The impact of COVID-19 on the format and nature of academic conferences in mathematics education

Johann Engelbrecht, Oh Nam Kwon, Marcelo C. Borba, Hyunkyoung Yoon, Younggon Bae and Kyungwon Lee

Abstract

The global COVID-19 pandemic has provided an opportunity to re-examine the possibility of organising virtual conferences in mathematics education, in which the social needs of participants can also be addressed. In this study we investigate the future impact that this change may have on the format and nature of mathematics education conferences. The study was conducted in two phases. We used an online questionnaire in which we asked participants to give us some input on the issues above. In the second phase of the project, focus group interviews were conducted with international mathematics education researchers. This study is an exploratory study, in which the sample was not developed in a way that could generate comparisons. The aim of the study was to raise possibilities about what may be the future of mathematics education conferences. Findings indicate that although academics are pro-actively thinking about alternative conference formats, the proven value of face-to-face conferences is still very real, showing that it is too early for us to have a clear vision of the future format of academic conferences.

Key words: Academic conference, mathematics education conference, virtual conference, face-to-face conference

1.   Background and introduction

Over the past more than a century, international conferences in mathematics education have almost never been cancelled, but due to the global COVID-19 pandemic, international mathematics education conferences such as ICME 14 and PME 44 had to been cancelled or adapted to a virtual or hybrid format, and academic conferences have been faced with the need to transition to virtual formats. For mathematics education to be an academic discipline, it is required to have the existence of a *learned society*, academic journals, and academic conferences (Borba, 2021; Leung, 2015). Particularly in the discipline of mathematics education, many conferences are highly prestigious and some have a reputation that is on par with peer-reviewed journals.

Authors, such as Borba (2021) and Engelbrecht et al. (2020a, 2020b) discussed possible changes in the future of mathematics education: the pandemic forced us to teach online with little or no research to support what we do. The increasing social inequalities throughout the world have grown even greater. Members of society should understand the way the virus spreads exponentially, the importance of social isolation and the growth of social inequality.

In this paper we want to discuss the impact of the pandemic on the future of mathematics education conferences. We report what is going on in mathematics education and do not claim that our findings are unique for conferences in mathematics education. Reporting what is going on in mathematics education is

meaningful within the mathematics education community and provides insights to the readers of this journal.

According to Kim (2020), conventional academic conferences are more of a habit than a necessity and much of the benefits of a conference can be obtained at virtual conferences for a small amount of the costs of a conventional event. But do we lose something if we move to a virtual model?

Although attempts in the past to organise virtual conferences have been made (Leong et al., 2008), there was too little reason to change the well-received face-to-face (f-2-f) model of meeting and conferences that was enjoyed by academics and proved to be a very good way of communicating new knowledge (Ahn et al., 2021). So, in spite of high travelling costs for meetings and conferences (accounting for 135.9 billion U.S. dollars in direct travel expenditure - 40% of all business travel in the U.S. in 2019), and on-going concerns about the climate change effects from the footprint of these events, the f-2-f meetings continued (U.S. Travel Association, 2017; Ahn et al., 2021), and there are many supporters of f-2-f conferences. In this sense, a different question than the one raised above should be asked: do the benefits overrule the burdens?

The global COVID-19 pandemic has provided an opportunity to re-examine the possibility of organising virtual conferences in which the social needs can also be addressed. Are the costs and the environmental issues relevant enough for not having f-2-f conferences? What are the economical impacts of not having conferences on jobs and alike? Answering these questions would require for a different kind of paper with a thorough economical discussion. With this exploratory study we want to start a discussion that could take place in online platforms as well as in f-2-f discussions.

2. Literature review

In their historical book, Menghini et al. (2008) traced the history of ICMI, showing the importance of the meeting of 1908 and those that followed until ICME got established. Although conferences were not the theme of this book, they mentioned the importance of the ICMI studies, ICME and of a special f-2-f meeting that took place in Rome in 2008 to re-enact the 1908 meeting. So f-2-f meetings are historically important for our field of research. The question is if these conferences will disappear once we overcome the pandemic?

Why conferences?
Disciplinary and professional conferences are part of the DNA of academia. Conferences are the places where knowledge is shared, careers are advanced, networking occurs and job interviews are held. For professional associations, conferences constitute a significant portion of revenue (Kim, 2020).

Literature on systematic study of the value of academic conferences for participants is sparse. Authors from a range of disciplines acknowledge the critical role that conferences play in academic careers (Oester et al., 2017; Ahn et al., 2021). Conferences give the opportunity to share new knowledge in the field and learn new skills; early career researchers can get mentoring (Parsons, 2015), and conferences help academics build social networks (Ahn et al., 2021).

As reasons why academics attend conferences, Verbeke (2015) highlights the opportunity to meet famous researchers in the field; to socialise and converse with other researchers; to learn about new directions in the field; to become more visible in the field and to visit other countries.

Social equity
Before the pandemic, there were authors who pledged that the scientific community lived in a context of reduced funding for participation in conferences with a large number of conferences taking place annually in various scientific areas throughout the world (Oester et al., 2017).

In the past there have been concerns about inequity in academic f-2-f conferences. Examples of inequalities include gender, race and social conditions (Sardelis et al., 2017). Walters (2018) emphasises under-representation of women, for example in the selection of keynote speakers and members of prestigious conference committees. In the transition to virtual learning, some new equity problems have emerged. Viglione (2020) looked at the trend that female academics were falling behind their male peers with research outputs and cites a number of studies confirming this suspicion (e.g. Frederickson, 2020). She mentions as possible reasons, increased childcare responsibilities, taking care of ailing relatives, and the fact that female staff members generally handle more teaching responsibilities, so the sudden shift to online teaching (and the curriculum adjustments that it requires) disproportionately affects women.

Sardelis et al. (2017) advocate the existence of "codes of conduct", with effective consequences in the search for fostering constructive stances, such as a free, critical and respectful exchange of ideas; controlling or preventing situations such as harassment; combating discrimination based on sexual identity, race, age, religion, nationality and academic status. Although valid claims, these authors do not speculate whether such a situation of discrimination would be different if the conferences were virtual. Little recognition is also given to efforts of communities such as the ICMI community that balance gender, race and geographical distribution, both in its traditional f-2-f conferences, and in the last hybrid ICME14 that took place in China, where representatives from various societies and countries were involved in the activities.

But authors, such as Kim (2020) also pose that faculty and staff from less well-resourced institutions have been under represented at disciplinary and professional conferences. At the same time, attendees from wealthier institutions were over represented at these events. Kim (2020) claims that virtual conferences can level the playing field and tend to result in events whose attendees better match the distribution of institutions. In the past, in some countries, there was better funding for attending f-2-f conferences than in others

Virtual conferences
Ahn et al. (2021) relate a brief history of the growth of virtual conferences, mentioning some of the successes and some of the issues that are still not running smoothly.

