Do old habits die hard? How university mathematics teaching may have risen to the challenges presented by the move to an online learning environment

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We report findings from a small-scale investigation into how university mathematics teaching (UMT) adapted to the challenges presented by the move to an online learning environment during the COVID-19 pandemic. Six interviews were conducted with lecturers in a UK university and then analysed through a commognitive lens. Two themes emerged from the analysis: the "faceless audience"; and, "coping without the chalk and blackboard". Amongst the innovative and productive UMT routines that emerged in the midst of the pandemic emergency and at quite short notice, were, for example, the use of multiple-choice questions and emoticons as a barometer for student engagement and understanding (replacing previous reliance on facial expressions and nods of heads). We conclude with reflections – and a call for further research – on whether these urgently devised and implemented innovations are here to stay or whether old UMT habits will prove too hard to die, and return.

Keywords: Theory of Commognition; online learning environments; Covid-19; university mathematics teaching

University mathematics teaching in the midst of a pandemic

The Covid-19 pandemic caused the shutdown of education institutions globally from early years through to the tertiary level. In total, 83.4% of the world's learners were locked out of in-person teaching (UNESCO, 2021). Before the pandemic, University Mathematics Teaching (UMT) had stood firm in its traditional approach to teaching mathematics employing chalk and talk as the main pedagogical routine (Viirman, 2021). However, as a result of the pandemic, UMT was forced to adapt and shift to an online learning environment with both student and lecturers having to adapt to a "new normal" (Hooper, 2021, p.42) of online teaching and learning. With the move to an online learning environment, "chalk and talk" was no longer compatible with this new normal.

The aim of the small-scale study we report in this paper – conducted as part of an MA dissertation project (Hooper, 2021) – was to investigate whether, and if so how, UMT rose to the challenges to learning and teaching presented by the move to an online learning environment. To achieve this aim, semi-structured interviews with six lecturers in a UK mathematics department were conducted. The data that were collected from these interviews were analysed through a commognitive lens (Sfard, 2008) in order to identify shifts in the pedagogical routines of the lecturers as their teaching shifted on line. We report two main themes that emerged from the analysis: one ("the faceless audience") concerns what replaced the lecturers' typical reliance on student facial expressions, gesturing and body language to gauge student engagement and understanding; the other concerns what helped the lecturers "cope without the chalk and blackboard". We start with an outline of UMT works that influenced the reported study.

UMT pedagogies and the emergence of blended learning and digital ink resources

Artemeva and Fox (2011) define "chalk and talk" as "speaking aloud while writing on the board, drawing, diagramming, moving, and gesturing, and so on" (p.355) and acknowledge benefits and drawbacks of this very prevalent pedagogical routine in UMT. In "chalk and talk", lecturers can model what mathematicians do, for example, when they prove a theorem (Viirman, 2021). Furthermore, standing and writing on the board allows lecturers to pace delivery and plan quite precisely what they can cover in a lecture. Yet, the effectiveness of "chalk and talk" has been often disputed: students report it as unengaging and conducive to mechanical note-taking (Iannone & Miller, 2019) – as opposed to engaging with the mathematics being demonstrated in a lecture.

"Blended learning" approaches to UMT have emerged in recent years partly as a result of this critique – and their endorsement has rapidly accelerated during the Covid-19 pandemic (Bawa, 2020). Blended learning involves a mixture of synchronous and asynchronous activities which can be conducted online or in-person. Its growth has been attributed to advances in technology (Owen and Dunham, 2015). Blended learning tends to be welcomed by students who appreciate engaging with material in their own time and at their own pace. Still, clear differences in academic achievement between blended learning and chalk and talk approaches are yet to emerge (Bawa, 2020).

Technological advances that have allowed the emergence and fast rise of blended learning approaches include online learning platforms such as Blackboard Collaborate (BC). The variety of functionalities in such platforms allows lecturers to organise asynchronous activities via the course zones but also deliver synchronous sessions using the collaborate live stream application (which is similar to Zoom© and Microsoft Teams©). BC was an integral part of the lecturers' arsenal in dealing with the shift from in-person to online teaching in the study we report in this paper. The small – but growing, and not always specific to UMT – literature on the utilisation of this and other similar platforms reports the promising pedagogical potential of functions such as polls, multiple choice questions, break out rooms and built-in chat (Cornelius, 2014). However, a significant drawback has been highlighted: student reluctance to turn on cameras and microphones (Chen et al. 2020).

