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Methods for recording video in the classroom: Producing single and multi-camera videos for research into teaching and learning

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Glossary

Action camcorder	Ultra-compact video camcorder designed for ‘action’ sports, including to be worn on helmets or clothing, and which generally sacrifices features such as optical zoom in favour of a compact size.
Boundary microphone	Designed to be mounted or placed on to a hard, flat surface. Paradoxically, this design can reduce the amount of sound reflections that are recorded in a compact space (such as a teaching room), resulting in a clearer recording.
Camcorder	Camera that features the built in capability to record video, as is the case with most video cameras available on the consumer market (as opposed to a camera that can only output video to another device, such as a webcam or TV camera).
Cardoid microphone	Designed to pick-up sound from a directional arc or angle of approximately 180 degrees, thereby reducing the sound picked up from ‘behind’ the microphone.
High definition (HD) video	Video formats that exceed certain levels of quality in terms of resolution (typically at least 1,280 × 720 pixels) and frame rate (60 frames per second), creating a sharper, more detailed, and smoother appearance.
Lapel / lavalier microphone	Designed to be worn, often by being clipped on to clothing.
Memory card	Storage device used in digital cameras and camcorders that uses ‘solid state’ memory to offer a compact, reliable and affordable means of storing data.
Omni-directional microphone	Designed to pick-up sound from all directions, equating to an arc or angle of approximately 360 degrees.
Optical zoom	Feature allowing cameras/camcorders to zoom in and out with no loss of image quality or ‘resolution’ (although some visual distortion can occur on lenses that offer a particularly wide and/or tight zoom).
Rendering	Process by which video editing/production software encodes and saves edited video footage into a compatible computer file for storage or playback.
Shotgun microphone	Designed to pick up sound primarily from the direction in which the microphone is pointing, while reducing the pick-up of sounds from other sources/directions.
Thunderbolt	Ultra-high-speed wired interface between PCs and peripheral devices, which is particularly suited to the demands of transferring video.
USB (universal serial bus)	The industry standard design for wired interfaces (connections) between PCs and peripheral devices. The latest commonly-available generation of USB 3.0 connections can handle significant more data than previous versions.
Video editing	The process of selecting and combining pieces of video footage, together with audio recordings, using computer software (in the case of digital recordings).
Webcam	Digital video camera that is designed to be connected to a PC, these typically boast compact proportions but cannot operate or record without being connected to a computer.

Introduction

This paper addresses the practical challenges associated with recording video in classroom settings and explores some of the technical solutions available to educational or social researchers working in schools, universities, training venues, or similar settings. Particular attention is paid here to the use of multi-camera recording as a method of capturing the fullest-possible range of actions and interactions within a teaching and learning context. This method involves combining video from two or more camera angles in order to simultaneously show both teachers and learners. By focusing on key considerations such as the choice of video and audio equipment and the various methods for recording and producing videos, it is intended that this discussion may act as a helpful toolkit for other researchers. In doing so, this paper explores the broader potential for digital technologies to support methodological advances in classroom-based video research through advances in the functionality, compactness, usability, and affordability of the latest recording equipment.

The technical and practical issues discussed here emerged from the experience of developing and deploying video recording as part of research conducted at the UK's National Centre for Research Methods (NCRM). This study sought to explore the processes through which social research methods are taught and learnt on training sessions and short courses (see Kilburn et al., 2014). The author worked as the researcher on this project, alongside two senior academic colleagues with considerable expertise in the conduct of qualitative research, including in the use of video-based methods for educational research. Our research design included the use of video-stimulated focus groups as a means of data collection, through which we sought to engage teachers and learners together in a dialogue over their experiences of the methods training courses sampled for this study (see Nind et al., forthcoming). These focus groups took place after the end of a day's training, creating a requirement for the video recording to be available for immediate playback. Given that the substantive focus on this research was very much on teaching *and* learning, there was also a requirement for the video to capture a perspective on what the learners were

doing as well as on the teacher(s). Lastly, with ethical considerations in mind, the video recording process needed to create the least possible impact or intrusion on the teaching and learning involved in these (often one-off) courses or training sessions. We therefore needed to design a method that used compact and unobtrusive equipment to record high quality video from multiple camera angles that could be available for immediate playback.

This paper is written from a social researchers' perspective, although the focus throughout is on the technical rather than methodological considerations involved with the recording of video. Of course, the use of video as research tool also poses a number of broader methodological issues. These include important questions of ethics (Wiles et al., 2008), especially conducting video research involving children (Flewitt, 2006). Transcribing and analysing video data also poses considerable challenges (Mavers, 2012). More broad-based methodological discussions are available elsewhere, whether with respect to the use of video in the classroom (Derry et al., 2010), in education research (Goldman et al., 2014), or in social research in general (Haw and Hadfield, 2011, Jewitt, 2012). This paper focuses instead on key practical considerations associated with video recording for classroom-based research. The first section considers the fundamental question of choosing a video camera (or cameras) and of how to mount and position video equipment so as to impose the least disruption to teaching and learning. The second section considers the issue of audio and addresses the challenge of clearly capturing the voices of both teachers and learners within classroom settings. The third section presents a range of options for multi-camera recording, based on the premise that capturing more than one camera angle offers an inherent advantage for video research that seeks to explore both teaching *and* learning. These observations are based on our experiences of producing video for the purpose of stimulating reflective dialogue, rather than for detailed analysis of multimodal interaction, and we do not presume to offer the last word on using video in either context. With that in mind, the final section explores how researchers may benefit from some of the current advances in digital video technologies.