The consensus has been that virtual platforms are not feasible or desirable as a standalone conferencing venue. (Ahn et al., 2021, p. 3)

The problem of hosting a virtual conference with attendees located around the world in different time zones has been discussed in a number of studies for more than a decade (Erickson et al., 2011). Ahn et al. (2021) came up with some insights for hosting virtual conferences as standalone events, rather than as an add-on element to support the main f-2-f event - hybrid conferences may diminish the benefits of attending academic conferences. Ahn et al. (2021) report that although attendees felt that the virtual conference overall was not effective in assisting their efforts to socialise and build networks, a virtual reality platform seems to have elicited some level of social presence in users. They recommend that future virtual conferences may want to consider using social virtual reality platforms (e.g. *Hubs*[1]) mainly as a means for socialising and building networks, while providing other platforms to address other conference needs. Providing a range of communication platforms may enable attendees to select the platform that is appropriate for their task and situation and may contribute towards a solving the problem of social interaction at virtual conferences.

The post-COVID-19 academic conference world might come to resemble the post-COVID-19 world of higher education. There could be fewer but better residential conferences, and more online (and improved) events.

3.   Research questions
Given the importance of academic conferences in the discipline of mathematics education, surprisingly little attention has been given to systematically studying the value of academic conferences for participants.

In this study we investigate the impact that the pandemic may have on the format and nature of mathematics education conferences in future. We address the issue under two subheadings
1.   Participating in conferences - what are the advantages, potentials and limitations of virtual conferences versus f-2-f conferences, referring to
         a.   Issues that are better addressed at f-2-f conferences?
         b.   New opportunities that arise in the new format of conferences?
2.   What are participants' views on the impact that the pandemic may have on the nature and content of mathematics education conferences in future – including the actual format of presentations?

4.   Framework that was used in the research
Our study is exploratory in nature, since the situation is highly original and nobody has ever had to deal with a similar problem: a pandemic and theorising about conference organising. We have selected, some findings from the discussion regarding conference organising to frame our research. For both parts of our study, the survey as well as the interviews, we structured our research according to the frameworks in Figures 1 and 2. These were developed using Oester et al. (2017) and Ahn et al. (2021). We used these frames to develop the questionnaire, to organise our

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[1] *Mozilla Hubs* is a web-based social virtual reality platform that can be joined from any internet connected device, web browser or smartphone.

interviews and also to analyse and group our findings. So this framework should be seen as a synthesis of findings of the literature review.
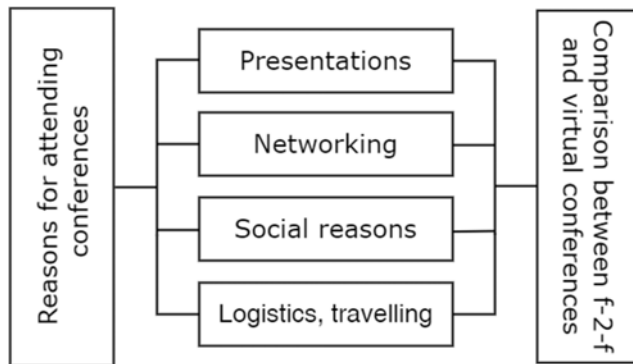

Figure 1. Framework for academic conferences

Academics attend conferences (f-2-f or virtual) for various reasons. These reasons are depicted in the left part of Figure 1. Presentations include a variety of conference activities, including keynote and plenary, keynote and invited talks, parallel sessions, panel discussions, workshops and poster sessions. Networking would include the opportunity to communicate academically with other colleagues in the field. Social reasons include the opportunity to get to know other colleagues on a social level through informal discussions as well as social events and excursions at conferences. Logistical reasons include e.g. the effort of being absent from normal teaching obligations by attending a conference in person, the problems that academics face with arranging their schedules while attending a virtual conference, and other logistical problems that academics have to manage when attending a conference. Travelling has become an important issue when attending a conference. Some academics see travelling as a great opportunity while others experience it as an obstacle. We used the same framework in our comparison of f-2-f with virtual conferences in both our measuring instruments. This framework was then also used to frame our findings and the discussion.

Views from participants on the future impact on the content and nature of mathematics education conferences and the general format of presentations at conferences, as well as at universities were sourced from the participants, using the framework as in Figure 2.
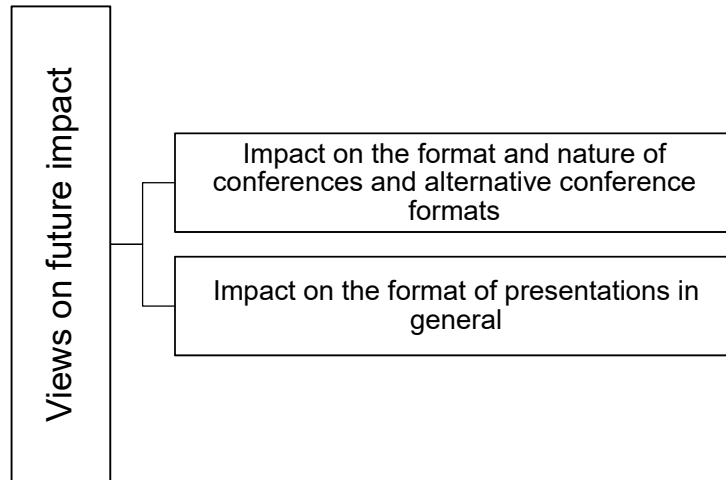
Figure 2. Views on the future impact

5.   Research design

The study was conducted in two phases of an online questionnaire, and focus group interviews in June 2021. We used an online questionnaire in which we asked participants, in open-ended questions, to give us some input on the issues above. We identified 193 mathematics education researchers and educators from participant lists of recent online conferences and webinars and invited them to complete an online *Qualtrics*[2] questionnaire. Questions in the questionnaire consisted mainly of open-ended responses in which participants reflected on their experiences on various issues in f-2-f and in virtual conferences. However, a few questions were in Likert format, in which participants had to express their input on a three-point scale. Participants were asked about their perceptions on advantages and limitations of the two conference formats, f-2-f and virtual regarding their values of different events at conferences, e.g. plenary events, parallel presentations and social interaction. They voiced their opinions on the impact that the "new" format of conferences could have on topics in mathematics education and also speculated on how the current presentation format may change in future conferences.

The questionnaire was completed by 88 (46%) respondents who were all identified as experienced researchers by themselves. The respondents were from diverse geographic regions in the world, though they do not represent the population (See Figure 3).

We did not aim at a sample that would represent the different parts of the world in a proportional way, and we do not claim that this sample is representative of mathematics educators worldwide. We purposefully aimed our research at experienced researchers who had ample opportunity to attend f-2-f conferences before the pandemic. The chart in Figure 3, however, indicates that there are representatives from all continents. (the numbers of respondents are represented on the vertical axis).

