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Supporting seamless learners: exploring patterns of multiple device use in an open and distance learning context

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Educators need to be aware of not just what their students are learning, but how and why as well. This study investigates how Open and Distance Learning (ODL) students make use of multiple devices for learning, particularly how students use their devices together. This study is situated in the context of 'seamless learning', where ODL students learn at different times, in different locations and with the use of different technologies. Understanding the needs and learning practices of students can help to improve the design of learning experiences and support offered to students. Data were collected through semi-structured interviews at two ODL universities, one in Spain and one in South Africa. The results show that while students mainly use one digital device at a time, they sometimes make use of two or more devices together. This usage can be characterised as sequential (moving from one device to another) or simultaneous (using two or more devices together at a time). This article describes the study patterns associated with sequential and simultaneous use of multiple devices, facilitated by the use of different devices and synchronisation tools. A continuum of seamless learners is proposed that can be used to help identify levels of support required by ODL students.

Keywords: seamless learning; online learning; multiple devices; higher education; mobile learning

Introduction

In the past, a common goal for educators was to ensure that each student had access to a personal device for learning (Chan *et al*. 2006). However, now students utilise one or more digital devices for learning (Galanek, Gierdowski and Brooks 2018; Newman, Beetham and Knight 2018). The use of personal devices impacts the study habits of students, yet the nature of and motivation for technology use for learning is not always well understood (Margaryan, Littlejohn and Vojt 2011). It is known that students have access to different digital devices, but it is not well understood how students use these devices together or move between fixed and handheld devices. This is of particular relevance in Open and Distance Learning (ODL), where students do not learn at fixed times or at a specific location. ODL students learn at different times and locations with the aid of different technologies (Cross, Sharples and Healing 2016).

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This article will explore how students make use of different devices for learning, either separately or together. The research question that guides this study is 'How do undergraduate ODL students make use of handheld devices together with fixed devices to perform their learning activities?'. The study is framed within the context of seamless leaning, where students can learn in a variety of scenarios, using technology to move between scenarios (Chan *et al*. 2006). The findings are important because they show emerging learning patterns as students make use of different devices together (either sequentially or simultaneously), supported by cloud technologies, to achieve their learning goals. These learning patterns can be characterised as sequential (moving from one device to another) or simultaneous (using two or more devices together at a time). This emphasises the changing role of educators in supporting students by knowing how and where their students are learning. Educators need to understand how their teaching methods and course design align with the flexible, mobile needs of their students (Awadhiya & Miglani 2016). Furthermore, educators need to consider whether they are able to deliver seamless learning experiences to students who want to learn in this way (Cross *et al*. 2019).

Review of the literature

The use of various digital technologies is now a common feature in higher education, with the widespread use of Learning Management Systems (LMS), online library services and online communication tools (Henderson *et al*. 2015). Universities are therefore interested in how technologies are used for learning. This requires an understanding of what technologies students have access to, why and where they study and their levels of digital literacy (Cross, Sharples and Healing 2016). ODL students may have multiple commitments (work and personal) and so may need to study at different times and in different locations (Cross *et al*. 2019). Various studies have shown that on-campus university students have access to various personal digital devices, particularly mobile devices such as tablets (Green *et al*. 2016; Reid and Pechenkina 2016). Digital devices include both fixed and handheld devices. Fixed devices include desktop computers and laptops, while handheld or mobile devices refer to smartphones, tablets or e-readers (Cross, Sharples and Healing 2016). While ODL universities may be aware of what technologies students have access to, there may not be a similar awareness of how students make use of different personal technologies for learning. It is important to address this gap because universities need to meet the changing needs of their students in a digital age. Understanding the learning patterns of students enables educators to address students' current needs and anticipate future ones, particularly as technologies are seen as essential for academic success (Galanek, Gierdowski and Brooks 2018).

The role use of technologies by university students is of interest to many academics. In several countries, annual quantitative surveys of students' use of technologies for learning are undertaken to determine insights and trends (Galanek, Gierdowski and Brooks 2018; Newman, Beetham and Knight 2018). These general studies show an increase in the ownership of technological devices and that many students make use of laptops and smartphones for academic purposes. Other studies similarly show higher education students' uptake of technologies for learning, particularly mobile devices and instant messaging services (Dolch and Zawacki-Richter 2018; Krull and Duart 2017). However, there is a need to investigate patterns of ownership and use in more detail through a qualitative approach (Cross *et al*. 2019; Newman and Beetham 2017).