Cameras

The choice over which video camera(s) to use is likely to be a primary concern. Advances in the digital technologies mean that camcorders boast increasingly impressive functionality, compact size, and comparative affordability. Most digital camcorders are capable of recording full high definition (HD) video in formats that can be played or edited on range of devices. An increasing number of webcams, smartphones, and tablets can also capture video in HD. With a plethora of devices available, this paper focuses on general considerations that may arise when choosing video cameras for use in classroom settings, rather than the specifics of particular models. As classrooms comprise numerous and mutable configurations of people, objects, sounds, and so on, all within a small and crowded space, video equipment may need to combine versatility with specific features that are particularly suited to these settings. Two key considerations emerged from our experience of recording in various classroom contexts, the first involved choosing a camera with a suitable lens angle and the second involved the positioning and mounting of video equipment.

Lens angle

Video cameras are equipped with lenses capable of capturing different angles of view, depending on their design. Many camcorders feature optical zoom lenses, allowing users to zoom in for a tight shot or out for a wide angle of view. When recording in a classroom, a tight shot may be best suited for framing the teacher, whereas a wide shot would be needed to capture groups of learners. However, classrooms can constitute challenging settings in which to obtain a wide-enough camera angle to incorporate an entire class group. The compact nature of most small-group teaching rooms can make it particularly difficult to position a typical camcorder with all of the classroom's occupants in shot. 'Panning' or moving the camera to cover different areas of the classroom is one solution. However, when filming students' learning for research purposes, one may find that a static camera – rather than one being operated and moved by a cameraperson – offers an easier and less intrusive approach. Selecting

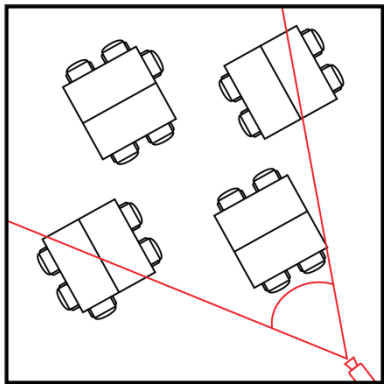
cameras that can offer a wide enough angle of view can therefore constitute an important consideration.

Figure 1 compares the viewing angles of three cameras that were tested for our research. The diagrams on the left provide an approximate representation of the lens angle, whereas the images on the right are taken from the video cameras themselves. For this comparison, the cameras were positioned to simulate a scenario in which learners might be filmed within a typical – albeit empty – small-group teaching room (of approximately 20 feet square). The first example shows a compact **digital camcorder** with its zoom lens set to its widest angle[1]. In this situation, it is clear to see that the camcorder does not offer a wide enough shot to accommodate all learners, five of whom would be cropped from view. While a camcorder such as this may be better for a 'tight' shot, focused on a teacher or presenter, it may not offer the flexibility to capture groups of learners. The second example is from an HD webcam (this time without a zoom lens). With this camera, the viewing angle is noticeable wider and only three learners would be slightly cropped from the shot. With a more compact seating layout or a larger teaching space, the **webcam** could feasibly provide a wide-enough angle to capture an entire class group. The last two images were taken using an **action camcorder**. These offer particularly wide angles of view as they are designed as wearable cameras and for filming sports or other activities in open or outdoor environments. The particular model tested in Figure 1 features two wide-angle settings. The narrower (120°) angle shown in the third example was easily able to capture the entire class group in our test. The second (170°) setting is amongst the widest angles available from a consumer video camera and could accommodate even the smallest or most crowded of crowded classrooms. However, the image in the fourth example also illustrates how this ultra-wide angle comes at the expense of some visual distortion, noticeable as a slight curvature to the image which has the effect of makes some of the seats in our test appear artificially distant.

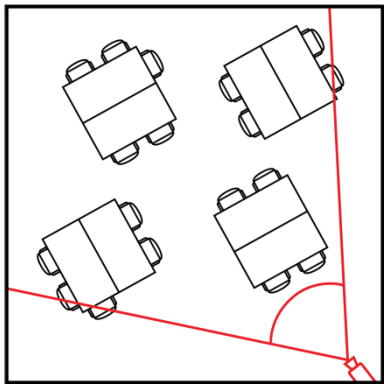
[1] This model featured a 29.8mm focal length lens, which is common for mid- to high- end camcorders.