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[2] *Qualtrics* is a web-based survey tool to conduct survey research, evaluations and other data collection activities.
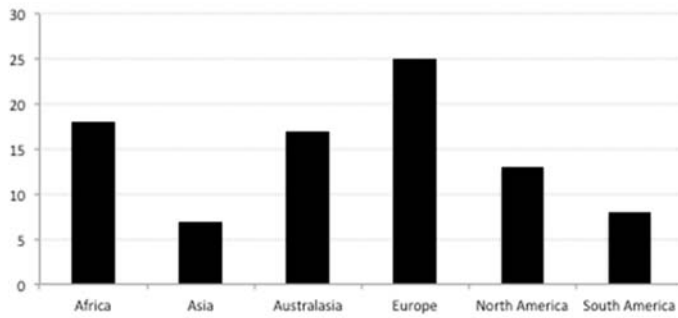
Figure 3. Geographical distribution (88 responses)

To triangulate the findings from the survey, in the second phase of the study, we conducted focus group interviews with 13 international mathematics education researchers from different backgrounds in terms of geography, gender, and academic careers. The focus group interviewees were not selected from the survey respondents. In the recruitment process, we sent an invitation letter with a brief survey on experience with virtual conferences to attendees in recent international virtual conferences and webinars that had been hosted by some of the co-authors in this paper. Based on their responses, we invited three groups of participants with respect to the diversity in regions, genders, and academic career in the field. All the participants had experience with both f-2-f and virtual conferences in mathematics education but had been involved in a different range of activities, including attending presentations, participating in discussion or working groups, giving a presentation, and organising conferences (See Table 1).

Table 1: Focus groups interviews

Group	Interviewees	Position	Country
FG1	A	Lecturer	Indonesia
	B	Elementary school teacher	Korea
	C	Research Fellow	Mexico
	D	Assistant professor	New Zealand
	E	Math education specialist	Philippines
FG2	A	Professor	Denmark
	B	Professor	Germany
	C	Professor	Germany
FG3	A	Professor	China
	B	Professor	Singapore
	C	Professor	Thailand
	D	Professor	USA
	E	Professor	USA

To inform us about emerging themes from discussions in each group sharing similar conference experiences, the interviewees were grouped by the extent they have been involved in organising conferences. The homogeneity of groups in focus group interviews is considered essential for facilitating group interactions, because

interviewees with similar experience are expected to share frames of reference in groups and feel comfortable with sharing their thoughts in their homogeneous groups (Grønkjær et al., 2011). In particular, we were interested in less experienced researchers and educators, presumably with less or no experience in organising conferences, because we were not able to collect their responses in the survey.

Focus group 1 (FG1) consists of interviewees who have had experiences of attending and/or presenting at conferences, but no experiences with organising conferences. All interviewees in focus group 2 (FG2) had been involved in organising international conferences in both f-2-f and virtual settings. Interviewees in focus group 3 (FG3) had been serving in leadership roles on organising committees for influential conferences such as ICME, PME, MERGA, EARCOME, etc. Each focus group participated in a two-hour semi-structured interview with three leading questions on (a) how the participants perceived f-2-f and virtual conferences, (b) their view on advantages and limitations of virtual conferences, and (c) how they envision mathematics education conferences in future. Following self-introductions of the interviewees, the interviewer addressed the leading questions and facilitated group discussion by letting the interviewees first share their responses and encouraged them to respond to others. The interviewer intervened as little as possible and moderated the discussion by asking questions to clarify and deepen responses of the interviewees.

In the analysis of the focus group interview data, we adopted the emergent-systematic focus group design (Onwuegbuzie et al., 2009) that employs the constant-comparison analysis on multiple focus group interview data to identify emerging themes across the groups. Once we created transcripts of the three sets of interview data, we segmented the data into small units with attached descriptors to reveal how participants experienced and compared f-2-f and virtual conferences in terms of advantages and limitations. Next, we grouped the descriptors into larger categories and identified themes emerging within each group and across multiple groups to inform us how the participants envisioned future conferences and addressed issues to be considered to improve virtual conferences.

The focus group interviews allowed us to identify emerging themes and various perspectives on virtual conferences. In addition, the results from the focus group interviews provided insights into how to improve virtual/hybrid conferences.

6.   Findings
In this section we report the analysed findings from both the questionnaire survey and the themes that evolved from the focus group interviews. In our reporting, quotes from questionnaire participants are indicated by *P* and from focus groups by *FG*.

6.1 Conference attendance
Questionnaire participants indicated the number of mathematics education conferences that they had attended during the period before COVID (2017 to February 2020) and during COVID (since February 2020). In Figure 4, on the vertical axis, we indicate the frequency percentage of participants who have attended the numbers of conferences (per year) that is indicated along the horizontal axis, during the two periods. From this graph it is clear that conference attendance has declined drastically since COVID.

Figure 4: Conference attendance (per year) before and since COVID (88 responses)
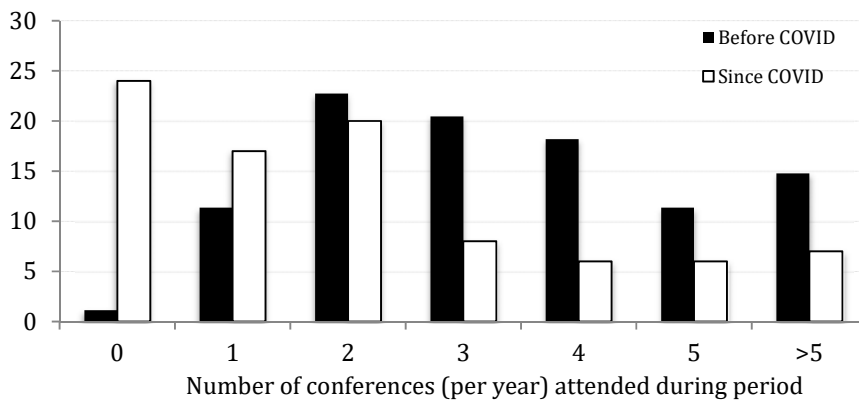
Participants were asked to rate the importance of the reasons why they attend conferences in mathematics education on a three point scale: *very important, neutral* or *not important*. In Figure 5 we show the frequency percentages of participants that indicated that they consider the reason as very important.

