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## The impact of technology on the teaching and assessment of 'systems' diagrams in two online environmental management modules

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## **The impact of technology on the teaching and assessment of ‘systems’ diagrams in two online environmental management modules**

### ***Abstract***

Diagramming is a creative process where the context and tools used to create the diagram may hinder or help students in learning how to create diagrams that represent a situation and how to learn about diagramming and the situation at the same time. These tools equally provide opportunities and challenges to tutors in teaching and assessing these diagrams and providing feedback, particularly for students studying at a distance. There is a long history of teaching ‘systems’ diagramming as a ‘thinking and doing’ technique at The Open University in the UK and of evaluating the mediating effect of technologies on this technique. A recent manifestation of teaching ‘systems’ diagramming has been in two mainly online undergraduate modules dealing with environmental management, where students share diagrams with other students throughout the duration of the module, have to work collaboratively on diagrams in small groups for one part of the module and include diagrams in all assignments. This paper reports on analyses of student postings in online forums; on samples of assignments with specific questions about diagramming as a practice; an online survey of students who studied one or both of the modules; and telephone interviews with a small sample of students and tutors. The study looked at students’ experiences of using diagrams before, during and outside their study of both modules to better understand the main factors that influence their educational value, in particular the part that familiarity, experience and confidence in the technique and the technology played in supporting learning and whether the act of sharing helped or hinders that learning.

Key words: diagrams; technology; teaching and assessment; systems

### ***Introduction***

Much of the literature on diagramming in relation to teaching and learning in science, technology, engineering and mathematics (STEM) focuses on how students can learn from visual representations (Blackwell, 1997; Carter, 2012; Eitel et al., 2013). While developing students’ visual literacy in being able to read and decode meanings from particular diagrams, either on their own or in combination with text is important, this literacy also needs to extend to being able to ‘write’ and encode meanings within diagrams they produce for themselves. Many of the diagrams used in STEM can also be particular to the subject discipline and context in which they are being used. The teaching and assessment of diagrams as a key skill is influenced by the students’ familiarity (or not) with both the technique (what to draw and when to draw it) and the technology (how to draw and how to share the diagram with others).

This paper reports on a study undertaken with students and tutors involved in two distance taught modules at the Open University UK (OU UK). The purpose of the study was to understand better the various factors that helped or hindered students in learning how to draw ‘systems’ diagrams (and tutors in teaching and assessing these diagrams) and in particular the role technology played in supporting that teaching, learning and assessment of diagrams. It firstly provides the historical and current context for the study before outlining the multi-mode research methodology. It then details the various qualitative results and findings illustrated by quotes from students and tutors before concluding that technology is at best an enabler but not an enhancer for teaching and learning this particular practical technique at a distance, and for some students the technology can be a barrier to their learning.

### ***Historical and current context***

There are some disciplines where creating and sharing diagrams can be important for sense-making, evaluation and communication, such that they form a significant

part of some programmes of study that students have to learn about. Systems thinking and practice is one such discipline where diagramming, as a form of representing peoples' perspectives on particular situations, is considered important; and equally it is a discipline that has mostly been applied to managing complex or messy situations in which people are trying to take action (Checkland, 1999; Reynolds and Holwell, 2010); and unsurprisingly has been extensively applied to managing contested environmental situations where knowledge and skills drawn from science, technology, engineering and social science can all play a part (e.g. Seiffert and Loch, 2005; Ison, 2010).

There is a long history at the OUUK of teaching systems thinking in practice (Lane, 1999; 2013) and of applying it to environmental situations and sustainability (Blackmore et al, 2015) although it is by no means unique in doing so (Karlson et al., 2000). However it is unique in that it has largely been doing so through open and distance teaching and learning. Open and distance teaching and learning of practical subjects and skills is challenging in many ways. Firstly, open entry, that is, registration without the need for prior qualifications, leads to students of mixed backgrounds and abilities. Second, learning at a distance, in the home or at work, may lead to issues of access to necessary technical equipment and also obstacles to collaborating with fellow students on particular activities. Thirdly, in a classroom setting, unlike at a distance, it is possible to use very low tech means (pens and paper) for individual students or group of students to collectively (and synchronously) create, share and discuss diagrammatic representations of complex or messy situations. Fourthly, for distance learners distributed through time (zones) and (geographical) spaces around the world similar activities rely on the appropriate use of information and communication technologies. Furthermore, whereas a classroom based cohort in a traditional university largely involves interactions between a single teacher and a relatively small group of full time students taking one, possibly two, related degrees, a distance learning module at the OUUK has a large population in the hundreds, with students taking the module part time as one component of different qualifications, and with groups of 20-25 students allocated to a tutor (known as an Associate Lecturer) who provides direct tuition and marks assignments that supplements and supports the teaching embodied within the module's multimedia educational resources.