Figure 1: Viewing angles for common types of digital video camera

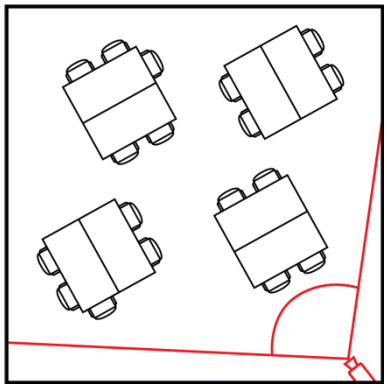
Digital Camcorder (50°)



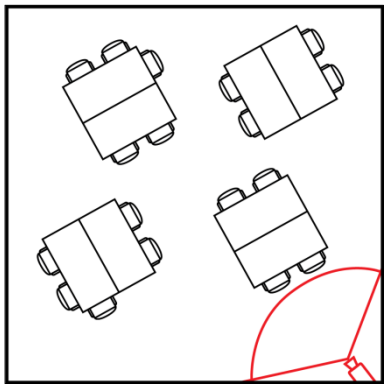
Webcam (80°)



Action Camcorder (120°)



Action Camcorder (170°)



In short, when selecting a video camera for use in teaching spaces similar to the one shown in Figure 1, lens angle will likely constitute a key concern. If the video only needs to capture the teacher or small grounds of learners, then a standard digital camcorder may suffice. If trying to capture larger groups of learners, however, a standard digital camcorder may not offer a wide enough lens angle. Instead, a webcam could be used (although this would need to be connected to a PC). Alternatively, an action camcorder with an ultra-wide lens angle may be preferable as a standalone recording device. Depending on a combination of factors – including the requirements of the research, the nature of the teaching space, and the size of the groups involved – different features will be required and, ultimately, for some projects more than one type of video camera may be needed.

Positioning and mounting video cameras

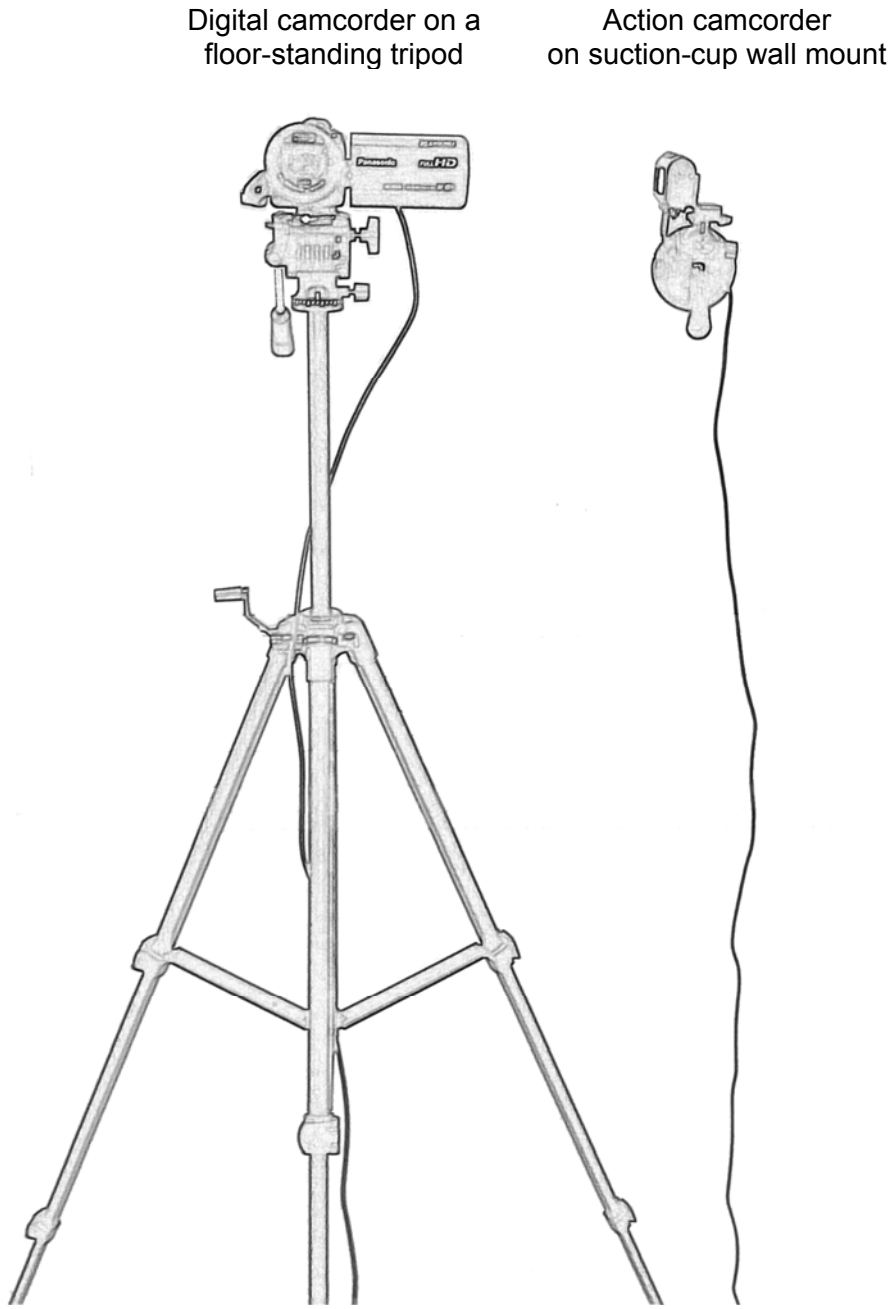
When working in a classroom setting, a second consideration includes the size of the camera equipment to be used, where it will be positioned, and how best to mount it. Although it is possible to use a handheld setup to record for a short period of time, a 'static' camera placed on a fixed mount may offer certain advantages. Operating a handheld camera may prevent the researcher from making and recording (in means other than video) potentially valuable observations while 'in the field'. A researcher pointing a camera at the teacher(s) and/or learners also risks becoming more intrusive and distracting than a static camera. Moreover, it is invariably easier to produce a stable recording with a camera placed on some sort of mount. The sorts of camera discussed above are all relatively compact – with standard digital camcorders typically taking up less space than a small bottle of drinking water, while webcams and action camcorders can be smaller than a pack of playing cards – this means that they can be easily positioned and mounted safely using a range of devices.