Figure 5: Reasons for attending conferences (88 responses)
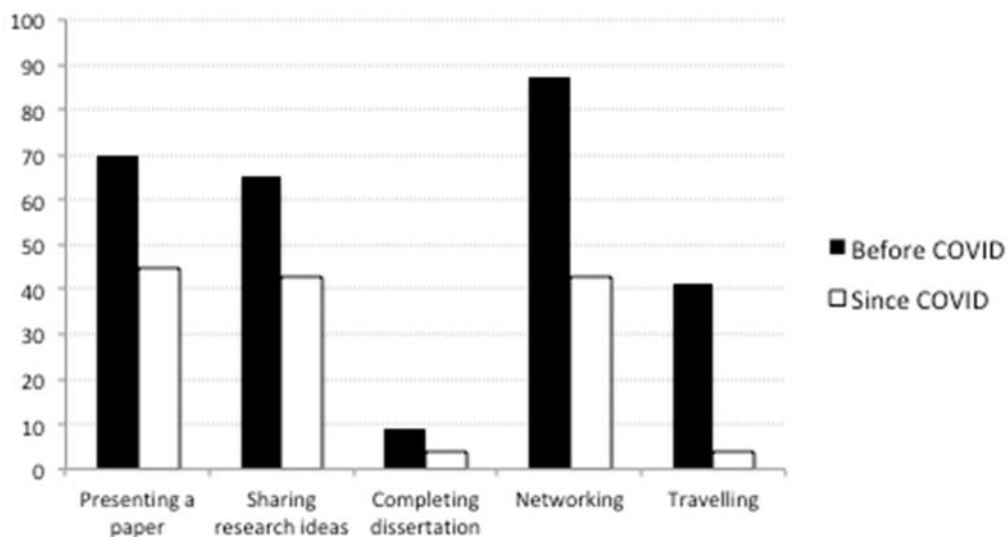
Again there is a clear decline in participants' opinions on all reasons why they attend academic conferences.

Other reasons (apart from the above-mentioned) that were mentioned by participants for attending f-2-f conferences, include cooperation issues
> *Being part of a community (P12)*
> *Catching up with collaborators (P21),*

official research community reasons
> *Organizational leadership (P64)*
> *Invited keynote (P71),*

social reasons
> *Renewing friendships and acquaintances (P72),*

academic reasons

Stay updated on the development in the field (P27),
and supporting and mentoring students and younger scholars
Mentoring early career researchers (P25)
Support your M and D students (P7).

Other reasons raised by participants about why they attend virtual conferences are similar to those for f-2-f conferences, but are more focused on staying in touch with what is happening in the field
Stay updated on the development of the field (P27)
and because of official academic reasons
*Actively participating in the community and profession (P55).*

6.2 Participants comparing f-2-f and virtual conferences
The analysis of the responses to the questionnaire as well as the three focus group interviews showed respondents' experiences and their reflections on different aspects of f-2-f and virtual conferences. We report our findings according to the framework that was developed earlier in section 4. In particular, the analysis revealed how they perceived those aspects as advantages and limitations of using virtual modality in academic conferences and some issues that had emerged in their past experience or that ought to be attended to for future improvement. In this section, we provide the analysis of respondents' perceptions on advantages and limitations.

6.2.1 Presentations
Regarding the different events at conferences, participants were asked to rate the importance of the opening ceremony, plenary sessions, parallel sessions, workshops etc., poster sessions, closing ceremony, excursion and the conferences dinner – again on a three point scale: *very important, neutral* or *not important*. With all events, fewer participants consider the virtual event as very important compared to f-2-f conferences. In Figure 6 we show the frequency percentages of participants that indicated that they consider the event as very important.

Figure 6. Importance of events at conferences (88 responses)
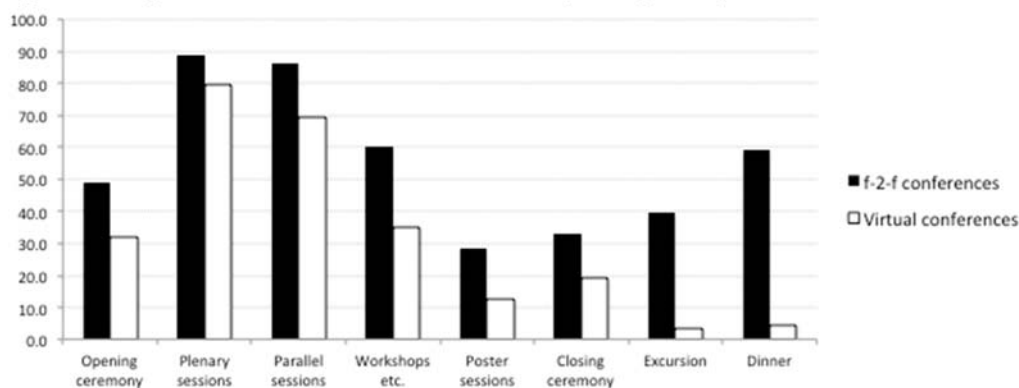
Participants then compared the value that they get from the different events between f-2-f and virtual conferences. With most events, the majority of participants prefer the f-2-f environment to that of a virtual conference.

In the interviews, FG1 and FG2 discussed the advantages and limitations of presentations. Interviewees like presenting at virtual conferences, because presenters can use technological features in virtual conferences such as presenting with pre-recorded videos, sharing presenters' screens, and seeing every participant equally in virtual space. FG2 shared an experience that sharing screens led them to be creative on how to improve what to present in virtual conferences. Interviewee A in FG2 said that he experiences virtual conferences as more fair and equal, since speakers can see and hear every participant equally (in the same space for their video and the same volume of voice).

> *There is no bad seat for the audience in virtual settings. (FG2-C)*

Interviewees in FG1 and FG2 discussed the limitations of virtual presentations. They pointed out that they did not know if the audience understood their presentation because the audience turned off their cameras, so they were not able to see faces in the audience. The presenters only see black screens with names.

> *I have a feeling if someone turns off the camera, then I think that the colleague is checking emails now, but he is still listening. But I definitely miss this f-2-f interaction. (FG2-B)*

FG1 and FG2 shared the view that presenters have difficulties interacting with audiences virtually, and monitoring the audience's understanding. Where the parallel presentations are concerned, most survey participants feel quite strongly in favour of f-2-f conferences, especially regarding interaction, logistics and social issues.

Workshops and other similar activities

Participants are concerned about running workshops online and refer to how difficult it is to do proper group interaction in a virtual environment.

	F-2-f conference	Virtual conference
P48	*Hands on practical experience of a topic, hopefully leading to new or enhanced skills*	*As for f-2-f, but delivering practical elements, especially if they are computer based requiring special software, is much more of a challenge.*

Online meeting rooms and video recordings

In addition to the overall benefits from technology, mentioned above, two particular features of technology were highlighted in the group interviews - user support features in online meeting rooms and video recording. Groups highlighted various features of online meeting rooms to improve individual participants' experience at virtual conferences. FG2 mentioned that they found that using the screen-share and screen-capture features as beneficial for a successful delivery of presentations.

> *To this format [online]… you can easily share your screen; anyone can see what you want them to see. (FG2-C)*

FG3 pointed out that non-verbal communication features in virtual meetings, such as the chat feature and hand raising, can engage participants in sessions when using their second language.

