 'international collaborations', 'the formation of an academic community' and 'mentorship' and the different ways participants learned about methods useful for science education research projects. Additionally, they described 'disadvantages' as, the lack of informal face-to-face (physical and verbal) interactions over breakfast or lunch (as would be the case if the summer school had taken place in Oxford). These initial codes were subsequently re-considered, to allocate them within the category of 'affordances' offered by the VDN (frequency of mention in interview transcripts = 147) or themes that related to constraints of the VDN (frequency of mention in interview transcripts = 53). Following the initial inductive analysis, the data were re-examined deductively in light of Wenger's theory of learning communities (Wenger, 1998). This combined process of inductive and deductive analysis is not unusual for this kind of qualitative research, which sought to understand the participants' voice on their own terms whilst also theoretically situating the ideas (Fereday & Muir-Cochrane, 2006). Where inductive analysis was conducted, the interrater agreement was found to be 79%, which was deemed reasonable in the context of the study (Miles & Huberman, 1994).

FINDINGS

Findings from the interviews and questionnaires are organised to respond to the two research questions in turn.

First, we indicate how participants perceived the digitally transformed summer school, afforded them, or not, assorted opportunities for learning.

Second, we further considered dimensions of learning within and beyond the immediate community of BRs and ERs. The findings highlight the nature and success of learning through doing, experiencing, becoming and belonging (Wenger, 1998). These evidence the different ways in which the doctoral students were enculturated into the science education research CoP.

Pseudonyms are used in the section below to ensure the anonymity of responders.

General comments regarding affordances of the VDN

BRs noted how the online nature of the international community of practice offered affordances for learning in several ways. The nuances of these aspects of augmented learning, elicited through the inductive and deductive analysis, are further illustrated below. One of the main affordances to emerge from the data was the overwhelming feeling of being welcomed or 'becoming' into the academic community. Many BRs commented that the virtual environment afforded the development of social connections and relationships and that they successfully felt inducted into this particular research community. This was a surprise for most who had thought it would be challenging to socially interact and get to know people. For example, Drew commented, "it wasn't that hard, given that our team was really cool, and our mentors were just awesome". When asked what he thought, James further outlines how he feels the VDN afforded him connection into the community.

[It] really help[s] young scholars to feel part of the science education community. So, there's like that sort of induction into this professional world. Meeting people who will, who right now might be mentors, faculty, but who will eventually be peers. You know, for a lot of scholars. People whose work you probably already read or may have read, or maybe in the future and making those personal relationships with them, so part of it is that professional induction. [James]

The VDN also enabled BRs to be more comfortable and flexible in engagement; for example, listening to keynote lectures, while also being able to move and drink coffee within their home environment. They recognised that in a face-to-face setting, they would have to sit in a fixed position in large lecture halls to listen to the speaker.

So, sitting around all the time was a bit annoying. But during a lecture or whatever, you could [...] walk around the room. And that's not possible, of course, in face-to-face. [Drew]

The virtual poster gallery was available throughout the summer school and for a few days afterwards. This allowed all BRs and ERs to view all the posters in a more leisurely manner rather than only at an allotted time in a face-to-face summer school. Furthermore, BRs felt that the flexibility of the digital timetable facilitated easy, rapid switching between the various activities. This was also facilitated through the central timetable that had been hyperlinked to each of the online sessions for swift ease of access.

The financial implications of engaging in an online summer school was referenced by many as the VDN not only removed travel costs but the enrolment fee for the face-to-face summer school was also waived. Other BRs also commented on the effectiveness of time management. The lack of commute to and from the intended location in the United Kingdom (UK) freed up time. It afforded the opportunity to integrate their "normal life" with the VDN.

I mean, it's certainly more efficient. There's no need to travel to the airport and spend all that time in transit getting to a place there and back, physically ... on the days of the session, it's, sit down in front of the screen, turn it on, you're there. [James]

Although the above points outline many affordances of the VDN, participants were also asked about missed opportunities or constraints they experienced. Some of these are contradictory to the affordances and they will be explored next.

General comments regarding constraints and missed opportunities

When asked about the limitations of the VDN, the overwhelming missed opportunity that the BRs noted was not being able to come to the UK for the cultural experience. For many, it would have been their first visit to the UK. They felt they had missed the opportunity not only for travel, but the deeper connections they may have forged through in-person social interactions. Despite many claiming the financial implications of reduced travel being a great affordance of the VDN, BRs had been looking forward to coming to the host city where the summer school would have been held.

