**Training teachers of mathematics virtually: Opportunities and threats**

**Yardley, F. and Cooper, C.**

# Training teachers of mathematics virtually: Opportunities and threats

Fiona Yardley and Charlotte Cooper

*Canterbury Christ Church University*

> We reflect on our experiences working with 35 Teach First Trainees in June and July 2020 in an entirely online environment. Trainees had had no opportunity to spend any time in a classroom or with young people before commencing on an 80% timetable in September, and we have (still) not met any of the trainees face to face. In this reflective piece we describe and reflect on the changes we made to our pedagogy, especially those which produced an unexpectedly rich and sophisticated discourse, as well as the challenges.
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> **Keywords: initial teacher education; online learning.**

## Context: entirely online initial teacher education

The Teach First initial teacher education (ITE) programme is unusual in that teaching commences in June rather than at the start of the academic year. In 2020 this meant that the first five weeks of the programme, the Summer Institute (SI), occurred towards the end of national lockdown due to the global pandemic. When SI commenced on 22nd June, schools had been teaching online and physically closed to all students except the vulnerable children and those of key works for three months. We received approximately six weeks' notice that SI, normally a face-to-face residential course, would be entirely online. In our case we would be training 35 secondary mathematics trainees who had been allocated to the East of England and South East/South Coast Teach First regions. In reality our trainees were widely distributed geographically, with one dialling in from Australia. Each of the first four weeks of SI followed the same structure with 7 hours of university input in subject areas on Mondays and Tuesdays followed by asynchronous activities and support sessions with Teach First colleagues on Wednesdays, Thursdays and Fridays. Universities were not involved in the fifth week.

In this paper we reflect on our experiences in delivering SI entirely online to trainees we had never physically met (universities are not involved in the recruitment of Teach First trainees), and who had not had the opportunity for recent in-school experiences. The platform we were using, Blackboard Collaborate, had advantages (for example, the connected virtual learning environment on Blackboard) and disadvantages (most notably the heavy use of bandwidth making it more or less impossible to use video). Following each two days of teaching we met to reflect, evaluate and plan, and noticed the emergence of two themes. Firstly, the tutor team agreed that some sessions exceeded expectations and trainee engagement and interaction was richer and more sophisticated than we had ever experienced in similar face-to-face sessions. Secondly, we all encountered experiences that left us feeling incompetent and questioning our professional abilities. We begin with a description of one session and thematic analysis of the transcript of the student debate during that session before going on to discuss whether and how the online environment might have influenced the richness of debate. We present the threats differently. Both

authors present a reflexive piece in which they reflect on an episode they felt did not go well and their learning from it, followed by a brief response from the other author who was also present during the session. Finally we draw together the opportunities and threats into a series of questions requiring further research.

## Opportunities

'Concept-process-fact' is a session that we have run on the first day of SI for over five years. Between us, we had taught this session seven times previously, always face-to-face, with mixed outcomes. Trainees often do not see the point of the session in which we attempt to categorise mathematical knowledge as to whether it is conceptual knowledge, a process or fact. This year the session engendered rich debate. In the thematic analysis below we provide a taste of the richness of the debate before reflecting on why we think it may have been so rich.

The themes that emerged were: the relationship between concept, fact and process; linguistic; cognitive; mathematical; and pedagogical.

- The first theme, the relationship between concept, fact and process, is a very broad theme which the debate revisited several times. For example, one trainee proposed a concentric circles model with concept as the outer circle containing facts which contains processes. This allowed another trainee to equate concepts with ideas, define facts as information about concepts and processes as a way to use facts, while another trainee challenged the implicit assumption in the model that it is possible to define a concept without using facts.
- Several trainees drew on their knowledge of language to aid their understanding, noting that processes involve active verbs, facts are often denoted by the use of 'is' and concepts by 'as', which helped other trainees to come to the conceptualisation of a concept as in idea of something, but not the thing-in-itself.
- The idea that it is the cognitive process involved that differentiates between concepts, facts and processes was raised. Facts and processes can be memorised, but a concept is an individual's unique understanding. This led to the idea that concepts are ideas that cannot be described, measured or observed – we need facts and processes to do that.
- The nature of mathematics and mathematical proof was explored. Are concepts human constructs, are facts and processes our attempt to tightly bound these human constructs, and is it right that these boundaries exist?
- Pedagogical implications of the above were raised by trainees, for example that we can teach facts without full understanding, but can't teach a concept without full understanding. Sophisticated issues (considering this was the very first day of initial teacher education) were explored, such as the difficulty of putting concepts into words and whether it is possible to assess concepts, or whether we can only assess facts and processes as a proxy for conceptual understanding.

Why was this debate so much richer than when we have taught it face-to-face? We considered – and rejected – factors unrelated to being online, for example stronger teaching or students who, on paper at least, were comparable with previous cohorts. However, we taught these trainees other sessions that we've taught before later on in SI, and they didn't go so well. The factors we identified as potentially contributing to

the success of the session were: online polling tools; the non-visual environment; and combining spoken and written interaction.