> *So the non-native speakers will be identified by the host very nicely, and they could even say, can you translate it or is this what you're saying. (FG3-D)*

On the other hand, the limitation of the current virtual meeting rooms filled with rectangular tiles with participants' profiles, was pointed out. FG1 mentioned the issue of *a weak sense of belonging* in this environment where participants can easily hide behind black screens and could feel that they are alone in the crowd, being isolated in their rooms. FG2 also pointed out that excessive exposure to virtual meeting rooms could result in negative effects on participants, for example, getting stressed out from watching others and oneself in meeting rooms, by sharing their own experiences. Though conference organisers have made efforts to adopt interactive tools for social events in online space, such as avatar-based platforms (e.g. *Gather Town*[3]), it seemed not successful in providing a satisfying user experience for the conference participants. Interviewees in FG2 and FG3 were not impressed with their experience with platforms using avatars.

Groups addressed the issue of providing pre-recorded video presentations for conference audiences in advance of live sessions at conferences. Pre-recorded presentations were preferred in some virtual conferences where the organisers wanted to minimise the risk of technical troubles with synchronous presentations.

> *We can have a pre-recording so that for some other time zone we cannot [attend] before participating. [...] This is a new way of thinking to manage [sessions]. (FG3-C)*

The possibility was raised to provide video recordings of live conference sessions through various online platforms such as a conference website, YouTube, or in a form of digital proceedings combined with conference papers and video presentations. On the other hand, the groups pointed out practical issues related to a wide use of video recordings for conferences, such as the privacy of research participants in presentations (FG2), consent from presenters to publicly share their videos (FG1), and efforts to maintain video archives complying with copyright policy in some countries (FG3).

A number of questionnaire respondents also appreciate that when presentations are recorded, people all over the world can have access to them asynchronously.

> *Asynchronous sessions with pre-recorded talks can make the conference accessible to people anywhere in the world, without having to travel. (P25)*

6.2.2 Networking and academic interaction

Many of the issues that participants consider as better addressed at f-2-f conferences, are about academic interaction.

> *All aspects in terms of learning, interacting and forging new collaborations better at f-2-f conferences. (P71)*

Interaction and networking are considered to be a problem at virtual conferences.

	F-2-f conference	Virtual conference
P21	*Interesting to hear both the lecturer and the presenter's responses to audience questions*	*Interaction seems somewhat stilted. It is often easier to hear questions and responses, however.*

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[3] *Gather Town* is an online platform that allows students and faculty to re-create some of the interactions that they had when on campus.

Also in the parallel sessions, participants highlighted the difference in the level of interaction.

	F-2-f conference	Virtual conference
P79	*The comradery that characterised plenary lectures was really important and stimulating and even encouraging.*	*Interaction during virtual conferences still possible, but the comradery is lost.*

Academic networking and collaboration with colleagues from other institutions and countries are considered as an important reason why academics attend conferences.

> *All aspects in terms of learning, interacting and forging new collaborations better at f-2-f conferences. (P71)*

6.2.3 Social interaction

Survey participants feel strongly about the benefits of social interaction at f-2-f conferences.

> *Meeting people and feeling part of a community. Sharing food and small talk help to identify people you connect with. (P3)*

The concern amongst participants about the absence (or small presence) of social interaction at virtual conferences is almost unanimous.

	F-2-f conference	Virtual conference
P48	*Great opportunity to get to know individuals and to gain deeper understanding of the way that others approach similar problems.*	*While video conferencing is of course possible with small or large groups, there is not the same level of informality.*

Despite the limited human interaction in a remote setting, conference organisers of virtual conferences have made efforts to provide participants with socialising and networking activities. However, interviewees reported that their experiences at virtual conference are not comparable to the quality of interaction at f-2-f conferences. In particular, the interviews indicated that the virtual conferences did not satisfy the interviewees' expectations on one-to-one conversations, serendipitous encounters with others, and physical environments for social events. Interviewees pointed out that the online chat feature does not provide a natural environment for one-on-one conversation, like talking to someone between sessions or during the coffee breaks at f-2-f conferences. Also, virtual conferences take place in online spaces that do not provide opportunities for serendipitous encounters among conference participants to meet others and develop relationships for future collaboration. Lastly, most social events heavily rely on physical environments such as excursions, school visits, banquet, or dance parties that cannot be easily replaced in virtual spaces. There are limited resources for organisers to offer social events at virtual conferences and there is a need for alternative ways to socialise participants that employ technological features to engage them in virtual spaces.

On the other hand, the interviewees noted a potential in virtual environments to improve conference participants' experience with socialising and networking activities. Increased accessibility to the conference allow participants to meet with

colleagues from more diverse backgrounds than in f-2-f conferences in terms of geographical regions, research interests, and types of positions in their affiliations.

Interviewees also discussed possible ways to improve virtual conference participants' engagement in socialising and networking activities and shared a few successful cases of virtual activities. For instance, FG3 mentioned that online school visits at a virtual conference were effective to introduce mathematics classrooms of the hosting country to the participants, by providing pre-recorded lessons in mathematical classrooms in local schools. Interviewee A in FG2 related a case of a social game with a mathematics quiz in a virtual conference where participants were able to actively participate in the event, and not just watch a video.

Survey participants referred to a number of issues, including the general atmosphere – especially at plenary sessions.

	F-2-f conference	Virtual conference
P20	*Fantastic atmosphere, can see all delegates, discuss the session with colleagues*	*Not the same focus as f-2-f session.*

6.2.4 Logistics, accessibility and travelling

All three focus groups attended to the advantages of virtual conferences in increasing accessibility to attend, present, and host academic conferences with no or less restrictions on physical environments. The three groups argued that virtual conferences could better serve educators and researchers who are traditionally under-represented in conferences and contribute to improving diversity and equity of the mathematics education community. People, who will benefit from the virtual modality with increased accessibility, include those with family duties (e.g. childcare) or other work-related commitments (e.g. teaching) and those who are not able to afford international travels (e.g. graduate students, researchers with less financial support from their institutions).

> *One of the great benefits of this situation is that you can work from home. And you can attend presentations without leaving home. I wouldn't be able to leave my wife with two kids here and travel to Thailand for a week at the moment. (FG2-C)*

In addition to the improvement in diversity of participants, FG1 also discussed the increased accessibility for teachers to virtual conferences that would contribute to connecting the mathematics education research community to practitioners.

> *There are many teachers actually interested to attend the academic webinars or conferences, and I find it positive that the teachers are also. [...] It's positive that maybe that's one way to bridge the gap between the practice and research community and teachers. (FG1-E)*

On the other hand, interviewees mentioned the problems of working from home when attending a virtual conference. Multiple tasks such as domestic issues and teaching duties continue while you are attending the virtual conference rather than you dedicating all the time for conference activities, as when attending f-2-f conferences.