In the past The OUUK relied on the postal system for students to submit their assignments, including hand drawn diagrams relevant to that assignment. Some students were also able to practice drawing diagrams individually and collectively in optional face to face tutorials (the geographical and temporal availability and accessibility of such tutorials has diminished in recent years). All students on some modules could also attend a one week residential school where they could have extensive involvement in creating, sharing and debating diagrams. However few residential schools are now run as costs of running them and demands on students' time, many of whom are in full time work and face difficulties in attending, made them unviable parts of the curriculum except for subjects requiring the use of specialist scientific or technical equipment in laboratories, workshops or in the field.

From the 1990s onwards the widespread adoption of personal computers and the emergence of the internet (in particular the World Wide Web) began changing the ways in which distance learners could create and share their diagrams. Firstly they could use graphical packages to produce diagrams to include in assignments. Second, the teaching and learning of diagramming as a skill that had been principally done through static text based material (sometimes with audio or video elements) could be supplemented and strengthened by being presented in dynamic interactive

media (Lane and Morris, 2001; Lane, 2013)<sup>1</sup>. Previous research conducted at the OUUK in 2003 has shown that:

*'students on a distance taught systems module preferred to learn diagramming in face to face situations as part of a group even though that was the least used mode. However, learning diagramming by themselves through a mix of technology mediated modes was not seen as substantially less valuable. Both print and web based teaching modes were the most popular in terms of use by the students.'* (Lane, 2013 p 328).

That study examined a module where some of the teaching materials and interactions between students involved use of information and communication technologies (there were also some face to face tutorials); and although students had to include diagrams in their assignments these could be either hand drawn or produced using a computer based drawing package, since assignments were still being submitted by post.

This paper reports on a study conducted in 2015 on two new, almost wholly online, modules from the OUUK on environmental management, where systems thinking and practice, particularly diagramming, is a defining feature. As well as nearly all the teaching materials being online, all interactions between students and tutors were online, and students had to undertake a significant group task online. Their assignments also had to be submitted online and so any diagram had to be in a digital format. These changed circumstances offered an opportunity to revisit the role and impact of information and communication technologies on the teaching and learning of systems diagrams.

The focus of this study was mainly on the experiences and perspectives of students, supplemented by those of three tutors, within two related modules dealing with environmental management studied at the equivalent of the second and third year of a three year honours degree (namely T219 Environmental management 1 and T319 Environmental management 2 respectively). These two 30 credit modules are core components of a 360 credit BSc in Environmental management and technology<sup>2</sup>; but they are also optional modules within a BA in Environmental Studies, a BEng (Bachelor of Engineering), and also within the OUUK's unique BA/BSc Open degree whereby students are free to choose which modules they take for each level (equivalent to year) of study. Furthermore, as students can choose their study intensity to suit their own situation, some will only be studying one module at any one time while others may be studying two or rarely three at the same time<sup>3</sup>.

The two modules have a similar structure and philosophy as well as approaches to teaching, learning and assessment. The 300 hours of notional study time for each module are broken down into three blocks of 100 hours, with the modules running for nine months starting in October. The first block looks at issues related to environmental management at the domestic or household context; the second deals with environmental management within organisations; and the third covers environmental management within community settings. Each module uses systems thinking and practice, including the use of diagramming, as a key toolset alongside an action learning model. Throughout each block there are a number of online activities, many of which include producing diagrams and sharing them with their tutor group or the whole module cohort through a technical application called the

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<sup>1</sup> A current example of this is the free [Guide to Diagrams](#) available on the OUUK's OpenLearn website.

<sup>2</sup> A full degree requires 360 credits; with 120 credits gained at each level.

<sup>3</sup> While a few students may study at full time intensity all OU UK students are classified as studying part-time in official statistics.

Display Wall<sup>4</sup>, and at the end of each block there is a tutor marked assignment (TMA), which again requires the inclusion of diagrams as part of the assignment. The third block requires smaller groups within each tutor group to spend 6-8 weeks on a group activity that informs the third TMA (while the activity is done in groups, students produce individual TMAs but have to reflect on the group process). Finally, students have to produce an end of module assignment (EMA) which once again requires the inclusion of a number of diagrams.

There is a consistent set of 'systems' diagrams taught within each module, which students have to both learn and apply. Some they might have met before in their studies or even in their working lives but for most students mastering the purpose, value and technicalities of this set of diagrams in themselves represents a significant outcome of the modules. The set of 'systems diagrams' is:

- Spray diagrams
- Systems maps
- Influence diagrams
- Causal loop diagrams
- Rich pictures

In calling these 'systems' diagrams the module teams were not claiming that these diagrams necessarily originated with the discipline of systems thinking itself, nor that they are unique to that discipline. They are being called 'systems' diagrams because they are diagrams that are regularly used as ways of thinking about and representing aspects of complex systems and are key features of systems approaches to managing complexity where situations are looked at as if they were a system from the perspective of those people creating the diagrams (Armson, 2011; Checkland, 1999)<sup>5</sup>. The teaching of diagramming as a technique is covered statically in a slim printed Resource Book and dynamically in an online Resource Bank<sup>6</sup> while all the remaining online teaching materials themselves include many examples of diagrams as applied to environmental management situations.