Another advance that has accelerated the rise of blended learning is the emergence of digital ink and pen (DIP) technologies which allow interacting with a touch screen interface using a stylus, pen or even a finger to produce words, notation and drawings of mathematical content. Using DIP technologies, lecturers can emulate mathematical writing in ways that are akin to that in a chalk and talk lecture. This near replication of chalk and talk has led some researchers to brand DIP as the "new blackboard" (Maclaren, 2014). Furthermore, the incorporation of new handheld technologies such as smartphones and tablets has made using screen recording software much more accessible (Maclaren et al., 2017). Lecturers can record their screen and upload recordings which can then be viewed (and paused and replayed) by students at will. They can also interact with other resources: at the touch of a screen, for example, they can flip between applications (Hooper, 2021). Having noted these exciting potentialities, studies have highlighted challenges, particularly in the initial stages of implementation (Fhloinn & Fitzmaurice, 2021). Such challenges include (but are not limited to) poor internet connection, downloading software onto home devices, aging old equipment such as microphones and cameras and limitations in technical support. Other DIP implementation obstacles include cost of devices and the time it takes to train lecturers and students in their use (Billman et al., 2018).

Adapting to the rapidly changing learning environments must surely be a challenge for UMT lecturers, themselves largely educated through decades of exposure to chalk and talk. Our study aimed to investigate whether and how a small number of them adapted to the shift towards online learning environments, especially in the midst of a public health emergency – the Covid-19 pandemic – that required these shifts to be orchestrated and implemented almost overnight. Our investigation adapted a discursive lens, the theory of commognition (Sfard, 2008), that has been deployed consistently and extensively in recent years in explorations of UMT and, increasingly, in studies of shifts in (university mathematics) teachers' pedagogical discourse (Nardi et al., 2021). We outline the main commognitive tenets that underpin our data analysis.

Commognitive tenets in analysing UMT data

The theory of commognition (Sfard, 2008) is a discursive approach to the study of learning and teaching mathematics that takes constructing and conveying mathematical meaning to be acts of communication conducted in accordance with shared rules within a community. In a UMT context (Nardi et al., 2021), university is such a community and university mathematics and its teaching is a discourse governed by rules that are distinctly different from those governing (e.g.) school mathematics. As such, this new discourse may intrigue as well as alienate newcomers to university. The role of university mathematics teachers is to welcome newcomers into the world of university mathematics. The pedagogical discourse of these teachers – thereafter UMT discourse – is made distinct by their word use of pedagogical and mathematical language as they teach (or talk about their teaching), the visual mediators they deploy to convey mathematical meaning as they teach, the narratives about mathematics and its pedagogy and, finally, the routines in which they engage regularly as they teach. As "commognitive accounts of teaching and learning tend to be fluid – non-binary, non-deficit – small-scale, snapshot dissections of communication (verbal, written and gestural) between learners and between learners and teachers" (Nardi et al., 2021, p.1), such accounts have the capacity to highlight shifts in teachers' and learners' discourses. As such, we deemed the theory of commognition as an appropriate lens through which to identify and dissect shifts in university mathematics lecturers' pedagogical discourse as they found themselves required to move from primarily in-person to exclusively online or blended teaching.

The participating lecturers and the interviews

Six members of faculty in the same mathematics department – located within a research intensive university in the UK that was recently awarded a gold ranking in the Teaching Excellence Framework (TEF, 2021) who had taught both before and during the pandemic. The participants' research expertise in mathematics was in a range of domains (calculus, advanced algebra, analysis, statistics, finance and logic). Two participants identified as female and four as male. Their UMT experience ranged from at least seven to more than twenty years. Interviews were semi-structured and lasted between 45 and 60 minutes. The participants were invited to offer accounts of their experiences, and reflections thereof, on the main ways in which they teach university mathematics, how they use technology and what their pedagogical training is. Open-ended questions were asked deliberately to trigger recall of key events followed by reflection. The university's Research Ethics Committee approved the study and participants were guaranteed anonymity, confidentiality and right of withdrawal at any time.

Analysis of the interview data

Following repeated listening and annotation of minute-by-minute summaries of the recordings, key lecturer utterances were identified and fully transcribed. In tracing the shifts in the lecturers' UMT discourse as they reflected upon the move from in-person to online teaching, we attended to evidence that concerned general pedagogical issues (such as using multiple-choice questions at the start of a lecture to energise and motivate students; or, technical details concerning BC capabilities in managing the planning and delivery of lectures) or issues germane to how the teaching of specific aspects of mathematics changed in the move towards online teaching (for example, how DIP technologies changed the way mathematical notation, charts and diagrams were constructed, used and interpreted during teaching). Eight categories emerged from the scrutiny of the data, first distinguished between those that referred to general pedagogy and those that referred to mathematics specific pedagogy. Selected utterances and codes were entered into a spreadsheet and tallying of utterances per code followed. The two themes we sample here emerged from noticing that clusters of tallies rallied around two key themes: the challenge posed by the absence of visual or auditory cues to inform the lecturer about how the students experience the session ("the faceless audience*"*); and, the challenges posed by the shift from chalk and talk to DIP technologies ("coping without the chalk and blackboard*"*).