And the third reason was that I really loved the UK. I really wanted the opportunity to come back. I've never been to Oxford. And so actually being on the campus was a main reason that I wanted to, to go and so that was the only disappointing

factor is that, you know, I really wanted the chance to be there in person. Yeah. But, you know, all of the professional and intellectual pieces were still available. So, I'm glad we still were able to have it even if I couldn't be there. [James]

While BRs had expressed surprise that the VDN afforded relationships to develop beyond their expectations, there was also a sense from their responses that the nature of interpersonal connections could not be fully replicated online. For example, some BRs indicated how they thought that informal networking and serendipitous interactions or conversations over meals were notably absent or less possible in the virtual approach. Such interactions can be insightful for them in eliciting wider comments on their research projects or helping them become better connected with science education researchers whose lives or work were closely related to their own within the community.

Maybe some deeper connections between participants were prevented, especially among participants that were in other groups ... mostly our conversations were about our research, about our work. Something that was maybe lacking was some more private conversations like, what are you doing? Are you married? Do you have someone? Do you have pets? ... it is this personal contact was maybe something that I missed the most. [Kennedy]

All the quotations above emerged from the interviews. The responses elicited via the questionnaires also highlighted similar constraints that centred around the lack of networking opportunities and fortuitous interactions, acknowledging the inevitable limitations of the virtual environment.

Networking outside of own mentor-group (eg, only time where one could meet and actually talk to people outside the mentoring group) was the non-mandatory kick-off social event on Sunday ... the other social events were super fun and engaging, but there wasn't time and opportunity to get to know the others well. That said, I honestly don't really know what could've/should've been done differently, since I feel the VDN [organising committee] did such an amazing job, providing a variety of different things, like workshops, plenaries and other events, already ... and bonding/meeting new people usually happen in the "off-time" between those things, something a virtual summer school is simply not equipped to offer. [Michele]

While there may be many anticipated and well-documented constraints to online learning, it is noteworthy in the context of the VDN, which aimed to integrate students into a community of practice, that the most prominent constraint mentioned was individualised personal and social connections.

To address the second research question, the following section discusses ways that learning within the CoP was developed through the VDN.

Learning evidenced within and beyond the CoP

The following considers the data elicited through a theory-informed approach that analysed instances of the four categories from Wenger's framework: (1) learning as doing, (2) learning as experience, (3) learning as becoming and (4) learning as belonging. Some excerpts from the interview transcripts act as representations for more than one dimension of learning. Communities take time to develop and being able to show that the VDN supported the

different processes and dimensions of learning in a week-long event is testament to the effectiveness of its design.

Learning as doing (developing practice)

Learning as doing from the Wenger (1998) framework was interpreted for this study as ways of engaging in talking about what was done by the BRs within their research projects. All BRs had carried out some PhD research work before attending the VDN. They had a range of academic and professional experiences, some only having worked on their own research projects, while others had collaborated with larger research groups on funded projects at their respective institutions. They were invited to describe, explain and justify what they had done, what they had found out so far and what they intended to do next. Presentation of their progressing work primarily took place within their small seminar groups to peers. However, they also communicated their research projects (to date) through their initial proposals submitted to be considered for the VDN, as well as their posters archived in the virtual gallery. All participants could view these at any time during the virtual summer school.

Each participant considered their development of practice as a researcher in collaboration with others through the different activities organised by the VDN (as listed in Table 1). The benefits of this shared virtual environment were recognised by those who responded to the questionnaire. One student noted the ease of access to online materials and how this afforded them pragmatic opportunities: *'Resources [sic] (e.g., presentations, references etc.) were shared more easily and quickly. You could personalise the mode of attendance'*. Arguably, the student was acknowledging how the virtual experience had enabled him and others to focus on specific aspects of interest during the live virtual presentations. However, the students also recognized how availability of asynchronous material enabled them to consider and discuss how others, beyond their seminar group, were using similar (or contrasting) techniques or frameworks. Blake commented that the VDN enabled her to easily contact others not in her small discussion group. This instance of connecting with others and their work was also facilitated through the static online poster exhibition available during and after the VDN. The VDN webpages also provided a means of disseminating and sharing academic work that could be discussed through written text that included consideration of each other's research design tools and theoretical frameworks.

Wenger's view of practice (learning as doing) suggests how discussion is used to share ideas socially. Verbal reciprocity between community members was an expectation of the attending students of the VDN network.

[At the VDN I wanted] to get several insights into other research and to have the opportunity to get in touch with other researchers. Possibility to discuss, review and thereby get helpful feedback on my own work. [Alex]

The exchange of perspectives to inform the students' work came from a variety of sources with one student (Alex), during the interview describing how she took the opportunity to talk (one-on-one, virtually) with a mentor who was an expert in her area (demonstrating self-efficacy).