> *But this is also something that that makes conferences hard when you are at home, because you never leave your home. [...] The emails are still coming in*

and the colleagues know you are at home - they want to reach you. When you are at a [f-2-f] conference you can say ... I will come back to you next week. (FG2-C)

FG1 and FG2 pointed out that virtual platforms enable diverse groups of educators and researchers with fewer resources to host and organise virtual conferences.
We can lower the costs, as you know about one third, because we can save costs for things like traveling and some other things. (FG3-C)

In this sense, all three groups were positive towards an increased accessibility to conferences in virtual spaces.

On the other hand, groups addressed limitations and possible issues on accessibility of virtual environments. Groups pointed out the time zone issue on scheduling virtual conference programs for participants from all over the world.
We are organising to run [a conference] across three different time zones which are Singapore, Australia and New Zealand and the difference in time between Singapore and New Zealand is four hours, so it was quite difficult to actually have extended sessions. (FG3-B)

Furthermore, the increased number of participants at virtual conferences may become problematic. Interviewee A in FG2 said that virtual conferences are more accessible but there will be more submissions to be reviewed, more presentations to be scheduled in parallel sessions, and larger discussion sessions that would need an effective orchestration. In addition, groups noted that virtual conferences with no travel might not satisfy participants with expectations on new experiences as in f-2-f conferences. In their discussions, conference travel was considered one of the primary purposes of participating in conferences.
I want to get a break from the day to day routine of work. [...] Attending a conference is like taking care of my own academic professional development. [...] To meet with old friends and make new friends in the academic community, because I think that's the way to go for us to develop professionally. (FG1-E)

Participants in the survey also enjoy the easier logistics at virtual conferences.

	F-2-f conference	Virtual conference
P86	*Though they are valuable, attending plenary lectures or invited lectures with large audience at f-2-f conferences are not efficient because of many limitations in physical environment cannot find a good seat, slides are not visible, difficult to listen clearly).*	*Watching plenary and invited lectures thru Zoom at home is much easier and effective.*

When referring to the logistics, participants also see advantages in virtual conferences.

	F-2-f conference	Virtual conference
P37	*Often is challenging when you have two competing talks or two follow-on talks when you have to*	*This was one of those advantages when you had separate zoom links to various parallel sessions to pop in*

run from one room to another. Also, it is also disturbing when people enter and leave.	*and pop out which was great as we didn't have to run from room to room in panic like most people do at most conferences.*

Ecological reasons were also mentioned – with virtual conferences there is less travelling and we leave a cleaner carbon track.

> *Ecological issues: nobody has to travel by plane to a conference venue. (P41)*

6.3 Future conferences envisioned by participants
Participants had the opportunity to voice their personal opinions on the possible impact that the COVID-19 pandemic will have on the future of mathematics education conferences and on the actual format of presentations at conferences.

6.3.1 Impact on the format and nature of mathematics education conferences – alternative conference formats
Survey participants and interviewees envisioned future conferences. Based on the advantages and limitations of virtual conferences, participants speculated on what conferences would be like in the future and how to improve conferences.

Alternative conference formats
Although most survey participants still prefer f-2-f conferences, they realise that the new virtual format of mathematics education conferences may not only be an interim arrangement. Participants suggest alternating conferences between the two formats or organising hybrid conferences in which both online delegates and f-2-f delegates are accommodated.

> *In my opinion, conferences in the future will be held in a hybrid-format, especially when they are international ones. […] The host has to integrate the participants who are present and the participants who are online. (P41)*

In the focus groups, all but one interviewee, said that they expected virtual or hybrid conferences in future. Researchers already had the experience of going to presentations, meeting people, and collaborating with others successfully without travelling.

> *Except big international conferences like PME, I would not travel for a smaller conference because now I know it is possible to attend conferences completely online. (FG2-C)*

Suggestions for future conferences
Interviewees shared ideas on how to handle the difficulties of virtual or hybrid conferences, such as time zone issues that they experienced.

Shorter and more meetings and talks
Interviewees complained about fatigue after attending a long virtual conference. They suggest breaking virtual or hybrid conferences into multiple days because shorter and more meetings will help participants focus on conferences. One of the FG3 interviewees suggested that multiple universities could host a conference based on their own time zone, allowing a higher number of participants to attend virtual conferences.

> *Presentations will have to be significantly shorter and visually more pleasing. Text-filled slides should be taboo. (P47)*

Pre-recorded or live streaming keynote lectures
Interviewees feel that pre-recorded or live streaming keynote lectures from speakers would provide better learning opportunities because people might not be able to attend virtual conferences due to time difference or technical issues. Pre-recorded or live streaming keynote lectures from speakers would also help disseminate the lectures to a broader audience who cannot afford travel or registration.

> *Maybe we have some sort of hybrid conference that you could have but also stream the keynotes. So everyone goes there, but people who cannot afford to go there can at least see the keynotes on YouTube or another online streaming. (FG2-C)*

New types of social events in virtual conferences
Interviewees suggest that new ideas could be introduced with social events in virtual conferences, such as board games or e-excursions, instead of coffee breaks.

> *The scientific programme and the social element of it has become quite a challenge. The only thing we are going to offer is a virtual (school) excursion. (FG3-B)*

She (FG3-B) took conference attendees on a virtual tour of schools as a virtual excursion and conference attendees seemed to enjoy the virtual excursion. Another suggestion she made was that virtual social events could be created by conference attendees, instead of by the organisers. At a virtual conference, a group of early career researchers created a separate virtual meeting on their own to have more private and interesting conversation - perhaps a good example of autonomous participation in virtual conferences.

6.3.2 Impact on the format of presentations
Formal presentations, as still used at f-2-f conferences, are sometimes seen as transmitting or communicating information in one direction – an approach that we often discourage mathematics teachers to employ. As a last question in the questionnaire, participants got the opportunity to speculate whether there should be any change in the actual format of presentations at conferences. Many respondents are of the opinion that the format should not change.

> *No, while there might be 'transmission', there is always opportunity to ask questions and discuss ideas with colleagues. (P10)*

They feel strongly about the personal interaction that comes with conventional lectures.

> *It is ironic that the online conference makes genuine person-to-person interaction so difficult. In this context, the classic lecture (which can be pre-recorded) is a safe and easy format. Genuine discussion, especially for people who really disagree, becomes very difficult online. (P15)*

Other respondents made interesting suggestions on what should change and how it can be organised. Suggestions include
- Having the audience watch a short video together and then having 20 minutes to discuss it

Questions and links could be posted in the chat by different participants simultaneously, reducing the amount of 'down-time' in the discussion. If recordings of these sessions are soon shared, you can make contact with presenters during the conference, allowing you to be at two clashing presentations at once. (P3)

- Grouping presentations together
  At AERA there is a format where paper presentations are done in a group with several related papers. This is the way Short Orals is organised at PME; perhaps it could also be used for longer presentations. (P4)

- Making papers available to read in advance
  … the model of reading a paper beforehand and having a small group of discussants has been very valuable in some conferences. (P9)

- And using moderators in presentations
  … there should be more interaction; several virtual conferences explore this very well with two moderators, one of them reading participants' comments and summarising them to transmit live to the speaker so that he can comment live. (P59)

7.   Discussion and conclusions

COVID-19 has changed life in many aspects. Engelbrecht et al. (2020a, 2020b) experienced how a survey paper about digital technology had to be modified with the pandemic and how mathematics in general is being transformed by it. Digital technology became very popular in a community that, before the pandemic, was not necessarily that interested in discussions on how online environments were transforming mathematics education. Borba (2021) built on these ideas and indicated the way in which different trends in mathematics education may be combined in the post-pandemic period. In none of these papers, however, issues regarding conferences were addressed. The voice of the data (Borba et al., 2018) helped us to gain insight into the issue of mathematics education conferences.