Figure 2 illustrates how the size of the camera and the device used to mount it may have a combined impact on the visual impact of the video equipment, which in turn may influence the extent to which the recording is perceived as an

intrusion in the classroom. Of course, video cameras are not an unfamiliar presence in educational settings. However, people may nevertheless find a conspicuous video setup to be a distraction. Figure 2 shows a silhouette view of two contrasting setups that were used for our video recordings. On the left is a 'typical' video recording setup comprised of a standard digital camcorder and a telescopic tripod. On the right is an action camcorder fixed to a wall surface (in this case, a whiteboard) using a suction-cup mount. The difference in the visible presence of the two setups is clear to see. In addition to any visual impact, the size and position of video equipment also risks obstructing lines of sight or interfering with movement around the classroom. Aside from the potential detriment this may have to teaching and learning, the positioning of camera equipment also introduces common sense issues regarding participants' safety. General precautions must therefore be taken to avoid trip hazards from wires or tripod legs, mount equipment securely so that it cannot tip or fall, and to adhere to any other safety requirements of the venues in which filming is taking place.

Several different methods for mounting cameras were tested and used as part of our study. A **tripod** offers perhaps the most versatile option, with height adjustment and 'pan-tilt' heads allowing the camera to be pointed in any direction. However, tripods have a comparatively large footprint, making them more likely to constitute obstructions and or be accidentally knocked or toppled in a busy classroom. **Suction-cup mounts** offer a far more compact means of mounting cameras to smooth surfaces, such as windows or whiteboards. Suction mounts also feature adjustable heads that enable cameras to be directed as required. Even the most compact suction-cup mounts can support cameras of around 500g (equivalent to a compact digital camcorder). Although the suction cups would not adhere securely to painted or textured surfaces, we found that most classrooms had plenty of smooth surfaces that could be used for filming. Alternatively, vice-style **adjustable clamps** offer a more versatile option than suction mounts, as they can be attached to wide range of fixtures and fittings after having tested that they can safely support their weight.

Figure 2: Comparing the visible profile of two contrasting camera setups



Once again, the particular characteristics of the room, group size, and teaching/learning approach – not to mention the nature of the research – are each likely to influence the positioning and mounting of camera equipment. Unless these factors can be anticipated in advance, the researcher may require a range of options at their disposal for different research scenarios.

Audio

As researchers seeking to capitalise on the affordances of new digital video technologies in the classroom, our technical pre-occupations were focused on the choice of camera. When it came to recording audio, it was hoped that the built-in microphones on our cameras would suffice. In practice, however, capturing the voices of those who were speaking in our videos proved far more challenging than anticipated. The audio recorded by our cameras suffered from high levels of background noise, while those speaking in the room – including the teacher(s) – sounded quiet and distant. Various issues hindered the clarity of our audio recordings. Firstly, members of the class groups we filmed tended to be positioned throughout the room, but the camera microphones picked-up those who were closer or directed their voices towards the equipment far more clearly than others. Secondly, people naturally tend to speak at different volumes and our equipment failed to clearly pick up those with quieter voices. Thirdly, classrooms have high levels of ambient noise, with the shuffling of papers, personal belongings, and bodies combined with the hum of ventilation systems, projectors, and computers. Perhaps the greatest challenge, however, was that these issues were not obviously discernable to the 'naked ear' as we made our recordings. Yet given the importance of speech and sound as a mode of interaction in the classroom, the resultant issues with the clarity of the audio on our early recordings hindered our ability to adequately capture and portray the teaching and learning processes taking place.

Those with experience of audio-visual recording would be familiar with the problems we encountered: A high 'signal to noise ratio' resulting from our cameras' microphones picking up too much background noise and a 'decay' in the volume of speech recorded by those positioned further from our equipment. For these reasons, professional sound technicians typically use '**lavalier' (or lapel) microphones** to capture speakers' voices and directional **'shotgun' microphones** mounted on poles (or 'booms') to capture audience questions or discussion. Clearly, such a setup could create significant disruption when recording video for non-participant educational research. Instead, it is possible

to configure classrooms with multiple microphones in fixed positions for high quality audio recording (Shure, 2007). However, this would require a considerable investment in specialist equipment, plus time to ‘wire’ an entire classroom for sound. We therefore sought a simpler and more affordable alternative, in the hope that this could yield at least a modest improvement.

After testing a number of separate microphones, the best all-round results were achieved by a **cardoid boundary microphone**. The particular model we used connected to a PC’s USB port, although other models are available with connections for camcorders or other recording devices. Cardoid microphones have a pickup pattern that approximately equates to a 180-degree arc in one direction. While no microphone can completely cancel out sound from certain directions, this does mean that a cardoid microphone picks up less ambient noise when pointed towards a target sound source. Other microphones, such as **shotgun** designs, have a more directional sound pickup pattern – but when tested these generally yielded recordings in which learners’ voices were too quiet when the mic was directed towards the teacher (or vice versa). We also experimented with **omni-directional microphones**, which capture sound equally around a 360-degree pickup pattern. These worked comparatively well, although the ability to direct the microphone towards the teacher/group and away from noise sources (such as windows or ventilation equipment) proved a more useful feature of the cardoid model. The ‘boundary’ design of our favoured microphone meant that it actually performs best when positioned on a flat surface, which was easy to do unobtrusively in most classrooms. Boundary microphones are light and compact, allowing them to be hung from walls or whiteboards, or placed on desks or tables.