The polling function in Blackboard Collaborate is anonymous. Trainees couldn't see each other's answers. We conjecture that one consequence of this is that they were more confident to try out their thinking because they knew that others couldn't see their answers. We noticed the results 'dancing' before settling to the final answers. We asked trainees if they could explain why, and they said that they were thinking so deeply about it that they kept changing their mind. While this makes sense, we wondered why we don't see this in face-to-face sessions. We think that it may be because it is easy to change by just clicking another button, and again because others can't see you wavering and so it is a safer environment in which to engage in critical academic thinking. We wonder if the safe environment was also a reason why we consistently got 100% returns on every question, unlike in face-to-face where some people never commit to an answer.

This was our first day of teaching online. We had reflected in advance on how our usual teaching style used non-verbal clues to encourage critical interaction and had discussed at length the risk of students being passive receivers. Therefore, we gave explicit instruction at the beginning of the session inviting dissent, and consciously invited students to 'defend your position' throughout the discussion. Because of the non-visual environment we were more explicit about our expectations for engagement. We were also more aware of our own teaching behaviours. As good teachers we constantly scan the room, usually scanning for those not engaged, trying to draw in those on the periphery. In this new environment we couldn't see our learners, and so found we were more focused on those contributing. While this meant that we gave speakers undivided attention and challenged them more, there is the obvious threat that some students were ignored. However, we know that 100% were engaged in the polling, and that two thirds (23/35) made at least one contribution to that debate which seems a high level of engagement (although we don't have comparative figures for face-to-face).

In the face-to-face environment students communicate orally or through body language. In the online environment they can communicate by using the virtual 'raise hand' function and speaking or sending through a note. Blackboard Collaborate records the order in which hands are raised which meant we were able to take all contributions. In face-to-face situations it is hard to keep track of whose hand went up first, people will often jump in ahead of others or lower their hand when the moment has passed, and very often a dynamic will develop in which some are more likely to participate than others. We found that a system was quickly established in which 'raise hand' and spoken contributions were used for making an initial point which was then interacted with via the written chat function. It was often in the chat function that ideas were developed, and the richest contributions made.

**Threats**

In the table on the following page, the first column is a reflexive account of one author's  online session that they felt did not go well. The second column is the other author's response.

| Account | Response |
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| **Fiona:** There was a session in which I was attempting to introduce different kinds of problem-solving tasks, and basically I just confused everyone. I think I confused them by having too many different ideas on the screen at once. I saw them as a list of different ideas that I wanted to talk through. I didn't realise that the trainees seemed to be seeing them as representing dimensions of the same thing. I saw them as separate things. Being online, I couldn't see their confusion until it was too late – I only found out because they started asking questions that I didn't understand! It seems pretty obvious now that you shouldn't put too much information on the slide and should only have the information that is relevant to what you are currently covering. I felt stupid because I am supposed to model expert teaching and instead here I was making a basic error about structuring resources and explanations! | **Charlotte's response:** I don't feel the issue was with the amount of information presented at any one time, although appreciate I am looking at this through experienced eyes in that I knew where Fiona was heading with this session and the understanding she was aiming to impart. I actually think the representation chosen was more effective than, for example, displaying each task one-by-one, as it gave students an idea of the breadth of possibilities out there (of which it was made clear there are many). As an "informed outsider" in the session, I felt Fiona's choice of representations were effective and the misinterpretation on the part of the students was unforeseeable. I believe that it was actually the online "isolation" of students which led to this confusion arising, or which certainly didn't help in its resolution – had they been together face-to-face as a group, based on past experience, a "whispered aside" between students would have cleared up any confusion very quickly. |
| **Charlotte:** The session I was most disappointed with looked at two aspects of using data. Firstly from a formative assessment perspective, using errors in student work (of which we had some real examples) as a means of identifying mistakes and/or misconceptions. The second part of the session looked at using summative data to aid progress. The first part of the session generated some very rich and informative discussions and debates, and I was acutely aware of my planned timings for the session becoming more and more inappropriate. At this point I felt a very real pedagogical dilemma – do I curb this very useful, relevant and instructive debate to be able to cover all of the content I had intended to, or do I stick with the first objective of the session only and cover the second at a later point in time (which in the back of my mind I | **Fiona's response:** It came as a huge surprise to me when Charlotte later told me that she was disappointed by the session. As Charlotte said, there were rich discussions. What had impressed me, as with the concept-process-fact session was the way that students reflexively drew on their prior knowledge and experiences to construct new knowledge. Although these students had not recently been in a classroom, it really felt as if they were visualising realistic contexts and engaging with them critically. The dilemma Charlotte refers to was not noticeable even to my highly trained eye! In the three years that Charlotte and I have worked together we have learned a lot from each other. The thing that I have consciously changed in response to Charlotte's excellent practice is my relationship with time and timings of sessions. I get anxious about time. I |