T219 was first presented in October 2013 and T319 in October 2014. This study primarily relates to students taking the October 2014 presentations of both modules, although some references will be made to other presentations where appropriate. There were 277 and 135 students who started T219 and T319 respectively in October 2014 and 171 and 94 who completed the module (the many reasons for non-completion are not the focus of this study, including the 29 and 5 respectively who deferred their studies during this presentation to a subsequent presentation, but it is important to note that the surveys only involve students who have completed the modules). Of the 135 students on T319 starting in October 2014 44 had taken the first presentation of T219 in October 2013 while seven students started both modules concurrently in October 2014. These student cohorts had 35-40% women and were variously studying towards the four different qualifications noted above. The student's' ages ranged from 18 to 70 although most fell in the 25-45 age range, with the majority in some form of paid work.

### ***Research methodology***

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<sup>4</sup> This is essentially like the photo sharing site Flickr

<sup>5</sup> Free resources explaining systems thinking and systems diagrams as taught at the OUUK can be found on the OUUK's OpenLearn website at <http://www.open.edu/openlearn/science-maths-technology/computing-and-ict/systems-computer/systems-thinking-and-practice/content-section-0> and <http://www.open.edu/openlearn/science-maths-technology/computing-and-ict/systems-computer/systems-diagramming/content-section-0>

<sup>6</sup> Although reference is also made to the free Guide to Diagrams mentioned earlier

The purpose of this study was to better understand the many factors influencing the experiences and perspectives of students (and tutors) with 'systems' diagrams in these two modules. It was therefore decided that qualitative data should be collected by different means in order to have results that both reflect the voices of the students and be able to triangulate the findings from these different sources. Much of the data was collected in the four months after the modules had finished. It was decided to do this post hoc data collection rather than during the presentations so as not to have any impact on the students' studies, although it is recognised that perspectives and recall may change over time. It was also decided not to collect or use any personal data on the students sampled within the analyses beyond knowing which module(s) they had studied as the prime aim was to thematically analyse the data for its qualitative aspects and not its quantitative aspects and to build up a representative picture by triangulating the analyses of the different data sources (although some inferences are made based on the student population characteristics outlined above).

First, both modules' online forums were examined to see if there were any conversation threads that involved diagramming and to analyse what the substance of those conversations was.

Second, the EMA for T219 had a part of one question that asked: 'Write a short commentary on your experiences (both positive and negative) of using systems diagrams in making sense of environmental management situations'. A semi-random sample of 58 of these 171 EMA answers were examined and analysed.

Third, a short online survey of 233 students who had studied T219 and/or T319 was administered by the OUUK's Student Statistics and Survey Team. This questionnaire involved 9 questions of which 8 mainly asked for free text responses. 42 responses were received, 30 where all answers were completed and 12 incomplete responses, giving a response rate of 18.0%. The Survey Team then provided a spreadsheet containing all the raw data from the respondents as well as a pdf copy to enable thematic analysis.

Fourth, a sample of six students from the 12 who had agreed to do a follow up interview within the online survey were contacted and interviewed by a freelance educational researcher. The students were asked six questions by telephone, their responses being recorded and then transcribed before being thematically analysed.

Fifth, three tutors from T219 and T319 nominated by the respective module team chairs, were also interviewed by telephone by the freelance educational researcher. They were asked a separate set of six questions with their responses also being recorded and then transcribed before being thematically analysed.

### ***Results and discussion***

What follows is a summary of the findings for each of the data sources noted above with quotations<sup>7</sup> from those sources exemplifying the findings. Together these provide a set of narrative themes on the perceived impact of technology on the teaching, learning and assessment of 'systems' diagrams.

#### Module forums

Diagrams and diagramming was not a significant topic in any of the forums in any of the presentations and generally formed between 5 and 10% of the discussion threads. No single thread involved more than 10 postings and most were under six

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<sup>7</sup> The textual quotes from participants in this research study are presented verbatim, including any spelling, punctuation or grammatical errors, as these do not affect the meaning of the quotes but ensure authenticity of this dataset for readers

postings. Almost all the threads on diagrams fell into one of three fairly equal categories:

1) Queries from students about the 'rules' around drawing diagrams in the modules and for assignments:

*I have been experimenting with rich pictures and enjoy drawing them. However, I have tried doing one using cartoons and images off the internet and really enjoyed the approach. Can I use this approach in TMA's? and if so are there any conventions I need to follow ?* (Student from T219 13J)

2) Queries from students about the technical aspects of creating digital versions of diagrams for including in assignments or posting to the Display Wall:

*For drawing rich pictures I've been able to borrow my daughter's iPad (very occasionally!) and I used an app called Penultimate.*

*For all the other diagrams I've used a free trial of Inspiration (free for 30 days). It makes it really easy to draw and link the components within the diagram. I was also told about Microsoft Visio but in true Microsoft fashion it's a nightmare to use and nowhere near as good as Inspiration though that is just my opinion! I did follow the tutorial in Inspiration so maybe I should try the same for Visio! Previously I was using Power Point and taking a screen shot but Inspiration is much faster and easier.* (Student from T219 14J)

3) Sharing of found or self-generated diagrams on environmental topics by students and AL moderators, often but not always in the styles used in the module.