... for me that conversation I had with [my mentor], it was actually 40 minutes [...] And so for me, that became a really useful feedback session because she gave me all sorts of thoughts and ideas and references which I was able to then go away and find. I actually bought a couple of books as a result. And yes, I really felt that moved my thinking forward. [Alex]

This mutual engagement subsequently facilitated a further verbal interaction with another PhD student who was also looking at the same concept.

... the other thing, which I did was that one of the students in our group was also looking at self-efficacy. So, we agreed to go off and have a one hour [...] meeting, [...]. And, we had a really interesting conversation. [...] I think it was just a slightly kind of unique opportunity to talk one-to-one with one researcher who was a student, but kind of looking at it from a different angle. [Alex]

Drawing on another BR's reflections of interactions, we can see how the VDN facilitated her in building interpersonal relationships and independently sustaining action in her research. This demonstrates the successes which can be supported, despite the constraints of the online VDN format.

Learning as experience (developing meaning)

Another student, James, acknowledged how the VDN experience helped him better understand the research process and consequently build his confidence; it had provided him with more faith in his identity as an educational researcher.

... exposing it [my dataset and academic writing] to that public for the first time was both nerve-racking but also it was gratifying when ... I finished my presentation, and you know, the group was supportive and [...] 'Your work is great', or 'I'm very interested in that', gave me additional confidence that I'm on the right path. [James]

This experiential development of meaning was echoed in his questionnaire response. That is that the VDN had afforded him the motivation to collaborate on research.

... the possibility of working in mentoring groups, creating these links in so little time, it's an achievement. I have ended my week full of motivation to continue my research and look for some other topics I had not considered before, and willing to establish some collaboration in the near future. [James]

Again, it can be noted that despite constraints, there is a clear sense in which the VDN has been able to afford individual BRs experiences of research in ways that have been meaningful and developmental for them.

Learning as becoming and learning as belonging (developing an identity)

Many of the students talked about developing their identity through the learning experiences of the VDN. They described how prior to attending, they had previously been a part of an already recognised smaller communities (e.g., at their educational institution). As a result of participating and experiencing the VDN they recognized they were "becoming" a researcher within the wider global academic community. This act of participatory becoming led to a feeling of belonging. Interestingly, this transition is reflected by Alex during her interview.

... I did come away from the week feeling that I was more part of science education community wider than just the circles that I've been living within, you know, within [University] and also within the early career researcher, science education networks in England. [Alex]

Here, her transition from 'Learning as Becoming' to 'Learning as Belonging' within the wider community is highlighted.

Drew likened his experience within the VDN to a debutant being introduced to society, implying a sense of acceptance into the learning community.

... I think there are two strengths [of the VDN]. One ... would be providing doctoral students with feedback on their work in a new environment from other people [other] than your own supervisors or your fellow PhD students from your own Institute ... The other ... would be networking ... So, getting to know one another, for instance, I felt this was really clear also in the final meeting ... the closing ceremony [was] introducing us to the [wider] network ... I imagined this [the VDN] also a bit like in the Jane Austen novels, entrance in society part. [Drew]

Drew's perception of his participation in the VDN was representative of many other BRs too; he recognised a changed status and introduction to wider societal (or community of) practices. This resonated with responders to the questionnaire, with many stating that the experience was about, building social channels with peers from other countries [mentors, seminar group members and researchers].

There were notable successes in transforming a doctoral summer school to an online experience for supporting BRs introduction to a wider research community. This is not an insignificant achievement, given the challenges and constraints in doing so at that particular time in history. We now reflect on the implications of what has been learned for future work.

IMPLICATIONS FOR FUTURE ONLINE DOCTORAL SUMMER SCHOOLS

The findings from this research indicate how it was possible within a week to 'make-a-difference' for developing science education researchers. Through the structuring of a timetable involving regular, focused small group interactions (such as seminars, workshops or poster presentations and evaluations) as well as a series of whole community interactions (such as plenary lectures, panel discussions and social events) facilitated through online platforms makes a difference. It appears including at least ten different ways (as indicated on Tables 1 and 2) whereby students can interact with peers and/or more experienced others, which mediates [remote screen-to-screen] learning interactions that can make a notable difference. Through the scaffolding that online platforms can provide, findings from the study show that most affordances ordinarily made available in real, face-to-face experiences can be made possible in a virtual environment. A real positive for international events such as a virtual week-long summer school involving ERs and BRs from around the world, which requires minimal cost and time, is that it is not only environmentally more desirable, but it can result in effective learning gains for doctoral students.