Ultimately, we were able to capture most instances of speech within the class groups we recorded using a relatively inexpensive cardoid boundary microphone. Although background noise was not eliminated, the voices of our participants could be heard clearly enough to make out what they were saying when played back over a reasonable quality audio system. As an aside,

however, we still encountered some unforeseen issues involving poor quality audio playback equipment in the venues used for playback. These issues were difficult to predict or address when using facilities in other institutions – in our case, teaching rooms of universities that were hosting our video observations and focus groups – short of investing in and transporting an entire projection and audio system for video playback.

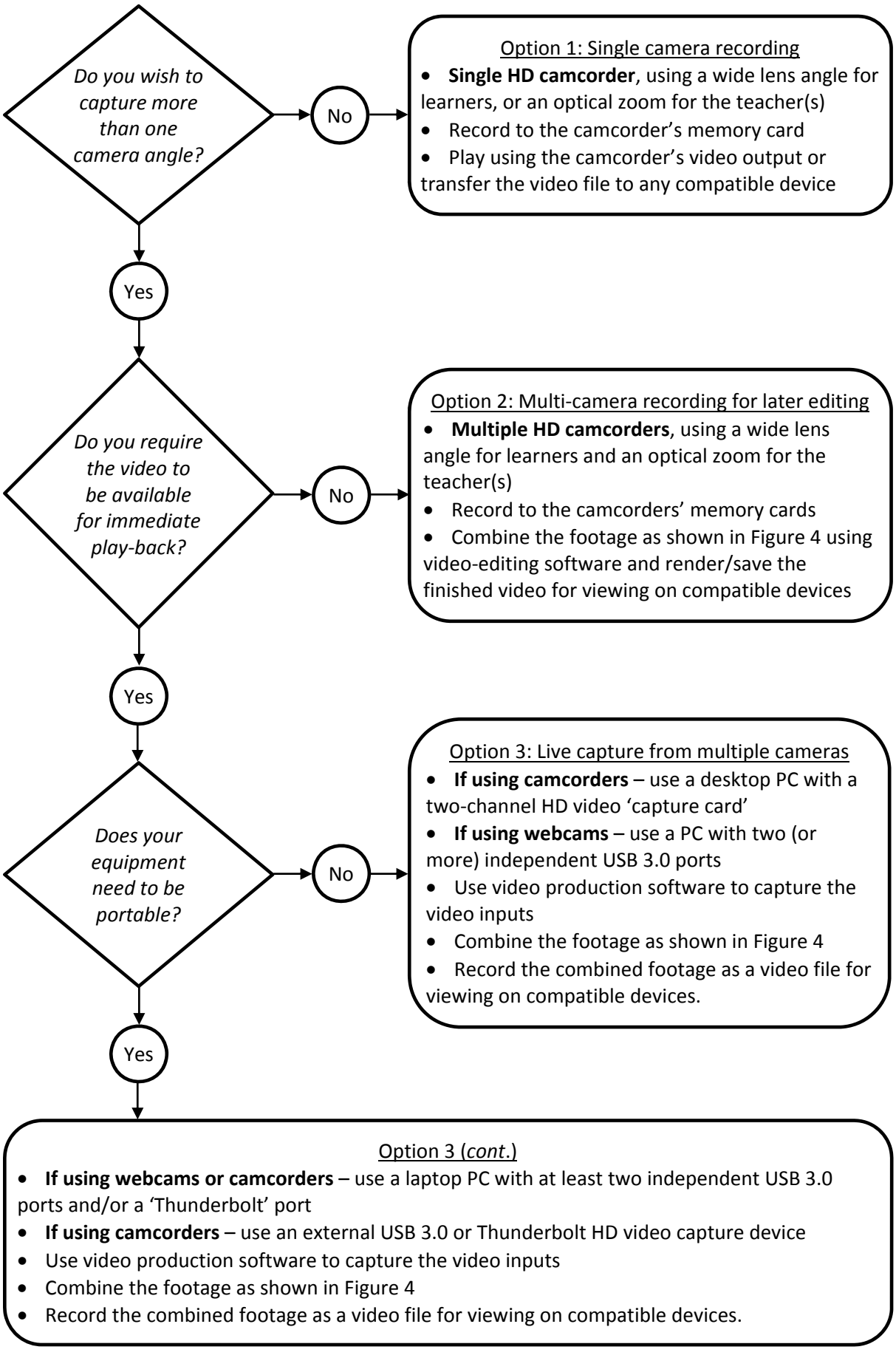
Producing Recordings in the Classroom

This section presents three possible methods for producing video recording within a classroom setting, including options for combining more than one camera angle into a 'multi-camera' video. Given the multitude of potential factors involved, the focus here is on outlining the general processes involved in the different video production methods. The flow-chart shown in Figure 3 offers a breakdown of the key decisions and steps that are likely to be associated with each of the options discussed below.