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Several previous studies have highlighted students' use of different devices for learning in distance or dual mode universities (Cross, Sharples and Healing 2016; Farley *et al*. 2015). However, these studies did not consider how students make use of their different devices together or only considered the use of handheld devices specifically.

This study uses the concept of seamless learning to frame the research. Seamless learning means that 'a student can learn whenever they are curious in a variety of scenarios and that they can switch from one scenario to another easily and quickly using the personal device as a mediator' (Chan *et al*. 2006, p. 6). Students can move between physical and virtual locations such as homes, buses, libraries and LMSs (Barden and Bygroves 2017). A blurring of the seams occurs when students learn in formal and informal settings, at various times of the day, with different resources and technologies (Sharples *et al*. 2012). For example, students can make use of cloud computing to access previously created learning artefacts wherever they are situated and not worry about losing any work (Barden and Bygroves 2017). Although there are many benefits for learners able to learn in a seamless manner, there may be challenges related to network access or device affordances (Sharples *et al*. 2012). The approach of seamless learning guides this research by investigating how learning occurs across time and locations through the use of different devices (Wong 2012). Learners need support in knowing how to navigate their learning across multiple times and locations when completing different learning activities. Not all students know how to positively adapt their study habits when confronted with new technologies (Cross *et al*. 2019).

Google (2012) found that consumers spent their time using a range of devices in a day, determined by their available time, the goal to accomplish and their location. Using a classification proposed by Google (2012) for consumer usage of devices, being either simultaneous or sequential, this research aims to explore these two patterns of device use for learning. Most commonly, studies of student multitasking behaviour tend to focus on students using two or more digital devices at the same time for unrelated tasks (Patterson 2017). However, there are few studies that explore the usage of devices for related learning activities, across different locations and times.

Methodology

This study made use of a qualitative approach through the collection of data via semi-structured interviews (Creswell 2009). A case study approach was used to investigate the use of different technologies for learning by undergraduate students at two ODL universities. The two universities were the Universitat Oberta de Catalunya (UOC) in Spain and the University of South Africa (UNISA) in South Africa. Both of these institutions are single mode (distance) institutions. These cases were selected on their basis of representativeness of ODL students in each country and because the researchers obtained approval to collect data at these institutions. Two cases were selected to understand any similarities or differences between the cases and provide a more robust and reliable study (Stake 2006). A semi-structured interview protocol was designed for students to provide explanations and examples of how they use digital devices and other technologies for learning. Appendix A contains the interview protocol. The data collection instrument was piloted with a small group of students at UOC for validation purposes.

A random sample of students who had previously completed an electronic survey about their use of technology for learning at both institutions were invited via email

to participate in a telephonic or online semi-structured interview. The results of the surveys have not been published yet. The results of the surveys were used to develop the interview protocol and expand on the experiences of students using devices for learning. Thirty-four interviews were conducted between July and December 2016. Prospective interviewees were asked to sign consent forms before the interview. Eighteen interviews were conducted with UOC students (case 1) and 16 interviews were conducted with UNISA students (case 2). Interviews were recorded and transcribed. Interview analysis was done using a grounded theory approach (Corbin and Strauss 2015). A three-stage iterative process was followed for analysis: (1) an initial or open coding of interview data to identify relevant and frequent concepts, (2) the generation of conceptual categories and themes and (3) analysis of theoretical patterns and details. The researchers made use of Nvivo Pro Version 11 to store and organise the data and compare codes. Each case was first analysed separately before comparing the results of both cases.

Results

The results from both universities are combined in this section. This is because although the two universities operate in different cultural and geographic contexts, the results of each case in this study were broadly similar. The major difference in results was related to Internet access and technology adoption. While UOC is a completely online university, many programmes at UNISA are offered via traditional distance methods (paper-based) with supplementary online support. The first section of the results analyses the data obtained regarding devices, learning locations and learning activities. The next section analyses the data regarding how students make use of multiple devices for learning. While each student makes use of the technologies they have access to for learning in a way that suits them, certain patterns of learning emerged.