In this particular study, it shows that it is possible to relocate an effective learning experience that introduces developing research students into a global community of educational researchers. In future, it may be possible that students from less affluent countries or those with family or other-caring commitments could participate in a blended way in the summer school. This could provide more equitable opportunities for would-be researchers in rather remote locations or isolated contexts.

CONCLUSION AND DISCUSSION

The development of an international cohort of BRs and their learning trajectories was facilitated by an elevated level of 'mutual expressibility and accountability' (Wenger et al., 2011, p. 197). This week-long virtual community of practice promoted the development of science education researcher identity. As participants in the social learning space afforded by the small seminar groups, they were able to recognise others' influence as their learning partners (Wenger et al., 2011, p. 9). They recognised, through the various online interactions, how it was appropriate to act and think to work out meanings from a wider global community of science education researchers. In other words, through recognising the range of international learning experiences each brought to the virtual community, there began a process by which they appropriated what constituted 'practice' in the world of science education research.

The transformation of the VDN ensured that 'didactic traditional teaching' was avoided (Alexander & Boud, 2018, p. 7). Interactions supported BRs successful learning through discussion, demonstration and consideration of ideas, concepts, approaches and skills (Whisker et al., 2010).

ER perspectives of the VDN could also have been explored. This would have elicited views offering a juxtaposition to that of the BRs. This could have further informed how to effectively support doctoral students becoming science education researchers within an established and experienced community of practice (Wenger, 2011). However, the nature of the practice that ERs are concerned with, to support BRs becoming familiar with research practices, is made explicit in this study (Tables 1 and 2). Narratives elicited from BRs demonstrated clearly that they developed expertise through exchanges with the ERs in 'the body of knowledge, methods, tools, stories, cases, documents, which members shared and developed together' (Wenger, 2004).

Being actively involved in 'doing something' (*ibid*) through individual, but shared experiences, provides the opportunity to engage in collective constructive critique of research endeavours. Within the interactive online spaces, created through the VDN, academic scholars [new and experienced] were able to engage with each other's work. This highlights how BRs can appropriate methods, tools, understanding and applications (Wenger et al., 2011, p. 197) of science education research, despite the remote and virtual nature of intellectual and dialogic exchanges underpinning the learning processes.

What is certain, though, is that it is not straightforward to plan an interactive online doctoral summer school. There is no room for complacency and assumption that just transposing the activities online will work. Preparatory work was required to afford the ERs and BRs with appropriate contextual background information that needed to be actively engaged with, prior to meeting for the first time. All the activities listed in Tables 1 and 2 had to be pre-planned carefully to ensure a spread and range of international experience and research expertise among the small seminar groups. For all online meetings, prior preparation required the generation of virtual meeting rooms, invitations and Greenwich Mean Time (GMT) timings sent out to everyone involved. Careful timing (as the summer school was international) had to be balanced for all time zones to participate. Setting up all the virtual meeting rooms, poster galleries and plenary audience invitations required checking for functionality, as well as ensuring inclusivity. However, from the questionnaire and interview data, it was apparent that the affordances set-up through the various interactive activities scaffolded a successful international summer school to develop a transnational community of practice. This successful digital transformation enculturated doctoral students into an academic community, comprised of scholars from around the globe. Activities that ensured the blend of the kind of synchronous and asynchronous activities, which extended across several days, promoted learners in becoming immersed in international learning communities, whatever their geographical setting and prior socio-cultural experiences. How these communities of practice can grow and thrive in the future, is yet to be explored; however,

it is our recommendation that what is essential is the adoption of a philosophy that nurtures an inclusive community of practice, which encourages the commonality of purpose and offers long term gains for both the BRs and ERs. Eliciting views from both groups of participants about their lived virtual experiences can continue to inform how the VDN (or an alternate approach to developing online international research communities) can be updated and evolve in future. What is evident from this research is that the kinds of digital learning interactions mediated successfully supported doctoral students to effectively become involved and more knowledgeable members of an international learning [about research] community.

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CONFLICT OF INTEREST

All authors state they have no conflicts of interest.

ETHICS STATEMENT

The research was carried out following the BERA guidelines (British Educational Research Association Ethical Guidelines for Educational Research) and was subject to the approval of the University of Oxford Central University Research Ethics Committee. This required us to provide a description of the research we intended to carry out, including the information and consent letters for participants, details of the questions that would be asked in both questionnaires and interviews, information about how the anonymity of the participants would be maintained, and how the data would be stored securely on a password-protected university server. The process of recruiting the participants was also described, along with the measures taken to reduce burden and risk to the participants. There was also a full description about how the findings would be disseminated.

DATA AVAILABILITY STATEMENT

The data is stored on a password protected virtual drive. Respondee gave their consent for the researchers, only, to interrogate and archive the data for 5 years.

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