

A model for selecting educational technologies to improve student learning.

Susan Lambert, School of Commerce
Rhys Williams, Department of Surgery, School of Medicine
Flinders University of South Australia

There are many reasons why tertiary level teachers incorporate technologies such as computer mediated conferencing, web-based classrooms and on-line databases into their courses. The premise on which this paper is based is that teachers want to use technologies to improve student learning even though there may be some other catalyst for change. The objective of this paper is to draw on the literature to develop a model for analysing existing and new courses based on Laurillard's conversational teaching and learning framework (Laurillard 1993) and then select suitable technologies taking into account the management and organisational issues facing teachers. A taxonomy of technologies developed by Curtis (1997) is utilised to assist teachers to select the appropriate technologies for their needs and Bates' (1998) ACTION model provides the final step which identifies the constraints facing teachers in the application of technologies.

The result is an information and decision making model that assists in the selection of appropriate teaching technologies to enhance student learning. To demonstrate the use of the model it is applied to the development of a medical school, post graduate topic.

Introduction

An increasing number of teachers are now being required to incorporate diverse and unfamiliar teaching technologies into their course delivery to make it more flexible or to make the course accessible to distance students. Educators with experience in using technology argue that tertiary institutions can (and should) use information technologies to deliver quality education more efficiently with improved access by students (Alexander, 1996; Bates, 1995; Curtis, 1997). However, teachers often do not know where to start. In many cases they are unaware of the available technologies and in other cases they know what is available but do not know how to choose the technology best suited to their teaching. The problem, as Bates (1995) describes it

"is not so much one of knowing how to use a particular technology, but the lack of an appropriate conceptual framework to guide the use of technology. Put simply, this means that many people with the responsibility to teach have not been given an appropriate instructional framework on which to base their practice." (Bates, 1995, p245)

There exists a danger that multi media and other modern teaching technologies are incorporated in teaching programs simply because they are available and have novelty value. Teachers are pressured into learning to use them and then incorporating them into course delivery without considering the resulting value added to their course. Adoption of new teaching technologies is frequently driven by commercial reasons - to develop a "high tech" image for the institution, to access otherwise unreachable student populations or to appeal to student demands for flexible learning. The technologies then determine the teaching activities and modes, despite the fact that "there is now overwhelming evidence that the mere presence of a particular technology does not, of itself, improve learning." (Alexander, 1998) The most important point is that technologies should only be adopted if they have a positive affect (or at the very least a neutral effect) on student learning. If teaching technologies are adopted to solve commercial problems such as reaching new student populations and these technologies

detract from the learning process, then the quality of teaching and learning will diminish. In the medium to long term the reputation of the teacher and the institution will suffer.

In a critique of the way in which technologies have (often unsuccessfully) been applied to education, Shirley Alexander (1996) argues that the focus is too often on the technology itself. To ensure that teaching and learning is effective, she suggests that:

"..instead of focussing on the features of the technology, the most important question is 'What do I want my students to learn?'. It is only when this question has been considered, along with other questions such as 'what is known about the way students learn this' that features of a number of strategies (both technological and non-technological) should be considered as to their suitability in helping students learn this course/concept."
(Alexander, 1996)

In this paper we argue that teaching technologies should be regarded as enabling rather than deterministic and embraced with a view to improving student learning. We develop a model for the selection of appropriate teaching and learning technologies to enhance student learning (Figure 1). The model considers the elements of the learning process, the range of technologies available to support that process, and the organisational and management issues that constrain the final choice of technologies.

Educational issues: what makes quality teaching and learning?

To be able to select the right technology to enhance learning it is necessary to first understand the learning process. In her book "Rethinking University Education", Diana Laurillard examines the ways in which students learn and critiques the different approaches to developing a teaching strategy. Her "learning process" model (reproduced in Figure 2) can be used to identify the elements of the learning process, analyse the learning activities already deployed in selected courses and then assess the adequacy of those learning activities to promote quality learning. If the course is new then the model can be used to determine from the outset the learning activities and teaching methods to be used.