Single camera recording

The process of using a single camera to record within a classroom will most likely involve a 'point and shoot' approach, based on intuitive decisions in response to the context in which the video is being made. Where only one camera is required, a digital camcorder recording directly to a memory card may be preferable. The video can then be transferred to a computer for play-back or editing, or even be played by connecting the camcorder to a television. A more important question is therefore likely to concern where the camera is positioned. For most purposes, the teacher will constitute the primary 'subject' for the video recording. In these cases, a standard HD digital camcorder can be placed at the back of the room, either on a tripod or a suction-cup mount. The shot can be zoomed in/out to frame the teacher as required. For the purposes of filming both teaching *and* learning, however, this setup poses a potentially major limitation by only capturing learners from behind.

Figure 3: Deciding between video production methods and the key steps involved in each



Alternatively, a single camera may instead be positioned at the front of a classroom to record the learners – although, as Figure 1 illustrated, a camcorder with a wider-than-usual lens angle may be required in order to capture an entire group of learners. Filming learners may satisfy certain methodological requirements, such as the ability to analyse gaze, facial expressions, or other actions/interactions. However, the teacher will be left out of the shot if using a single camera. A single camera recording may therefore present certain limitations when used to study teaching and learning in traditional classroom setups. This is not to overlook the advantages of a simple single camera setup, which may be cheaper, less intrusive, and easier to operate.

Multi-camera recording for later editing

Once the decision has been made to deploy multiple cameras, the next question concerns how best to combine the footage for the purposes of playback. This will depend heavily on the nature of the research design. For instance, if the video is only intended to be used for analysis by researchers then there may be no need to combine the footage at all, as one may wish to code or analyse each camera angle in turn. However, it is more likely that the analytic advantages of viewing the footage for different cameras simultaneously will precipitate the need to somehow synchronise and combine the footage into a single video. The second question then concerns the time and resources available to undertake this task.

Conventionally, footage from camcorders is combined through a process of video editing. Although digital technology has made this quicker and easier than in the past, certain constraints remain. Firstly, video editing requires powerful computer hardware and software. As a result, many office-type desktop or laptop PCs may still lack the processing power to undertake these tasks efficiently. Secondly, operating the software requires a reasonable level of knowledge and skill. For instance, the footage from each camera must be synchronised precisely and combined with an audio track. While there are

plenty of resources available to guide researchers in this task, it is almost invariably time consuming and tricky to complete, especially in the field. Lastly, and perhaps most frustratingly, even the process of saving or 'rendering' the edited video can also be frustratingly slow. This may seem surprising, as most computer files save in a matter of seconds (or quicker). However, even when using the latest video editing software combined with a high-spec PC, it can easily take 30 seconds to render each minute of video footage. A one hour recording would therefore take half an hour, while a whole day's video observation could take several hours.

Despite the time and effort required to edit and produce a video using footage recorded on multiple camcorders, this method does bring certain advantages. Firstly, camcorders can be used to record to on-board memory cards, without the need for wiring or additional hardware to connect them to a PC or other device (as discussed in the following section). Secondly, the editing process also provides the researcher with an opportunity to review the footage and make refinements where necessary. For instance, some software offers 'noise reduction' features that can improve the clarity of the audio. Finally, as the recording itself is not being made 'live' the researcher does not have to commit to one of the various formats for combining multi-camera footage (as discussed in the following section). Instead, these decisions can be made later at the editing stage. Should the need arise, the researcher can even 'cut' between footage from different cameras – as is done with television or film production – although this does introduce a degree of 'creative license' on the part of the researcher. Ultimately, however, even the most basic form of video editing is unlikely to be feasible in situations where the finished video is needed for playback in a short period of time (as was the case with our research).

Live capture from multiple cameras

If a multi-camera video recording is required for immediate playback, or if the work required for video editing is unfeasible, then other solutions may be explored. Despite of the advances in digital and computing technologies,