#### T219 End of Module Assignment answers

The 58 answers sampled were copied and pasted into a word document and coded A, B, C through to Z, then AA through to ZZ, and finally AAA through to GGG. They were then examined and categorised for two aspects. The first was the predominant narrative approach used; the second was for particular issues to do with the process of diagramming.

The question was designed to get a personal reflection on the students' experiences of diagramming, both good and bad, and yet the narratives used in the answers was surprisingly varied. Six sets of narrative types were identified, five of which provide a spectrum from the very positive to the very negative responses. These are described below.

At one extreme is the 'sceptic' (n=2; 3.4%) where the students did not find the diagramming at all useful:

*My overall experience of systems diagrams has not been a positive. Systems diagrams do not allow me to be or feel natural in communicating my thinking effectively as I should be and therefore I struggle when trying to fulfil my sense making of environmental management situations. Systems diagrams feel like a forced and channelled method of expressing this, hampering/suppressing my creative and freethinking flow.* (Answer VV)

The fact there are so few sceptics could be influenced by few wanting to take such a negative line in an EMA on a module which promotes diagramming plus it could be that there were fewer sceptics amongst completers because they were more likely to have withdrawn from the module because of their views on, and difficulties with, diagramming as a thinking and communicating technique.

Next are the 'sceptical converts' (n=15; 25.9%) who initially expressed being wary of or unconvinced of the value of diagrams but who recognised their usefulness by the end of the module and were now generally positive:

*I have found the process of using system diagrams quite challenging to learn as a process due to the fact that this style and form of presenting data was an alien way of working for me. I have however found the experience very valuable and the skills that have been learnt will be put into practice and used going into the future with in my present line of work. (Answer M)*

*I found drawing multiple diagrams to be tedious, particularly as I had to learn how to use new software to enable me to draw them. I persevered and gradually they started to make sense, showing me why they are valuable in analysing and interpreting an environmental management situation. They help to focus on the issue and help to highlight potential problems. (Answer AA)*

Close to the sceptical converts are those with 'mixed responses' (n=14; 24.1%). These students detailed what they liked and did not like (as might be expected from the question) but did not portray such a strong negative attitude from the outset nor be as strongly positive at the end:

*My experiences of using systems diagrams has been varied but most importantly I have come to understand the importance of them when making sense of E.M situations especially when working with people (Answer KK)*

*I can't say that I have found using diagrams easy and at times immensely frustrating, although some made more sense than others. (Answer UU)*

At the other end of the spectrum were the 'enthusiasts' (n=16; 27.6%), who provided an overall positive account of their experiences with diagrams and any doubts were over the time needed to create them or technical issues with creating them:

*I generally had a positive approach to systems diagrams; I found they clarified situations in my mind; they helped me understand case studies better for example. I like how they can break things down into component parts; and can link seemingly unrelated issues to a common factor. (Answer S)*

*The use of systems diagrams in the course has been highly beneficial to my personal understanding of both particular case studies and course content as a whole. (Answer CCC)*

The fifth narrative set, 'the party line' (n=11; 19.0%) are largely sub sets of both the enthusiasts and mixed responses in that they exhibit features of those narratives but are written in a more abstract and impersonal way, in effect repeating what was said in the module material rather than providing a personal reflection:

*Systems diagrams help to focus on the specifics of environmental management situations such as the specific systems they affect and what lies within those systems. However this can also be a negative as the system boundary and the context has to be broken down into smaller subsystems to identify these. (Answer H)*

*Systems diagrams are invaluable tools in understanding environmental situations. They help to make sense of situations by capturing them all in one diagram. They are also extremely flexible because they can be applied to any situation. (Answer R)*

Finally, there was a small number who 'answered a different question' (n=2; 3.4%) in that they focussed on systems thinking more than diagramming:

*Systems thinking was more difficult for me than environmental management. I found the diagrams straightforward to draw, and I understood what they represented. But what took time and effort to master was applying the module's systems thinking approach to environmental management. (Answer I)*



These narrative types offer an insight into students' perceptions of diagramming as a technique within the study of environmental management largely separate from issues of the use of technology (although one of the quotes does raise technology as an issue). However, as well as these narrative types there were three other issues which were each present in around ten of the students' answers. The first of these was students professing an 'inability or lack of confidence in drawing':

*As someone who doesn't draw or have any past experience of using diagramming I initially found the use of systems diagrams to be a challenge. (Answer V)*

*Initially I found it hard to use diagrams as I was never really a visual learner, I liked to just write down bullet points. (Answer RR)*

*Certain ones I didn't engage with as much such as rich pictures. This is possibly due to my own embarrassment of how bad my drawing is, or just that I felt it didn't create a picture of the situation as clearly as others did. (Answer YY)*

The second issue was about how 'time consuming' drawing diagrams could be:

*I found working with systems maps problematic due to difficulties in making decisions about what to/to not include within the system boundaries. This became time consuming as having to often change boundaries but the end result was a more accurate reflection of the situation. (Answer L)*