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| knew was very limited). I am aware that this is the only time I am seeing these students before they venture into the classroom and felt a very real sense of "but they need to know this…!" I chose the former option and as a result felt I shoehorned into a very reduced amount of time the second objective, which I personally believe is a very important skill and a crucial part of a teacher's armoury. The result of this "panic" on my part was that I felt neither objective was covered effectively. I have since reflected on why the timings of this session went so wrong and believe in large part, this was down to the unforeseen additional time needed when delivering sessions online - everything takes longer! Even simple question and answer sessions require time for students to put their hand up (electronically), for you to cue that student to speak, for them to put their microphone on etc. etc. The rapid dynamisms of a face-to face session are lost and as a result my timings, something I am so keen to enforce with trainees as a part of their planning, were very, very wrong. | used to write timings in plans to the nearest minute and stick to it. Charlotte has a much more responsive, fluid approach and I found myself in awe of the engagement and sophisticated thinking that she elicited through her teaching – I took all but the most general timings out of plans and have worked on adjusting my pedagogy to focus on learning rather than clock-watching. So the dilemma Charlotte raises here surprised me because her fluency and responsiveness is always so impressive, and I saw no difference in this session. I see myself as being anxious about time, and Charlotte not. This incident opens my eyes to what is the 'opposite' of being anxious about time, and it is not being relaxed about time. Charlotte's reflections here show the conscious expertise with which she normally handles time in sessions and how important it is for both her practice and her professional identity. <br><br>Interestingly, the only thing I did notice in this session was Charlotte getting flustered about the meaning of a key term. I thought this to be out of character, but I find it interesting that I wasn't able to identify the underlying cause and reflect on the implications of this for our practice as teacher educators. |

**Discussion and Conclusions**

At first glance there does not seem to be any link between the opportunities and the threats. We interpret the opportunities as being because of the technical tools that were available to us and the threats in terms of our planning and delivery. It would appear that we are being the opposite of bad workmen here, crediting our tools when things work out well, and blaming ourselves when things go wrong. We often observe this tendency in our highest achieving trainees too, and we tell them that they need to take more responsibility for their successes as well as continuing to reflect on areas for improvement. We will take our own advice and do the same here.

The technology that we credited with the success of the concept-process-fact session was the polling tool, lack of visual clues, 'raise hand' and chat functions. These functions alone would have been insufficient to generate such rich debate. What these functions have in common is that they differ significantly to the tools commonly available in a face-to-face environment. It is not novelty that rendered them successful, but our identification of their novelty and explicit awareness that we

must adapt our pedagogy in response to them. As noted above, we put a lot of thought into how we would encourage critical engagement: we had pre-empted the potential for poor engagement because we realised in advance that we would not be able to read the room. As well as anticipating the difficulties of a non-visual environment, we had also put a lot of thought into how we would carry out the polls, with one of us assigned to the technical task of setting up and sending out the polls while the other led the session. When planning this session for face-to-face teaching, it never crossed our mind to think about how we would elicit opinions from trainees. Now that we've had to think about it, and seen the benefits, we will harness technology to use more sophisticated polling procedures in face-to-face environments. We did not anticipate the way in which spoken and written contributions would interact with one another so productively. However, we did consciously adjust our pedagogy in real time to respond to how trainees were using these functions. In our face-to-face team teaching we have developed a fluent interactivity in which one of us will often step in to add a thought or ask the other for an opinion. In the online context we found that we stepped in more as an advocate for a trainee who had made a comment in the chat or to reinforce a student's point. Once again, this is taking an aspect of our face-to-face pedagogy and consciously adapting it to fit a strange environment.

In contrast, the threats we encountered appeared to us to be purely to do with our pedagogical approach regardless of teaching environment. Fiona laid out her resources badly, Charlotte's pacing was poor. In the extensive and detailed work we put into redeveloping sessions to move to online teaching, we did not consider major changes to resource layout and pacing. We did consider some changes in these respects. For example, Blackboard Collaborate essentially shows PowerPoint slides as pdfs, so we had to remove all animations by painstakingly copying and pasting slides with information being added slide by slide, and we programmed breaks much more regularly than usual because of our awareness of screen fatigue. Revisiting the threats following the discussion of opportunities, maybe our self-analysis and responses to each other all fail to identify the underlying cause. In both cases we had not adjusted our pedagogy to account for our inability to read students' faces and body language and adapt to different forms of communication with trainees. We had failed to do this because we had not identified that these skills were needed during that particular teaching episode.

We are left with many questions. How can we capture the opportunities in the online environment and use them to enhance our face-to-face teaching? What have we learned about the complexity of our practice in terms of the vast array of skills we are using consciously and unconsciously in any teaching episode? What are the implications for this knowledge for initial teacher education? What are the implications for our role in formatively and summatively assessing the classroom practice of beginning teachers in the light of our reflexive accounts, responses and analysis? And the most prosaic, can we get back in the classroom so that we can start using students' phones as polling devices?