Our analysis suggests that what participants meant by *attending conferences* has a new meaning after attending virtual conferences. Before the COVID-19 pandemic, attending conferences provided special physical and time-sensitive experiences because participants had to leave their daily lives and regions to attend f-2-f conferences. Most participants liked traveling, sightseeing, and excursions when attending f-2-f conferences. However, the extra-ordinaries of previous academic participation appear to be somewhat weakened at virtual conferences because participants can attend conferences in their own space (at home or workplace) without travelling.

The issue of *attending* a conference is also causing confusion. When attending a f-2-f conference there is some inconvenience since you have to make alternative arrangements for your agenda at home, but colleagues and bosses excuse conference attendees from their regular activities during the period of the conference. With virtual conferences this seems to be less likely and participants struggle to attend to virtual conference activities and multiple normal tasks simultaneously. At the plenary panel at ICME 14 (ICME, 2021) a question was raised about *privacy* when

participating in virtual conference from home. This issue should be addressed – some delegates participate in a virtual conference on a fulltime basis (as in a f-2-f conferences) but there are people who only participate in selected virtual conference activities. On the other hand, it can be inferred, that if homes become a major factor in mathematics education in general, and in conferences in particular, we may reinforce an agenda for social equality, as it would be necessary to have good homes to participate in mathematics education (Borba, 2021).

This new meaning of attending conferences shows new potential of meeting and collaborating with more diverse people. Firstly, participants usually give a presentation after submitting papers or posters when going to f-2-f conferences. However, they have participated in virtual conferences without submitting papers or giving a talk. Secondly, participants agree that one of main differences between f-2-f and virtual conferences is conference travelling. Most participants liked travelling, sightseeing, and excursions when attending f-2-f conferences. However, they did not travel for virtual conferences. Thirdly, participants claimed that "participating in virtual conferences" was not the same as "participating in f-2-f conferences". They were all in the same place at the same time for f-2-f conferences whereas they participated in conferences in their own space (home or workplace). Fourthly, participants could ask for institutional support such as being freed up from teaching or travel funding when attending f-2-f conferences. However, they could not request institutional support for virtual conferences. Lastly, participants had many opportunities to network from social events or coffee breaks when going to f-2-f conferences, but they had difficulties developing professional or social contacts when attending virtual conferences.

The analysis of the focus group interviews showed that all three groups emphasised the advantage of virtual conferences in the increased accessibility to participating in academic communities. The interviewees addressed inequity in traditional conferences as they described who would benefit from virtual conferences. Virtual conferences increase the accessibility to attending academic conferences, especially for participants from under-represented groups including, but not limited to, those with disabilities, parents and caregivers, pregnant female, graduate students, and researchers and educators with less financial support from institutions or from countries with no affordable flights to conference venues. Given that conference presentations and proceedings account for academic achievement and faculty evaluation at many institutions, an increased accessibility to conferences will provide equal opportunities to improve their academic careers to researchers and educators who were not able to attend f-2-f conferences for presenting their research due to relatively more barriers than their colleagues. In particular, it will benefit early-career researchers who are supposed to actively participate in conferences to develop their careers but are not able to afford conference travelling. With virtual conferences, more participants can volunteer for playing leadership roles in academic communities by participating in organising committees or attending business meetings for academic associations than they could do in traditional conferences.

Another finding from the voice of our respondents is that there were different views on virtual networking between early career researchers and established researchers. Early career researchers in our focus group interviews feel comfortable with the virtual environment, whereas established researchers prefer f-2-f settings. For

example, some early career researchers enjoy networking by playing board games and dancing in a virtual environment. However, most of the established researchers in the interviews do not like using virtual networking platforms such as *Gather Town* because they did not experience virtual networking as real. Most established researchers seemed to miss f-2-f conferences where they enjoyed meeting people f-2-f. On the other hand, early career researchers seem to adapt to the new format of virtual conferences to suit their needs. One of early career researchers in FG2 said COVID-19 allowed him to see that remote collaboration could be more productive than f-2-f collaboration given the problems with time and travel expenses. Would there be a generation gap in the responses? This is an open issue that could generate some research.

Although a large number of participants in this study still favour f-2-f conferences, there is some evidence that virtual or hybrid conferences will probably become one of the ways in which we organise conferences in future. F-2-f academic gatherings come at high costs, including travelling costs, days of disruption to work and personal lives, logistical planning for parents or families, and funds to cover registration, accommodation, and meals. On the other hand, virtual conferences also do not come without a price. There are still problems with hosting a virtual conference with attendees located around the world in different time zones, as discussed previously.

With some support from empirical data, Borba (2021) argues that, due to the inequality of homes, online mathematics education from home, developed during the pandemic, has brought more inequality to mathematics education.

> Most students did not have access to the Internet. When they had access, they did not have the money to buy credits to operate the Internet. … But with less interaction with teachers, and without an environment to study in poor homes, through no fault of the teachers or the school, very little mathematics education or science education occurred." (p. 12).

Teachers concluded that the difference in Internet access, or even the learning space at home was a key difference (Borba, 2021). In the conference scenario, the same problem may arise. People with different access opportunities will participate differently in the conference. While not attending a conference physically, a person may have to take responsibility for multiple tasks simultaneously. So, whether virtual conferences *open* or *close* doors, stays an open question.

It is clear that COVID-19 has provided an impetus for us as conference organisers to come up with innovative ideas on how to organise virtual conferences in a unique way that will also address the issues that delegates are currently missing at virtual conferences. But it is becoming more likely that even after the travel restrictions have been lifted, the way we organise conferences will be different. However, a f-2-f conference has an intricate structure that has developed over many decades. It consists of formal and informal activities, social and academic, structured and less structured and synchronous and asynchronous.

Moving to virtual or online spaces is, unfortunately, not as simple as attempting to replicate the f-2-f conference activities online. If we have to move to virtual events in future, these events should provide added value that is unique to virtual conferences. Features at the virtual conference should overcome the limitations of f-2-f events in unique and creative ways.