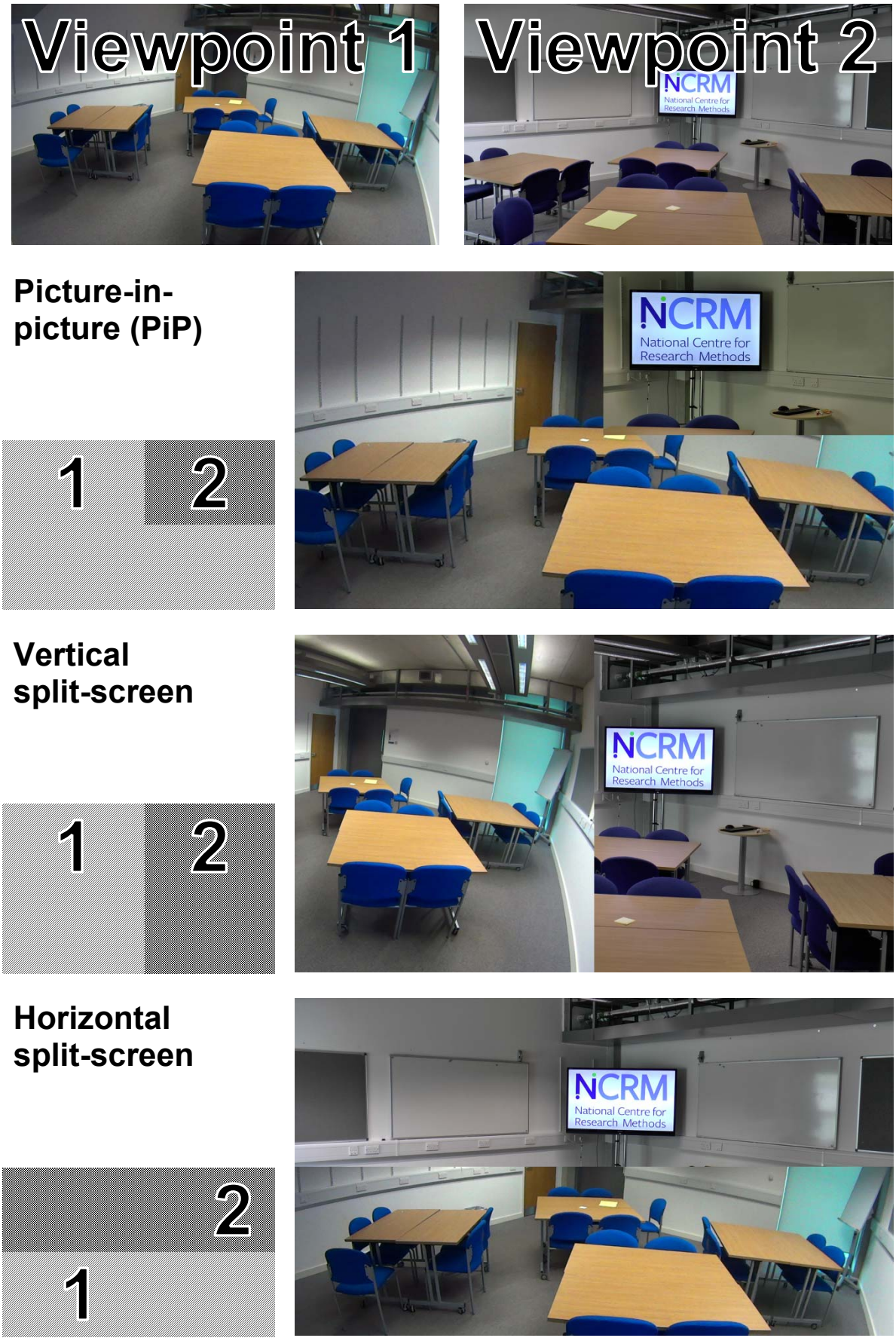
alternative solutions are not widely-established. A considerable amount of investigation and experimentation was therefore required before we arrived at a workable solution for 'live capture'[2] from multiple cameras which satisfied the requirements of our study.

We wished to combine simultaneous recordings from two cameras – one on the teacher, the other on the learners – into a single video. We had various ideas in mind as to how the end product may appear. For instance, video surveillance systems commonly use 'split screen' to display four or more video images on a single monitor. Similarly, TV broadcasts also use 'picture-in-picture' to simultaneously display two video sources in different areas of the screen. As Figure 4 illustrates, we experimented with three similar methods to combine our two camera angles. In these examples, viewpoint #1 is camera a positioned at the front of the room to capture the students and the camera in viewpoint #2 is positioned in the back corner of the room to capture the teacher. It is clear that each of the methods shown in Figure 4 may have advantages and disadvantages depending on the requirements of the research. The 'picture-in-picture' approach would capture all of the students – although some still have their backs to the camera – but affords less space to show the footage of the teacher. A vertical split-screen offers more space for the teacher, but in doing so it crops some of the students from the shot entirely. A horizontal split-screen allows a wide angle on both the students and the teacher, although this may not be suitable for a narrower classroom. The decision over which of these methods to use, or whether to develop an alternative approach altogether, thus depends on a host of factors including the room/group size, camera locations, and the nature of the teaching/ learning exercise(s).

When seeking to combine video from multiple camera sources using a live capture approach, additional hardware is needed in the classroom. As the flowchart in Figure 3 suggests, this poses a question as to the portability

[2] We use the term 'live capture' mainly to distinguish from recording methods that involve editing. In practice, however, the approach we used is not dissimilar to that which can be used for live video production.

Figure 4: Different formats for combining two camera angles for recording/playback



required from the video setup. Our research called for equipment that was could easily be transported. Ultimately, we therefore designed a setup based around a laptop computer to ‘capture’ and combine video feeds from two cameras. A desktop PC could also be used for this purpose and, in fact, may offer several advantages. Firstly, any PC required for this task must be powerful – ideally, with the latest specification of processor – and a high-spec desktop will usually be cheaper than an equivalent laptop. Secondly, desktop PCs can usually be upgraded with additional hardware for the purposes of video capture, allowing more cameras to be connected to a single PC. Whatever computer one choses, it must be able to run one of a handful of video production software packages that are capable of combing camera sources in the ways illustrated in Figure 4. This software will also record the combined video as a file on the computer’s hard drive in a format that could be played back on other compatible devices. As the video is recorded ‘live’, there is no need for rendering. For our setup, we typically paired an HD action camcorder to capture a wide shot of the students (as illustrated in Figure 1) with an HD webcam to capture a tighter shot of the teacher. These were both compact enough to safely mount using suction-cups.