Laurillard maintains that "The learning process must be constituted as a dialogue between teacher and student, operating at the level of academic knowledge," and that the learning process must consist of a combination of discursive, adaptive, interactive and reflective activities (Laurillard, 1993, p94-95). An explanation of these activities follows.

Discursive dialogue

This involves the transmission of data between teacher and students. The teacher conveys concepts and ideas, the students feedback their interpretation to the teacher and confirmation of understanding between the two parties takes place.

This discursive interaction should include course goals and task goals that may or may not be negotiated. The teacher must create an environment within which students feel they can feedback to the teacher and that the parties can reflect and act on that feedback.

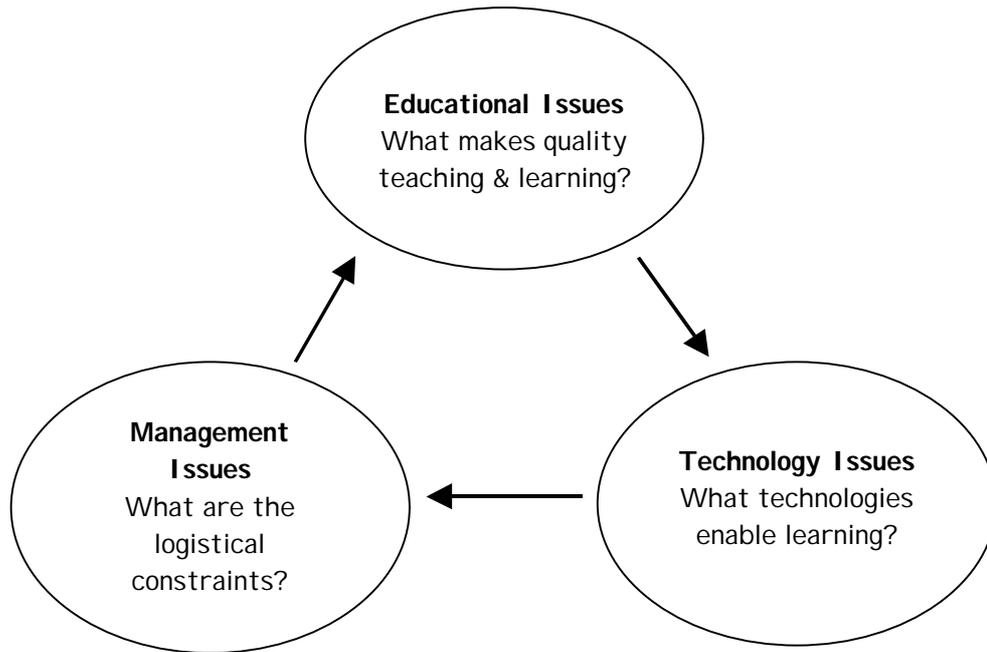


Figure 1: A model for choosing educational technologies. The three steps - Educational Issues, Technology Issues and Management Issues.

Adaptive activities

Between interactions the teacher and the student should consider the previous experience, be it an activity or a dialogue, as a basis for future dialogue and activities. The teacher should modify future descriptions and activities according to the feedback received from the student and as a result of their own reflections.

Interactive dialogue and activities

This requires the teacher to set task goals for the student; the student must carry out the task goals giving the teacher feedback on the action. The teacher then gives the student intrinsic feedback to facilitate achievement of the goals. The student carries on with the task goals taking into account the feedback provided by the teacher.

Reflective activities

The teacher must provide opportunities for the students to link the feedback on their actions to the course goals. Allowing the students to control the pace and timing of the activities facilitates reflection.

This “conversational framework” (Figure 2) is useful for analysing the teaching and learning requirements of individual courses and determining the educational media that may be useful in the course delivery.