Theme One: The faceless audience

> What is really difficult is that you don't get to see the student's faces…no one has had their cameras on almost all year. [Zeta]

Students' insistence on keeping cameras and microphones off was highlighted by all interviewees as the biggest challenge of the move to an online learning environment. A ritual of in-person teaching is that lecturers scan their audience to gauge levels of engagement through facial expressions, gestures such as head nods and body language. This pedagogical routine was no longer viable online. New routines for instant assessment of content endorsement employed by our interviewees to rise to the challenge of the faceless audience included: (1) use of the BC built-in multiple-choice function to ask mathematical questions. The lecturer would set a 'pass' mark, say 80%, to signal that the class is content with the content presented. A pass mark, say, lower than 50%, would signal the need to revisit the content. This demonstrates a shift in the lecturers' narratives about what constitutes endorsement of the mathematical content presented in a lecture (before, a bewildered facial expression; now, a response to a mathematical question) and pedagogical routines through which said endorsement is assessed (before, scanning visual and auditory cues in the room; after, setting question and pass mark and collating answers to the question). (2) utilising and interpreting facial emoticons, another BC built-in feature. Students would be asked to select from sad, neutral or happy face). A tally would be interpreted by the lecturer as a cue to repeat, try again but differently, move on. (3) utilising the chat BC built-in function. As students insisted on keeping cameras and microphones off, exchanges turned to the chat, and spoken exchanges turned to written, but written in language and notation that by necessity became casual (BC chat cannot accommodate mathematical notation). To an extent that would be deemed almost unfathomable in exchanges during a lecture or a seminar before the switch to online teaching (for example, the capital letter S standing in for ∫, the notation for the indefinite integral in Calculus!). A marked shift then in question-posing and answering routines for students and lecturers occurred: interaction

between lecturers and students seems to have survived – and also morphed into something potentially more appealing to shy, less confident students who were now free to engage with the material without everyone's eyes fixed upon them.

Theme Two: Coping without the chalk and blackboard, turning dusty to digital

> Short videos were made covering the content, with me going through the slides, leaving space for me to write in proofs and video myself writing. [Gamma]

In chalk and talk, what is written on the board is the ultimate visual mediator of the mathematics in a lecture. All interviewees listed several uses of DIP technologies to mitigate the absence of chalk and board. DIP came in to substitute for the omnipresent routine of handwriting. One interviewee showed us how they would open a digital page and write on it using a stylus/pen. Furthermore, using a tablet whilst delivering a lecture made it easier to switch between tabs and applications. This ease of access to other resources meant that the lecturers were more inclined to incorporate them into their teaching. For example, previously, graphs were drawn free hand on the board. Now, graphs were projected using applications such as DESMOS (an online graphing tool) or MAPLE (coding software used in helping construct mathematical formula). By using DIP technologies in conjunction with apps, the dusty became digital. As Lecturer Gamma notes in the quote above, in the shift towards a blended approach, the lecturers transitioned from often purely monologic chalk and talk to incorporating synchronous and asynchronous elements of mathematics teaching that have the capacity to be seamlessly dialogic. Videos can be viewed before the lecture; thus more time can be dedicated to discussion and examples in the live lectures. Pre-recorded materials provide students with a key revision resource allowing them to access content in their own time and pace. Chalk and talk is an often esoteric comfort blanket. A blended approach takes that blanket away and opens exciting, if challenging, possibilities for students and lecturers to witness – and take part in – mathematics in the making.

Will old UMT habits prove hard to die? Or is there a better new normal ahead?

In this small study, we explored how university mathematics lecturers adapted to the challenges of the move to an online learning environment. While drawing generalisations from such a small study is inadvisable, we see our findings as a solid springboard for future studies that: explore the longevity – and further improvement – of the changes adopted so quickly during the pandemic; include the student voice; and, access direct UMT evidence, not just self-reporting accounts of it. The field (Gillard, et al., 2021) is starting to respond to this need and our study – a drop in the ocean as it may be – is a modest contribution to this much needed response.

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