Capturing high-definition (HD) video outputs from multiple cameras also introduces some specific issues concerning compatibility between video cameras and computer hardware. Although many camcorders feature a video output, no PCs available on the mainstream market currently feature connections capable of receiving this output without the use of additional devices to convert video signals to a compatible format. These devices can be costly as they are aimed at the video production market. One alternative is to avoid using camcorders in favour of webcams that are compatible with most PCs. However, a further issue arises from the hardware in many laptops PCs not being capable of handling HD video input from more than one device (be that a webcam or camcorder). Put simply, this is due to the quality of the video exceeding the computer’s ability to process the large amounts of data involved. In essence, this presented two significant challenges. Firstly, we had to find a laptop powerful enough to handle two video inputs and the funding needed for

this. Secondly, we had to find a compatible hardware device capable of 'capturing' video from our camcorders. We achieved the best results from using an external 'capture device' that was compatible with our laptop's 'Thunderbolt' port. In the near future, it is likely that advances in connectivity and data transfer between PCs and peripheral devices may create a wider range of options for multi-camera video capture using HD webcams or camcorders.

The setup described above is by no means perfect. While it does allow for reliable multi-camera video capture using compact and readily-available equipment, relatively advanced computing skills are required to configure the various components (some of which, such as our action camcorder, were not specifically designed for such as task). We required guidance from more experienced videographers. Compared to using camcorders to record for later editing, this method also required that both cameras be connected to the PC via cables. This meant cables had to be taped and routed carefully around the classroom to avoid obstructions or trip hazards. One advantage of a 'wired' setup such as this, though, was that we were able to deliver electrical current to our cameras – a necessity given that our day-long recording sessions would have exhausted the camcorder's batteries after a few hours.

New Technologies and Future Advances

Using video recording for classroom-based research is not new and while there is little to indicate that a multi-camera approach is widely used, this method only constitutes another means of recording video rather than a methodological innovation in its own right. That said, advances in digital video technology do hold potential to support new methodological approaches or developments and this final section offers some brief reflections on how these technologies may be utilised for research into teaching and learning.

One particularly promising technological advance comes in the form of **wireless connectivity** – a feature offered by an increasing number of camcorders and

video cameras. In short, this allows video to be transferred or ‘streamed’ to a nearby device using a wireless (‘Wi-Fi’) network connection. Many devices have the ability to connect to a wireless network, which theoretically means that high quality video from compatible cameras can be captured wirelessly by laptop PCs, tablets, or smartphones. Aside from a few seconds delay, these video and audio signals can be viewed or recorded ‘live’. This brings obvious potential for video-based teaching observations, whereby an observer could even be positioned in separate (but nearby) room thus creating minimal disruption to teaching. More broadly, wireless connectivity reduces the need for obtrusive wires to be trailed around the classroom when undertaking a live capture recording. However, as most PCs can only maintain a single wireless network connection, it may not be possible to connect multiple different cameras to a single device. The potential of these new technologies is nevertheless significant, especially as some manufacturers are now incorporating the means to wirelessly control features such as the camera’s zoom.

Smartphones and tablet computers have been mentioned here a number of times and the ever increasing functionality of these devices mean that they hold potential for technological advances in classroom-based recording. Many smartphones are equipped with the potential to record HD video, although they lack the range of features found on camcorders (such as optical zoom or microphone connection). The increasing popularity of tablet computers, especially within educational institutions, brings further benefits as these can also be used to edit video. Smartphones and tablets are not only able to record video, but can also take advantage of the same sorts of wireless network connectivity discussed above to transfer video to other devices. In fact, software developed for Apple devices even allows multi-camera recording from smartphones or tablets connected to each other wirelessly. Although these technologies will struggle to match the quality and functionality offered by the latest camcorders, they do offer a viable alternative for those seeking a compact and easy-to-use alternative, especially if such devices are already available.

Wearable cameras are not a new technology and are widely used by sports enthusiasts (or even by the Police). Education researchers are also increasingly experimenting with these devices as a means of recording teachers' or learners' perspectives (Henriksen et al., 2013). With ongoing improvements in the video quality, usability, and cost of ultra-compact wearable cameras, these are bound to see more widespread use in the classroom. Lastly, the (current) cutting-edge of video technologies includes the ability to capture video in **'ultra' high definition** (also referred to as **4K**, because it offers a resolution of over 4,000 pixels). This theoretically equates to a four-fold increase in image detail and clarity compared to the current generation of HD video. Aside from simply offering an increase in quality, this level of ultra-high definition could have particular applications for video capture within the classroom. For instance, the level of detail could allow researchers to clearly see and observe learners' facial expression, or potentially even their gaze, without the need for a close-up shot (personal communication with John Schulz, Southampton Education School). The cost, availability and bulkiness of 4K cameras may prove prohibitive in the short term, although this situation is likely improve as the technology proliferates.

Although the use of video in itself no longer forms part of the cutting-edge for social research, constant advances in technologies are creating ever more opportunities for researchers to innovate in response to particular requirements or challenges. Since learning inherently involves multiple modes of interaction and experience, there is a strong methodological rationale for using video for classroom-based research. By experimenting with different technologies, we were able to capture aspects of the teaching and learning that other methods of observation may have missed. Moreover, the video remains as a record of the event that can be used in multiple ways, whether for later analysis or – as in our case – for video-stimulated focus group interviews with teachers and learners. Improvements in the functionality, compactness, and affordability of video equipment will unboundedly yield further methodological advances and afford access to new empirical insights for social researchers working in classroom settings.

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