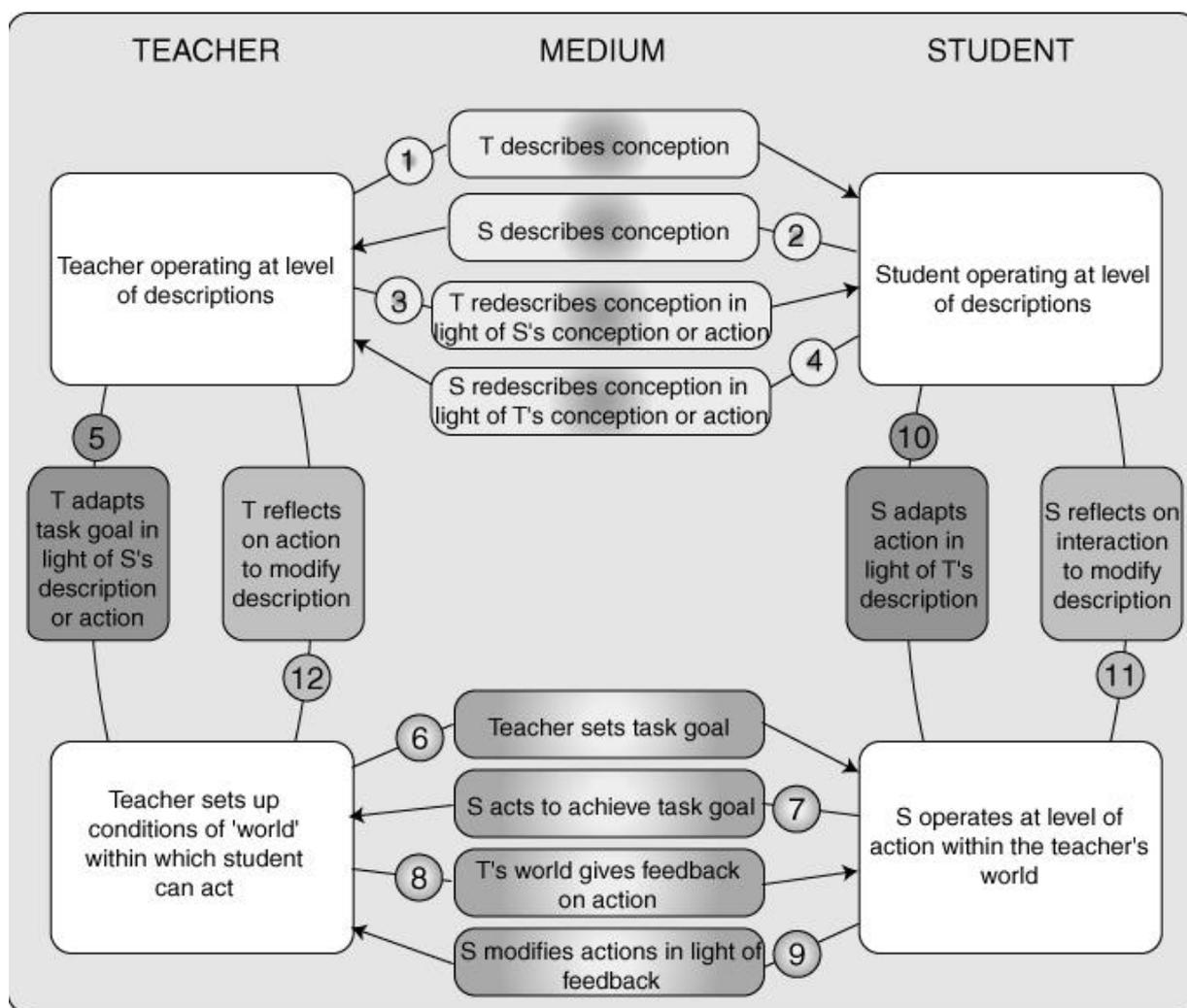


Figure 2: Laurillard's "conversational framework" model of the learning process (from Laurillard, 1993, p103)

Technology issues: what technologies enable learning?

For learning to be truly effective, teaching methods and media (whether or not they are technology dependent) need to be selected on the basis of their impact on the learning process. The next question to be asked when choosing technologies is therefore "Which technologies will enable and enhance learning?" Several authors have developed schemes for classifying technologies based on their technical characteristics or their educational application. For example, Price (1998) distinguished technologies based on their ability to facilitate learning synchronously or asynchronously and based on where the learning can take place.