Devices

UOC students (n=18) had access to between three and five digital devices, while UNISA students (n=16) had access to between two and four devices. In total, each interviewee had a smartphone, while all but one interviewee had access to a laptop. Other devices included desktops, tablets and e-readers. All interviewees used at least one device regularly for learning, with the average being three devices used for learning.

Learning locations and activities

Interviewee data showed that digital devices were used in multiple locations for learning purposes, thus demonstrating the potential for seamless learning. These included private locations (such as at home) and public locations (such as at work, or in-transit). The use of different devices means that students are able to study in different locations and at different times. The portability of the device influences the locations where it is used for learning:

> I use the laptop because of the convenience. I'm usually in the dining room [at home], but if my daughter wants to watch the TV, I go to the kitchen. That is, with the laptop I can easily change my location of where I am learning. (Interview 1-10)

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> I use the smartphone when I'm out on public transport, during work breaks, at lunch-time, etc. I can continue studying on the public transport... For example, I can continue at the same point I stopped reading when I was at home. The mobile phone allows me to study anywhere anytime. (Interview 1-13)

> When I'm somewhere waiting for the bus, I start reading on the iPad… Sometimes when I'm travelling, I want to use my iPhone, instead of iPad so I can receive a call, I can be on the internet, and also I can save some files, downloaded from the internet to my iPhone and transfer it back to my computer or to my iPad. (Interview 2-14).

Interviewee data also showed that students use their devices for similar and different learning activities. Fixed devices, such as laptops and desktops, tend to be used for a wider variety of learning activities, such as reading study materials, watching videos, conducting research and doing assignments, whereas handheld devices, such as smartphones, tend to be used more for quickly checking information (such as results), although some students do use their phones to read materials or watch videos. These study habits are demonstrated in the following quotations:

> I do practically everything with the laptop and the PC, I do the assignments, I check the material and I do Internet searches. I use them to print material for reading the material in depth. (Interview 1-13)

> I basically use [the laptop] for doing my assignments mostly, because it's easier to type on, it's a lot easier to use. I use it for doing assignments, for going to the online portal and to obtain our textbooks. I use it for things like that. Also looking at interactive videos that our lecturer sends us. (Interview 2-02)

> Using my phone, I check my results now and then on myUnisa [the LMS]. As well as download any other PDF files should I require them, to read them at any given time, so I have them on my phone. (Interview 2-03)

Multiple device usage

Although students indicated that they mainly use one particular device for learning, they do sometimes use multiple devices together. Students use devices together in one of two ways, either sequentially or simultaneously. Sequential use refers to students starting a learning activity on one device and continuing or finishing the learning activity on a different device. Simultaneous use refers to students using two or more devices at the same time to perform a learning activity.

Sequential use

Interviewees were asked to explain how they used their devices sequentially for learning. Sixteen (89%) UOC students and 13 (81%) UNISA students interviewed described how they move from one device to another. The main types of sequential usage were found to be students moving between different locations, students moving to a different (but related) learning activity, continuing the same learning activity at a later stage and moving between devices because of device features. Table 1 illustrates these usage patterns together with student interview examples.

Table 1. Sequential use patterns and examples.

Sequential patterns	Devices used	Interview examples
Move from one location to another, such as from work to home	Tablet/laptop -> laptop/desktop	If I am working with my laptop or iPad outside home, once I arrive home and switch on the laptop or the home Mac I would be able to see the same page in which I was working on when I was outside home. (Interview 1-03)
	Desktop -> laptop	I'm looking at the time, maybe my assignment is due, I have to finish, so I will do part of it at work and as soon as I get home I continue where I left off. I do what I need to at home then I continue. (Interview 2-01)
Move from one related learning activity to another, such as reading materials and then starting to write	Laptop/desktop -> tablet	In my case I study law (court rulings and similar issues) so these documents are long to read, so what I usually do is I find it on the laptop or desktop PC and then I read it on the sofa with the tablet. (Interview 1-07)
	Smartphone -> laptop	With, say something a little more complex to understand, I would move from my smartphone to my laptop. To research it further, to be able to open a lot of tabs or whatever. (Interview 2-12)
Pause and continue the same learning activity at a later stage	Desktop -> laptop	Sometimes I come here to the desktop computer, work for a while… half an hour, three quarters of hour and then see that the progress has been almost none… and then I take the laptop and go to a different room. (Interview 1-12)
	Laptop -> tablet or smartphone	Having to work full-time and having a family, there are things you will need to do. I will always start with the Mac, but I could finish on the iPad or iPhone. I pretty much don't have a preference between the two. (Interview 2-09)
Move from one device to another because of device features (lack of battery or internet access)	Laptop -> tablet	Because usually I'm not using the computer for connection to the internet…To submit the assignment, I can take it from my laptop and transfer it to my iPad. From my iPad I can attach and send to UNISA for electronic assignment submission. (Interview 2-14)