*In block 1 the early rich pictures I drew took a considerable length of time and I found it frustrating thinking I could have typed up a list to convey the same points in less time. (Answer V)*

The third issue revolved around 'group working'. In most cases the students said how much better they found doing diagrams in groups rather than individually:

*I enjoyed the group work as I felt it simulated as closely as possible diagramming in a real situation. I didn't appreciate until the 'water stories' how diagramming can convey information to a wide group of people, enabling them to work together. (Answer G)*

*However by the time we got to the group activity I could really appreciate the benefits of rich pictures as a way of making sense of an environmental management situation. The way we pulled our individual rich pictures to produce one collective vision was invaluable throughout the task. (Answer V)*

Nevertheless, one or two students' answers noted downsides to group work:

*In this module the only downside I found was reluctance of some students to share their diagrams with the group. (Answer D)*

Overall, these findings indicate that the value of systems diagrams in environmental management can be successfully taught online but not everyone takes to this form of representation whether through inclination or ability, that learning about diagrams and diagramming is a challenging and time consuming process and that collective approaches (i.e. diagramming in groups) may be beneficial. None of this is surprising and mostly fits in with previous research in this area (Lane, 2013). The one question that these findings do not answer is the role and impact of information and communication technologies on their views, which is why it was the primary focus of the online surveys.

#### T219/T319 online survey

Of the 42 respondents to the online survey questions 73.8% had taken T219 and 38.1% T319 (with 11.9% having taken both; hence a total greater than 100%).

Similarly, 40.5% had used systems diagrams before studying the modules (and 59.5% had not).

#### *Prior use of diagrams*

Of those that had used diagrams before studying the module(s) 8 out of 17 (47.1%) had done so when studying other modules or courses and 7 (41.2%) had done so through their work. For some it was not clear whether it was through studies or work as they mentioned a topic only.

#### *Reactions to having to use diagrams*

The reactions of those who had not used systems diagrams before can largely be grouped into the four main categories found in the T219 EMA answers: enthusiasts, sceptics, sceptical converts and mixed responders (and thus providing a useful comparison with the EMA answers).

There were five 'enthusiasts' among the 25 responses (25.0%):

*I found the study materials clearly explained the function of and how to create the various systems diagrams.*

There were also three 'sceptics' (12.0%)

*Wasn't too interested in this aspect of the course - it felt like forcing ideas to conform to a certain scheme/format. While it helped with exploring some new ideas in the diagram, for myself at least the overall time and effort did not seem to be worth the end results.*

The majority (ten) were 'sceptical converts' (40.0%):

*Curiosity followed by confusion and frustration as to how to draw in an electronic format. A little angst as to the time required to complete a diagram followed by a lingering doubt of "am I happy with it?" However, the process of constructing the diagram, including multiple re-draws, gave clarification to my own ideas and was quite enlightening. I now use them for all sorts of everyday applications and find them especially useful when trying to explain complicated situations.*

A further four gave more 'mixed responses' (16.0%).

It is clear that relevance, confidence in drawing ability and role of technology are consistent themes in these comments.

#### *Use of technology*

Most of the 30 responses focused on the use of technology to create and submit diagrams but a small number (six; 20.0%) focused on broader issues:

*As the entirety of T219 was presented online there is little distinction between use of technology for studying and assignments. The gallery where we were supposed to upload our diagrams was ineffective as a collaborative learnign tool as no-one commented on posts, despite requests for feedback. We were encouraged to draw diagrams freehand rather than to use clipart for rich pictures but this was ignored in our group rich picture task. I would scan freehand drawn systems maps and pictures for upload into assignments. Freehand allowed me to observe my personal interpretation more clearly. Mostly my experinece of technology within this course was negative and reduced the enjoyment and effectiveness of the learning. All course reading was online which drastically reduces capacity to interact with the text. It also reduced my capacity to refer back to find and check information. It neither had my notes and marks as guides or any physical sense of how far along in the course a particualr page had appeared.*

Of the remaining 25 the biggest number (eleven; 44.0%) hand drew and then scanned their diagrams, often following advice:

*I hand drew the diagrams as I found this fastest and easiest. It was trial and error related to how effective the diagrams were in relation to the situation being assessed. Lots of drafts sometimes. Didn't have the time or patience for fiddling around with software that I had to hunt around for myself.*

While another two (8.0%) hand drew their diagrams and then photographed them through a lack of a scanner, and which was troublesome:

*Overall this meant that the learning process was lengthened and created a frustration, The theory was fine, but the practicalities were a pain.*

A further eight (32.0%) only used their computer to create their diagrams, although sometimes with difficulties:

*I hated the process of drawing electronically. I struggled to find a piece of software that I could draw effectively and quickly. I'm also a bit of a luddite with technology and found this aspect frustrating. A little more tuition in this area would have assisted me greatly.*

Four students (16.0%) did a mix of both hand drawn and computer drawn diagrams although 3 of those 4 switched from hand drawn to computer drawn; while the use of technology was particularly a problem for students with disabilities:

*As I said, I had to use assistive technology and software to enable me to draw the diagrams as I find holding a pen for writing quite difficult. Once I learnt how to use the software drawing the diagrams was fairly easy. I would've preferred to use a pen though as it's more natural and your thoughts flow more easily when you're writing. I started off trying to use the iPad with an app my tutor recommended but it was quite frustrating having to email everything to myself and working from a smaller screen.*

The overall picture from these findings is one of technology enabling learning in the context of a wholly online module but not necessarily of enhancing learning due to many factors. In fact it could be argued that the necessity to use technology was disabling for some in that the difficulties experienced when using technologies severely impacted on their ability to learn about and learn from drawing diagrams to help with understanding complex environmental management situations.

### *Sharing diagrams*

The responses (n=30) to the question - *What did you feel about sharing diagrams with fellow students and did that help your studies?* - fell into four groups: those with only positive reactions, those with only negative reactions, those with mixed reactions and finally those who were initially negative and became positive (and could be seen as a subset of the mixed reactions).

Those with 'positive' reactions (n=10; 33.3%) tended to give short, sharp responses:

*I enjoyed looking at others work to get ideas to aid my own diagrams, and I was happy for people to look at mine and gain the same insight.*

Those with 'negative' reactions (n=6; 20.0%) could be equally blunt (*Did not gain anything from sharing*) but most spoke about technical problems or poorly functioning groups:

*The gallery where we were supposed to upload our diagrams was ineffective as a collaborative learning tool as no-one commented on posts, despite requests for feedback. This site also became an obstruction to learning when working on the collaborative task as students posted their diagrams here*

*while others posted them as attachments to conversation threads. Posting diagrams here did not contribute to my learning about the course content. I ceased to use it eventually as it provided no additional benefits. The navigation was clunky and the smiley/sad face indicator useless.*

Those with 'mixed reactions' (n=10; 33.3%) generally could see value in sharing but technical or group issues spoiled their experiences:

*I can see the point of sharing diagrams with the students as a means of exchanging thoughts and ideas and in order to give one confidence that you are on generally the right track. I do not like the use of smiling/unhappy faces to signal progress towards completion of the required number of images, I think people with busy lives could easily be put off by this.*

And as noted above there were 3 students (10.0%) who were initially sceptical but changed their minds as their studies progressed and their confidence grew:

*I was a little reluctant at first as I thought my diagrams were a little inferior but once I gained confidence in creating the diagrams I was happy to share. Seeing other students diagrams also helped at times to see that I was heading in the right direction.*

#### *Tuition and feedback*

The final area explored around their study of the two modules was the students' views on tuition and feedback about diagrams from their tutor (n=30). Seven (23.3%) were very positive about their experiences:

*Both were excellent. The feedback helped me to improve and was very useful during the EMA. The tuition was helpful and often having someone to bounce your ideas off was useful and enabled you to work through to your own answer.)*

14 (46.7%) were negative about their experiences:

*There was little feedback during tuition and the TMAs*

While one or two noted that their response was influenced by their tutor's personal circumstances the majority were not happy with the nature and type of feedback. This is also seen in the fact that the remaining seven (23.3%) students had more mixed views:

*The tuition could have been better with live examples during tutorials and the feedback on the display wall examples from memory was very little. TMA feedback was better but with only three TMAs, learning by doing and getting feedback doesn't work well. Face to face tutorials would have been much better.*

The impression is that many students were struggling with these unfamiliar modes of presenting their work and that neither the teaching materials nor the tutor feedback were helpful:

*Tuition was negligible and feedback almost useless, being generic and often took the form of 'see my notes' which were a list of hyperlinks back to the course pages and these hyperlinks didn't work. If I have failed to apprehend a point of learning from my first reading, providing the page for me to read again is likely to be ineffective then too.*

#### *Using diagrams in the future*

The responses to the questions looked also far generally paint a picture of most students being happy with diagrams and diagramming but with a significant minority not at all happy with both, although even the happy students had complaints about

some aspects – the time consuming effects, the problems with technology and sharing, and inadequate levels of tuition and feedback. It was therefore surprising to find that 86.7% (26 out of 30) said they would use systems diagrams in future:

*I now use systems and spray diagrams along with rich pictures in my day to day work. I run continuous improvement workshops and find these methods well accepted by the attendees.*

*I am already using them. I am involved in several local projects including bringing BB to rural areas and encouraging local use of renewables. System diagrams have helped both to inform and motivate.*

The four (13.3%) who said they would not use them again were inevitably sceptical of their value:

*because i don't understand them, didn't find them helpful or useful, found them complicated and time consuming and i don't see a place in my future studies or career for them*

### Student telephone interviews

These interviews were designed to get lengthier responses than could be expected from respondents in the online survey. Unsurprisingly, the responses of these six students largely reflect the many issues and aspects noted above but do provide a little more detail on some key areas.