Having developed her conversational framework model for the learning process (Figure 2), Laurillard (1993) analysed different educational media for their ability to support learning at each step of that process. The results are summarised in a "media comparison table" (Laurillard, 1993, p 177). Based on Laurillard's framework, Curtis (1998) developed a classification of technologies that we use as the second part of our decision model (Figure 1). This classification (Table 1) groups technologies according

to their ability to support the following categories of learning: Information transmission and processing, discursive, adaptive, interactive and reflective.

There is little difference between the way that Laurillard and Curtis categorise the technologies except in one important area. Laurillard places steps 1,2,3 and 4 in the Discursive category whereas Curtis creates a new category called "Information Transmission" for step 1. The inclusion of this additional category is useful when determining the needs of the course because the technologies serving step 1 are different to those that serve steps 2, 3 and 4 (Table 1). Curtis recognises that the original transmission of concepts may not be by the teacher, it may be through printed materials or on-line documents. Unlike steps 2, 3 and 4, step 1 is a one-way transmission of information that the student can access alone.

Table 1 is an adaptation of Curtis' taxonomy of technologies based on Laurillard's learning process. From this table the possible technologies suitable for the course delivery can be chosen. The course developer can check that each of the learning elements has been addressed by the selected technologies. More detailed discussions of each type of technology, and its strengths and weaknesses in supporting learning can be found elsewhere (Laurillard, 1993; Bates, 1995; Curtis, 1998; Paulsen, 1995).

One additional consideration is the combination of technologies. Having discussed the different media available to teachers, Laurillard concludes that ". none of the media can [individually] adequately support the discursive activities that are essential to academic learning." (Laurillard, 1993, p176). This view is also shared by Bates who advises that "all technologies have their strengths and weaknesses [and] therefore have to be combined." (Bates, 1995, p13) Using combinations of technologies can maintain student motivation and enhance learning outcomes (Mason, 1997), and may help accommodate the learning preferences of different students. On the other hand, too many varied media can be confusing and distracting, and may significantly increase development and delivery costs (Curtis, 1997).

Management issues: what are the logistical constraints?

Having addressed the educational requirements of the learners and identified the technologies that could potentially be used in teaching, there are many other constraints, which need to be considered before making a decision. In his book "Technology, Open Learning and Distance Education", Tony Bates proposes a set of criteria which can be used to identify these issues (Bates, 1995). According to Bates' "ACTIONS" model (Table 2), individual teachers and institutions faced with decisions about educational technologies need to answer a series of questions, grouped under the headings of Access, Costs, Teaching and Learning, Interactivity and User Friendliness, Organisational Issues, Novelty, and Speed.

Access

Staff and students need adequate access to technology. This includes provision of adequate computers and/or network access, consideration of the varied needs of different groups of learners, and a strategy to help students and staff feel comfortable using the proposed technology.

**Table 1: Classification of technologies for enabling learning
(Adapted from Curtis, 1997)**

Learning Process	Suitable Technologies
<i>Information Transmission</i>	
Presentation	Print-based documents On-line documents File transfer Broadcast radio or TV Audio-tape Video-tape Electronic white board
Search & Retrieval	Library catalogue Hypertext Online databases
Learner response	Document preparation
<i>Discursive</i>	Telephone Audioconferencing Videoconferencing Audiographics, Shared whiteboards Computer-mediated communication E-mail Computer conferencing
<i>Adaptive</i>	Computer based testing Multimedia
<i>Interactive</i>	Simulation Computer based tutorials Intelligent tutoring systems
<i>Reflective</i>	Computer conferencing Multimedia

Costs

Bates considers cost a "strong discriminator between technologies", and it is often the first issue considered by institutional decision-makers. When comparing costs it is important to distinguish between One-way and Two-way technologies. One-way technologies – such as print, audio or videocassettes and computer-based learning/multimedia – have high initial production costs but lower ongoing costs. Two-way technologies – such as computer-based conferencing – are relatively inexpensive to set up, but require ongoing tutorial-style interaction with students which can be expensive for large numbers of students. Bates (1995) and Curtis (1998) provide a more detailed discussion of the relative costs of different technologies for different class sizes.

Teaching and learning functions

The relative strengths and weaknesses of different technologies to support learning need to be clearly understood. These issues are discussed above in Step 2 of our model.