Interviewees acknowledged that the reason they move from one device to another is for practical reasons, to make use of devices they have access to at that time or to take advantage of available time. Occasionally, students may have to study without Internet access and then later submit assignments when they have Internet access again:

> When I am at the library working on my assignments without Internet, what I do is work on my assignment at the library, afterwards, when I arrive home and make some corrections (if needed), I then submit my assignment through the UOC campus. (Interview 1-03)

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Simultaneous use

Interviewees were asked to explain how they used their devices simultaneously for learning. Eleven (61%) UOC students and 11 (69%) UNISA students interviewed described how they use two or more devices at the same time. The main activities performed simultaneously were found to be writing assignments together with searching for information or reading materials, watching a video and taking notes, writing an assignment and communicating with others and reading materials and searching for information. Table 2 illustrates these usage patterns together with student interview examples.

Interviewees acknowledged that the reason they use different devices for learning at the same time is because of efficiency. Students did not want to have to toggle between two windows on one computer, but wanted to be able to see the information on two screens at the same time. This means that students are able to undertake complementary activities in an easier way, as shown in the following quote:

> It's the ability to be able to multitask. I can have the library online, I can have the textbook I need to work from, either in PDF or in paper in front of me, and then the assignment or the paper I am working on, on the computers in front of me. (Interview 2-08)

Table 2. Simultaneous use patterns and examples.

Simultaneous patterns	Devices used	Interview examples
Write assignment and search for information/read materials	Tablet + laptop	An example would be to use the tablet as a device for reading (the subjects' PDFs) and being able to answer the different questions in the assignments on the laptop. (Interview 1-16)
	Laptop + tablet + smartphone	I would use the laptop and I would be typing up an essay. And I would use my tablet or my phone to either watch a video or look at the source documents. (Interview 2-02)
Watch a video and take notes	Tablet + desktop	If I'm watching a video I usually watch it on the tablet, then I use the computer for taking notes. (Interview 1-04)
	Laptop + tablet	It's mostly during exam periods. I actually sit and make the notes on the Mac, while watching videos and tutorials on the iPad. (Interview 2-09)
Write assignment and communicate with others	Tablet + desktop	I have the forum open on the tablet, the messages from teachers or information that the teachers send us through the forum while I am doing the work with the computer. (Interview 1-04)
	Laptop + smartphone	When I use them at the same time most of the time is when I'm doing assignments. When I have to look up something on the internet or I have to gather some information or I need to ask someone to help me explain what I don't understand over the social media. Then I do call them or I just send them a text and they help me out. (Interview 2-16)
Read materials and search for information	Tablet + smartphone	If I'm busy with the tablet, and I need an extra screen and I want to just cross-reference something that's on the article that I'm currently reading, I can do it off the cell phone. It's just to verify the data that's on the one. (Interview 2-11)

Cloud services and synchronisation

Interviewees affirmed that moving between devices is facilitated by the synchronisation of files using cloud services. The cloud is the key enabler for switching between devices as synchronisation is automatic and students can continue exactly from where they left off. Students make use of cloud services such as Google Drive or Dropbox, as shown in the following quote:

> But always taking into account that I have everything in the cloud, the books are in the cloud, the continuous assessments. As I have it in Google Drive, I don't mind from which device I'm accessing because everything is always at the point at which I left it before. (Interview 1-06)