First, there was an outright sceptic among the six:

*It was so disappointing. It was the only course that I have done from the OU that... I mean if that was the first course that I did I would never do another OU course. I don't understand why, I just don't understand how you can put it on and I can't believe that everybody else's feedback isn't the same but I understand that it isn't. Weird.*

The others were more positive but one did highlight a related issue of perceived identity for the module(s):

*I found it quite difficult at times to know what the course wanted. I thought at times the course didn't know itself what it wanted, whether it wanted to be sort of technical in terms of the environmental action plans and LCAs and what have you, and the technical side of the various systems diagrams or whether it wanted more of the what I call the flowery waffle language in terms of thinking about thinking and putting honest philosophical viewpoints across.*

In addition to this potential issue of confusion as to the nature of the module content it looks as if other factors may have contributed to difficulties that some (many?) students faced, particularly that the modules were seen as time consuming:

*Also the other thing I found in the course generally; the amount of reading material, the material that you actually read through was, compared to other courses that I have done, excessive I thought. It was just difficult to get to... you had to get all the reading done that you needed to and cover all the various exercises and that that you were doing as you went along so the course became very very intensive and I know from comments on the forums during the course, from other students, they also found the same thing; the course content was rather heavy.*

The online delivery of the modules added to this sense of heavy workload and difficulty in keeping up with the work as noted in these two quotes:

*[...] what I found was going through the course, that there was a lot of... on any particular part of the course there was a lot of sidelines that you had you*

*click on to and then read. What I found was that doing that you started to get slightly disjointed and in particular, later on when you are looking at doing the EMA and that, was trying to backtrack and find out where this information was. It wasn't on the main text but on a subtext and this made it very very difficult to collate.*

Looking more specifically at diagramming the general dislike of online delivery (and love of the one printed item) was not just confined to the main teaching material. Students were not generally happy with online tutorials (particularly in comparison to face to face tutorials), while the means of sharing and commenting on diagrams did not work well:

*I think course actually needs, you need to have written text books. I appreciate the environmental aspects of printing all this stuff and the fact that it all becomes out of date, which will solve that by having it online, taught on line, but it is a very complicated course and I think you need to have a paper in front of you to understand it.*

[...]

*I actually thought the resource book was probably the thing that helped me the most because it was fairly succinct and it had got lots of examples in it of how systems diagrams... first of all how systems thinking works and why it is important and second how systems diagrams need to be put together.*

#### Associate Lecturer telephone interviews

Finally, this section triangulates the key themes from the interviews with the three Associate Lecturers (tutors) with those above from students.

#### *Teaching diagramming*

These three tutors had varying prior experience of diagramming before being appointed to these modules but all are very keen on their use in environmental management. However, their views on how systems diagrams are taught in the modules spans all the mixed bag of issues already covered above, from the technical to the conceptual:

*I think they are extremely difficult to teach online, distance learning wise because all we can do is show them direct routes to videos or diagrams or the books, the literature of you like, to show them how to create diagrams but it is not quite the same as actually watching somebody do the work, map it out and discuss it in real time and I think students really struggle with that. The other things I have noticed as well is that they struggle with actually constructing them. Again because we can't show them physically where you would start on a piece of paper or we can't talk them through the software that we might use or the programmes we might use. I can direct them to online programmes which you could use to create certain diagrams but with mixed results.*

[...]

*Some of them are happy with it; they seem to think in that way, they have that kind of disposition if you like. They like to use diagrams, they like to draw, they like to explore. They are the students that do well. Then we have others who are completely the opposite, they just drift when you are trying to direct them to do these pictures they don't allow themselves to be creative, they tend to be more restrictive and it affects their marks because you can see that although they are really trying, they are scared to go with it, to use it as a tool. So yes it is very mixed, they either love it or hate it, like marmite. [Tutor A]*

These tutors all thought there needed to be more or better ways to teach diagramming, whether that is by having more teaching material on this:

*[...] we should have a better bank of resources to show them how to do diagramming [Tutor A].*

Or by offering up their own examples:

*Sometimes I respond myself and draw a diagram rather than write something. I will respond or intervene with my own visual interpretation or say, thoughts. So it is continuously keeping alive the exercising of diagramming [Tutor S].*

Or by lamenting that fact it is hard to find some examples out in the wider literature

*It would be quite nice to be able to find published examples where the authors say 'we have taken on this, we have examined this environmental issue and in doing so we have found that getting a community or getting a school or a group of business people, whatever it might be, together and using some of the examples such as rich pictures and this is how it worked for us [Tutor R].*

They also talked about how doing everything online is more limiting than it would be face to face, particularly around diagramming, but that this does not in itself overcome some student views on the primary value of using diagrams in environmental management:

*At the same time I teach environmental management at another university and, at Level 3, and I have taken some of my experiences from T219 into there, into that situation and those Level 3 students look at me a bit gone out when I say 'one of the easy of exploring this in given situations is by using rich pictures' and they end up encountering similar kinds of conceptual and theoretical challenges to the ones I have had on my T219 presentations so it is not unique to it being on line by any means. It is not unique to the OU and it is not unique to any of the materials presented in T219. [R]*