**Table 2: The ACTIONS model for selecting educational technologies
(from Bates, 1995: 1-2)**

A	Access	How accessible is a particular technology for learners? How flexible is it for a particular target group?
C	Costs	What is the cost structure? What is the unit cost per learner?
T	Teaching & Learning Functions	What kinds of learning are needed? What instructional approaches will best meet these needs? What are the best technologies for supporting this teaching and learning?
I	Interactivity and User Friendliness	What kind of interaction does this technology enable? How easy is it to use?
O	Organisational Issues	What are the organisational requirements, and the barriers to be removed, before this technology can be used successfully?
N	Novelty	How new is the technology?
S	Speed	How quickly can courses be mounted in this technology? How quickly can materials be changed?

Interactivity and user friendliness

Interaction between learners and learning materials, other learners and the teacher are all important for the learning process. Indeed "achieving quality in teaching and learning in higher education depends substantially on making learning resources and activities as interactive as possible." (Curtis, 1997, p10) The type and degree of interactivity differs significantly between technologies. For example, online or Web-based conferencing encourages student-student interactions, reflection and collaborative learning (Harasim, 1989; Williams, 1998). On the other hand, Web sites produced by "repackaging" existing paper-based resources offer very little interactivity and produce little if any favourable effect on learning outcomes (Alexander, 1996).

Organisational issues

The level of organisational support given to a technology is critical to its long-term success. Changes in administrative structures and procedures, improved technical support for staff and students, and additional staff development and training will almost certainly be necessary to ensure effective adoption of technologies. In the longer term, tertiary institutions will need to undergo significant structural changes to keep pace with the demands of employers and students, and the changing roles of academic and technical staff, as well as technological advances. Bates discusses these organisational changes at length, and concludes, "existing educational institutions were created to meet the needs of a society that is fast disappearing. We need educational organisations

that can exploit the new technologies to meet the needs of the twenty-first century.” (Bates, 1997, p249)

Novelty

The novelty of a technology may be important for attracting initial funding or obtaining new equipment, but will probably have little benefit in the long term. There is some evidence that students respond enthusiastically to the use of novel technologies in teaching, resulting in a short term improvement in student satisfaction and learning outcomes (Alexander et al, 1998). This improvement will be short lived, however, unless the technology is sustainable and able to consistently enable more effective learning.

Speed

The time required to develop, update and deliver educational resources is a key consideration, especially for busy teachers. Delivery speed of particular technologies (for example delivery of text compared to delivery of video over the Internet) also needs to be considered, although this will change with improvements in network speed and other technical developments.

Applying the model to an open learning module in evidence-based medicine for postgraduate medical trainees.

To demonstrate the potential use of the model (Figure 1) we will now apply it to the development of a new topic for medical graduates undertaking training towards a specialist qualification

Characteristics of the course

The recently established NH&MRC Centre of Clinical Excellence in Urological Research (CCEUR), is currently developing a training programme in Clinical Research Methodology for postgraduate medical trainees, particularly surgical trainees. This new course is being designed as a series of modules to teach "generic" research skills such as critical appraisal of literature, basic epidemiology and biostatistics, and research study design. The first module under development is that on evidence-based (EBM) which has been defined as the "conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients" (Sackett et al, 1996). It requires clinicians to articulate a focussed clinical question, efficiently search and critically appraise medical and scientific literature, apply rules of evidence, and interpret the results for management of individual patients. The objectives of the proposed module are for students to develop knowledge and skills in critical appraisal of literature, and an understanding of EBM approaches and their application to clinical practice.

Students undertaking the course will be postgraduate medical trainees, working full-time in teaching hospitals throughout Australia and New Zealand. While trainees are typically highly motivated and IT-literate, they also work long hours and are under pressure to study for fellowship examinations. To give these busy students flexibility, and to allow the course to be offered to all Australasian trainees, it is being designed at the outset for flexible delivery. This is an example of an increasingly common scenario where the initial focus of course design may be on the technologies to be used for

course delivery. However, as described in our model (Figure 1), it is important to first consider the learning processes.