However, for some students in South Africa (the UNISA case), Internet access and cloud services are expensive or inaccessible. Internet accessibility remains a challenge for some students who rely on mobile data. Similarly, some students rely on older technologies such as memory drives or email to manually synchronise their work across different devices. These patterns are illustrated in the following quotes:

> I don't have any other ways to access the internet. Just on my phone. I just buy airtime bundles and convert them to data. It's quite expensive. Because now and then you need to download the files as well as watch YouTube videos. (Interview 2-03)

> So I'll be running two simultaneous projects and I'll either copy my data onto Google Drive or I'll carry the data on a memory stick to the home computer. (Interview 2-15)

Discussion

While students at the two different ODL universities study in different contexts, several commonalities in the use of technologies for learning existed across both interview sets. The only real difference in study patterns was the limited access to (and relatively high cost of) quality Internet services for several students at the South African university. Although the use of one device at a time is more common, students at both universities make use of different devices at different times or locations to complete learning activities. More students used their devices sequentially than those who used multiple devices simultaneously. Students move between devices for practical reasons, to make use of devices they have access to at that time or at that location to take advantage of available time for study. They also move between portable and fixed devices, depending on their location. This is because students can use a larger device when in a stationary environment such as home, but usually have their smartphone with them at all times to use in various locations. Four patterns of sequential use for learning were identified: (1) students moving between different locations; (2) students moving to a different (but related) learning activity; (3) continuing the same learning activity at a later stage and (4) moving between devices because of device features. Students also sometimes make use of multiple devices at the same time for learning to be more efficient. They are able to view 'two screens' at the same time to perform complementary activities. Four patterns of simultaneous use for learning were identified: (1) writing assignments together with searching for information or reading materials; (2) watching a video and taking notes; (3) writing an assignment and communicating with others and (4) reading materials and searching

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for information. While few studies have explored students' use of multiple devices, these findings match an Australian campus university study about the use of tablets (Reid and Pechenkina 2016), which found that students tend to use their devices simultaneously and in a complementary manner, rather than using one device for all learning activities. A similar campus study of tablet usage found that students move between laptops and mobile phones based on the type of task that they want to perform (Green *et al*. 2016).

The movement between devices is facilitated by cloud services that facilitate automatic synchronisation. Students are able to act on an idea with immediacy, make adjustments to assignments or record or share ideas wherever they are located (Barden and Bygroves 2017). Useful tools for accessing and storing resources are the institutional LMS, Google Drive and Dropbox. While cloud services are useful for students, because of Internet accessibility or cost issues, they are not used by all students, particularly in the South African context. Some students rely on older technologies such as email or memory drives to move information between devices.

The use of multiple devices (both fixed and handheld devices), supported by cloud services, has made it possible to achieve the aspiration of seamless learning. Students are able to learn across physical places and virtual spaces. Many students are able to learn in different contexts, but, more importantly, are able to maintain or continue their learning across contexts. However, this does mean a minority of students currently cannot yet learn seamlessly. The results from this study have led to the proposal of a continuum for seamless learners, as shown in Figure 1. Individual students may place themselves at a particular point along the continuum, rather than at one end. Some students are able to more easily achieve seamless learning (seamless learners), while the learning of other students has clear 'seams' (discontinuous learners). While the use of multiple devices has positively affected the study habits of some students, the study habits of some students have been affected to a lesser extent.

Students who are able to learn more seamlessly typically make use of multiple devices for study and make use of automatic synchronisation and cloud services to easily move across devices, locations, times and learning activities. At this end of the continuum, quality and affordable Internet access can be taken as a given for students. In addition to device access and connectivity, learner characteristics and preferences affect the degree of seamless learning. Some students feel more comfortable using many different types of technologies for learning, while other students