But equally some students are seen to 'get it':

*Overall, as I say, I am really positive about diagramming in these courses. I think overall I have seen a lot of students really change and transform their understanding of environmental management. [S]*

### *Assessing diagramming*

The Associate Lecturers are faced with marking and giving feedback on diagrams used in assignments submitted by their students. Technological limitations were evident in their responses to how they fared in assessing them:

*Difficult, with some mistakes. They would take all different forms. So you get ones that are beautifully hand drawn, you get ones that used clip art, you get ones that had used drawings off the internet, cut and pasted in. So it was quite difficult really to kind of compare or to be consistent in the marking so you would have to really try to look for the ... not be too hard on them for the execution and look for the actual content. A lot of them really struggle because of the size restriction of the TMAs when uploading via the Open University assignment handler. So they would do these really nice pictures, take a photo of them for instance put them in there and then it would be way over the size that they could use so often then they have to reduce the photo down and then I get a picture which when I try to scale it up on my computer to interrogate it, it is too fuzzy or I can't read there writing so that was very difficult. So sometimes I would have to go back to them and ask them to resend me these pictured by email. [Tutor A]*

But more important was how they approached diagrams within the context of the marking guides:

*I think I had to learn in the first presentation to not expect too much and to learn to kind of be less critical of them and go with the flow sort of thing, and to look for bits in their diagrams in terms of the process they have used and even some of the specific outputs', and to look for the positives rather an look for the negatives; this diagram doesn't work, say why it doesn't work and actually step back and say why it does work or why parts of it work so that the student can then build their confidence because they are going to be doing that diagram again almost certainly, to feel confident that they can actually use it to explore the next path through the T219 cycle in another context. [R]*

## **Conclusions**

The literature (Blackwell, 1997; Eitel et al., 2013; Carter, 2012) implies that learning from diagrams is very much influenced by the subject discipline context and the relationship of the diagrams to associated text. While Carter (2012) indicates that the teaching and learning of visual representations in one STEM discipline may be enhanced by reference to similar visual representations in other STEM and non-STEM disciplines there is a lack of research on the impacts of the technologies used to support that teaching and learning and the effects of the mode of teaching involved. This study has tried to address this lack of research by looking at students' (and tutors') experiences on distance taught modules that rely on the use of technologies to support teaching, assessment and learning.

The findings of this study draw upon solicited and unsolicited sources and cover a lot of contextual material as well as that directed specifically at the use of technology in teaching and assessing diagramming. This was deemed necessary in order to tease out the complex interactions between different elements of the two modules, of which diagramming is but one part; and other matters which might influence the students' disposition towards diagramming and the use of technology in both the module generally and for diagramming specifically. At the same time it is clear that with diagramming and technology (in terms of online study and digital practices) being integral to both modules there are a number of interacting factors at play which makes drawing absolute conclusions difficult. However, some points were fairly consistent throughout the different data sources.

Few students were familiar with the type and nature of the diagramming techniques involved in these modules before they studied these modules. This unfamiliarity undoubtedly played a part in students views on the relevance and value of such diagrams (why they should draw them) and also their views on the conceptual (what to draw) and technical (how to draw and share using technology) aspects of diagrams.

In terms of learning about the necessity and mechanics of diagramming students seem to very much like the printed resource book over the online materials. The mainly online delivery does not, it seems, provide the most useful context for learning about diagramming. Many would have liked to see face to face tutorials as well as printed books to aid their studies, including the use of diagrams.

The problems with the Display Wall, difficulties with creating digital copies of diagrams, the limitation of sharing and discussing diagrams in online tutorials and within the group work, also appear to hinder first order and probably second order learning about the value and relevance of diagramming for improving their own learning in general and for use in environmental management in particular.



While many did gain value from, and see relevance in diagramming, it looks as if the number of diagrams to learn about, and the number of diagrams that needed to be produced throughout study of the modules, contributed to a significant intellectual and practical time burden that may have contributed to the more negative views expressed, with technology a contributing factor.

Despite this array of factors that has hindered students' learning about diagramming most claimed that they were very likely to continue using them in their studies and possibly in their work. For a few diagramming was seen as a waste of time anyway and the technological issues just seem to have compounded this negative view.

Therefore it seems that these two modules have shown that while information and communication technologies can be used to successfully teach diagramming it is printed texts that are favoured. Further, that this success in teaching and learning may be conditioned by the disposition of the students towards the teaching strategy being used; by the need to interact more directly with other students in group work; and by the limitations of the technologies for creating and sharing diagrams. As already noted earlier, technology in this case is at best an enabler but not an enhancer for teaching and learning this particular practical technique at a distance, and for some the technology can be a barrier to their learning. In that sense, the findings mirror those seen for most distance learners, where it is not a case of distance learning being their most preferred mode of learning, but the one that most suits their circumstances. Having said that there are improvements that can be made to reduce the more disabling aspects of the use of information and communication technologies for teaching and assessing 'systems' diagrams and both module teams are working on these for future presentations. Equally, this study has highlighted the need for further research into this complex and complicated picture.

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