As for the future, it is impossible to predict. One respondent concluded

> *I am convinced that we will never get back to the situation with conferences that we had before. There are many things that virtual conferences give and this will become an argument. They don't require flying so eco-oriented people will be happier. And funding of cause, I have the felling that traveling will be more expensive and the financial support that academics get is unlikely to increase. Content-wise, mathematics education likes to follow trends and this one is hard to miss as it feeds nicely into many topics that have been discussed for years (e.g., equity, teaching and learning with technology). My hope is that we will still be allowed to share research that is not part of this trend. (P55)*

Perhaps we should conclude with a remark made by one of the participants in the questionnaire.

> *For me there is warmth in f-2-f meetings, which does not happen in virtual situations. A warmth that enables us to strengthen personal ties, similar ideas and different ones, too. I believe that, as human beings, we still have to learn how to do this in a non f-2-f relationship. This warmth I refer to actually stimulates the challenge and the utopia of changing the world as educators. I fear for the content of math education if this affectionate relationship is weakened and we may very well emphasize informing students rather than forming citizens. But I do not know. (P73)*

And then, some people simply have strong opinions

> *I think everything is better at f-2-f meetings. Never the same online. No interactions, always something else to do in the office so not fully concentrating on the conference, no relationship building at the conference dinner, no discussions of possible collaborations. (P42)*

To summarise – academics realise the need to adapt the format of conferences in mathematics education and new ways of presenting, of addressing problems of engagement, collaboration and the social and academic interaction are being explored. The academic and social value of the traditional f-2-f conferences, as developed through centuries, is still very real today and it is clearly too soon to predict what the format of conferences will be in future.

We hope to have presented some research questions that should be explored by the research community - perhaps the main objective with an exploratory research paper. We may raise a few more questions: Do experienced researchers have different views on f-2-f versus virtual conferences than early career researchers? What is the role of the virtual and f-2-f formats in having equity in keynote speakers at conferences? What is the importance of deciding on one model of conference in order to have equity in participation? We had some measure of hybridism in conferences before the pandemic: what kind of hybridism will we have at future conferences?

Some of these questions may have answers imbedded in them.

References

Ahn, S.J., Levy, L., Eden, A., Won, A.S., MacIntyre, B., & Johnsen, K. (2021). IEEEVR2020: Exploring the first steps toward standalone virtual conferences. *Frontiers in Virtual Reality, 2*:648575. doi: 10.3389/frvir.2021.648575

Borba, M.C. (2021). The future of mathematics education since COVID-19: Humans-with-media or humans-with-non-living-things. *Educational Studies in Mathematics,* https://doi.org/10.1007/s10649-021-10043-2.

Borba, M. C., Almeida, H. R. F. L., & Gracias, T. A. S. (2018). Pesquisa em ensino e sala de aula: Diferentes vozes em uma investigação. [Research in education and the classroom: Different voices in research] (1st ed.). Autêntica.

Engelbrecht, J., Llinares, S., & Borba, M.C. (2020a). Transformation of the mathematics classroom with the internet. *ZDM Mathematics Education, 52*(5), 825-841.

Engelbrecht, J., Borba, M. C., Llinares, S., & Kaiser, G. (2020b). Will 2020 be remembered as the year in which education was changed? *ZDM-Mathematics Education, 52*(2), 821–824.

Erickson, T., Sadat Shami, N., Kellogg, W. A., & Levine, D. W. (2011). Synchronous interaction among hundreds: an evaluation of a conference in an avatar-based virtual environment. *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems 13*, 503–512. https://dl.acm.org/doi/abs/10.1145/1978942.1979013

Frederickson, M. (2020). COVID-19's gendered impact on academic productivity. https://github.com/drfreder/pandemic-pub-bias/blob/master/README.md

Grønkjær, M., Curtis, T., De Crespigny, C., & Delmar, C. (2011). Analysing group interaction in focus group research: Impact on content and the role of the moderator. *Qualitative Studies*, *2*(1), 16-30.

ICME (2021). Panel discussion "Mathematics education reform post 2020: Conversations toward building back better". https://www.youtube.com/watch?v=WesfS_2uxRo&list=PLiBUAR5Cdi626BU0bpVt fkpZGQCrNGGCm&index=15&t=714s

Kim, J. (2020). Is flying to disciplinary and professional academic conferences a habit we might lose? https://www.insidehighered.com/blogs/learning-innovation/academic-conferences-after-pandemic

Leong, J. J., Kinross, J., Taylor, D., & Purkayastha, S. (2008). Surgeons have held conferences in second life. *BMJ.* 337:a683. doi: 10.1136/bmj.a683

Leung, F. (2015). The coming of age of Mathematics Education as a discipline and the role of East Asians. Honorary plenary lecture, 7th East Asia Regional Conference in Mathematics Education (EARCOME-7) Cebu, Philippine.

Menghini, M., Furinghetti, F., Giacardi, L., & Arzarello, F. (Eds.) (2008). The first century of the International Commission on Mathematical Instruction (1908-2008). Reflecting and shaping the world of mathematics education. Rome, Italy: Instituto della Enciclopedia Italiana fondata da Giovanni Treccani.

Oester, S., Cigliano, J. A., Hind-Ozan, E. J., & Parsons, E. C. M. (2017). Why conferences matter: An illustration from the International Marine Conservation Congress. *Frontiers in Marine Science, 4,* 257. doi: 10.3389/fmars.2017.00257

Onwuegbuzie, A. J., Dickinson, W. B., Leech, N. L., & Zoran, A. G. (2009). A qualitative framework for collecting and analyzing data in focus group research. *International journal of qualitative methods, 8*(3), 1-21.

Parsons, E. C. M. (2015). So you think you want to run an environmental conservation meeting? advice on the slings and arrows of outrageous fortune that accompany academic conference planning. *Journal of Environmental Studies and Sciences, 5*, 735–744. doi: 10.1007/s13412-015-0327-8

Sardelis, S., Oester, S., & Liboiron, M. (2017). Ten strategies to reduce gender inequality at scientific conferences. *Frontiers in Marine Science, 4*. https://doi.org/10.3389/fmars.2017.00231.

U.S. Travel Association (2017). Economic Impact of Meeting and Business Events. https://www.ustravel.org/system/files/media_root/ document/Research_Fact-Sheet_Meetings-Mean-Business_2017.pdf

Verbeke, J. (2015). Designing academic conferences as a learning environment: how to stimulate active learning at academic conferences? *Constructivist Foundations, 11*(1), 98–105.

Viglione, G. (2020). Are women publishing less during the pandemic? Here's what the data say. *Nature, 581*(7809), 365-366. doi: 10.1038/d41586-020-01294-9.

Walters, T. (2018). Gender equality in academic tourism, hospitality, leisure and events conferences. *Journal of Policy Research in Tourism, Leisure and Events, 10*(1), 17–32. https://doi.org/10.1080/19407963.2018.1403165