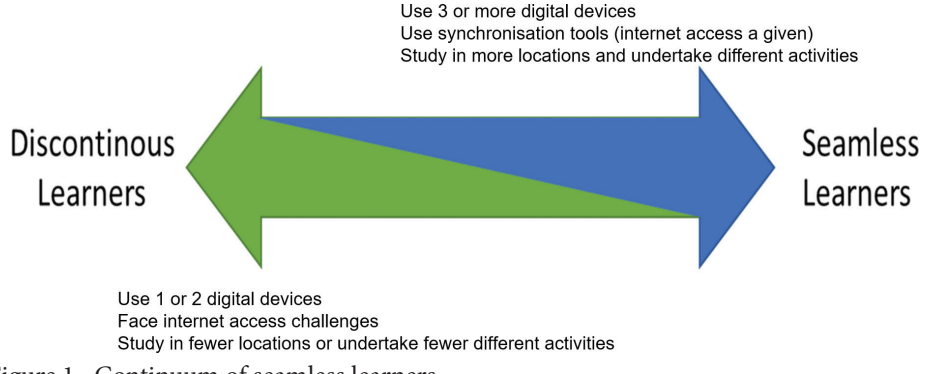

Figure 1. Continuum of seamless learners.

prefer to stick to the technologies they know. Furthermore, seamless learners tend to study in a wider variety of locations and may undertake many different types of learning activities in these locations. At the other end of the continuum, discontinuous students are not able to learn seamlessly and move with great difficulty across devices, locations, times and learning activities. These learners typically have access to only one or two devices and Internet access is intermittent or expensive. These students rely on older technologies (like memory drives) to manually synchronise across devices. They may also study in fewer locations or use their devices only for specific learning activities. However, more representative of ODL learners is that their learning patterns are likely to exist at various points between the two ends of the continuum. Furthermore, the position of each student will move along the continuum, depending on their location, the learning objective they intend to achieve and the device(s) and tool(s) they are using at a particular point in time. In supporting students, educators and ODL universities need to recognise that students in a particular course may exist across this continuum and that students need to be supported in different ways. For example, some students may struggle with access to devices and connectivity. In supporting students, educators and ODL universities need to recognise that students learn in different contexts and with various levels of technology use and need to be supported in different and personalised ways. These contexts include a variety of learning activities, devices, locations and times. Therefore, educators may need to develop more flexible and effective pedagogies to support 'anytime, anywhere' learning (Cross *et al*. 2019).

Conclusion

This study explored how students' use of multiple devices affects their learning patterns. Universities are seeking insights into the study habits of students using different devices, particularly handheld devices, and the impact on learning (Cross, Sharples and Healing 2016). The aim of this study was to explore how undergraduate ODL students make use of different devices together, both fixed and handheld devices. The research study made use of a qualitative approach to interview students at two ODL universities in two different contexts. ODL students were found to sometimes use their digital devices together to be more efficient or take advantage of available devices or time. Two patterns of using devices together for learning were explored, either sequential or simultaneous use. A continuum of seamless learners was proposed that can be used to determine how easily students are able to learn seamlessly, based on their contexts and practices. An area for future research is how educators can better support students using multiple devices and how to reduce any potential 'seams' in their learning experiences. This study has contributed towards the understanding of the educational value of technologies and how they support learning, specifically how students use multiple devices, together with supporting technologies, to support their learning. A greater understanding can inform improved educational practices (Margaryan et al. 2011).

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Appendix A: Interview Protocol

Student Code:	Interview Date/Time:
Interviewer:	Interview Tool:

1. Which digital devices do you have access to?
2. Use of a desktop or laptop:
   a. If you learn with a desktop or laptop, please give me one or more examples of how you use it for your learning?
   b. If you have it, but do not use it for learning, why not?
3. Use of a mobile phone or tablet:
   a. If you learn with a mobile phone or tablet, please give me one or more examples of how you use it for your learning/?
   b. If you have it, but do not use it for learning, why not?
4. In what contexts (places) do you use your different devices?
5. How do you access the internet for your studies?
6. If you use more than one device for learning, can you explain why you choose a specific device to perform learning tasks?
7. Do you ever move from one device to a different to complete a learning activity? If so, please provide examples.
8. Do you ever complete a learning activity using two or more devices at the same time? If so, please provide examples.
9. When you have a challenge or issue completing a learning task or while studying, what do you do?
10. When you have a technical problem related to your studies, what do you do?
11. What do you see as the most important tools, technologies or services for your learning?
12. If you think about your study habits, how have they changed since you started using the different devices that you have available to you?
13. Any general comments?