The educational issues

EBM has classically been taught in face-to-face settings using tutorials, journal clubs and/or intensive workshops (Sackett et al, 1997; Green and Ellis, 1997, and references therein). A large number of paper-based resources are now available for teaching EBM, and some of these can now be downloaded from Web sites. Most EBM and critical appraisal (CA) courses involve the following types of activities:

- Students are given a set of paper-based resources, including introductory material on EBM, checklists for critical appraisal of literature, sample articles, and technical information for using literature databases.
- With the assistance of a more senior clinician who acts as a tutor, students formulate a clinical question based on either a real patient or an area of particular interest or concern in clinical practice.
- Using the printed resources and CD-ROM or Internet-based databases, students undertake a literature search for key articles that address the clinical question.
- Students then critically appraise the article(s) using a set of established criteria and procedures, and make recommendations for clinical practice.
- Observations about the process, findings and recommendations are then reported back to other students in the group and further discussion takes place.
- Students and tutors reflect on their individual learning experiences and the information the skills and knowledge they have gained, particularly focussing on the ongoing application of evidence-based approaches to clinical practice.

At each stage in this process, students need access to a tutor and fellow students (usually in a tutorial setting) to discuss their progress and guide the development of their skills and ideas. These activities are summarised in Table 3 (column 1) according to Laurillard's learning process model, together with the typical delivery methods employed in face-to-face teaching.

The technology issues

When designing an EBM course for flexible delivery, technologies need to be selected which will support all aspects of the learning described above (Table 3). The "Information transmission" category can easily be satisfied using print-based documents, on-line documents and Internet-based databases. However, providing tutorial-like discursive and interactive learning without face-to-face contact is a much larger challenge. This requires a conferencing technology and Web-based conferencing (computer-mediated conferencing) is the most cost-effective and educationally effective choice. Specifically designed multimedia products, such as multimedia case studies, could also facilitate adaptive and interactive learning, but would require significant resources for development.

The management issues

Access and costs: These issues are less problematic for this particular student group, since all trainees are expected to pay for their training and to have access to a computer. There may be a need to offer a short "induction" course for students new to open

learning, so that they are able to feel comfortable with the technology and actively participate in the online discussions.

Interactivity: Interaction between students, as would occur in carefully planned tutorial sessions, is critical for the success of this topic. This will be facilitated mostly through Web-based conferencing although a synchronous session, such as a videoconference could also be used towards the end of the topic to maintain student interest and provide a forum for reflection and wide-ranging discussion.

Organisation: Infrastructure and technical support for establishing Web-based conferencing will be available, but training will need to be offered for staff involved as on-line tutors, as this requires a particular set of skills (Berge, 1996). This topic could serve as an example for other topics offered within the institution which rely heavily on paper-based resources, but need to use technology to encourage discursive learning processes among students.

Having considered all three steps in our decision model (Figure 1), the final recommendations for flexible delivery of the EBM module are summarised in Table 3 (last column). Students will utilise paper-based documents, on-line documents, and on-line databases as support resources. They will individually formulate a clinical question in (on-line or telephone) consultation with their tutor, and participate in online discussions with their tutor and with other students using Web-based conferencing. Finally they will join all tutors and students in a videoconference to discuss the processes and findings of their work and reflect on key issues and implications for ongoing clinical practice.

Summary: a model for choosing educational technologies

In summary, we have developed a three-step model for selecting technologies to enhance the quality of teaching and learning. The model considers the elements of the learning process, the technologies available to enhance that process, and the logistical constraints impinging on the final choice of technologies. We have demonstrated the use of the model by applying it to the development of two very different topics. The approach to technology selection offered by this model will be useful to educators seeking to use technology effectively in their course delivery.

1. Educational issues		2. Technology issues		3. Management issues
Learning process	Learning activities and resources	Current delivery methods Face-to-face	Potential delivery methods Flexible delivery	Proposed delivery methods Flexible delivery
Information transmission	EBM/CA summaries and "checklists" and other general resources Literature database searches	Seminars/lectures Print-based documents Literature searches using CD-ROM or Internet databases	Print-based documents On-line documents CD-ROM & Internet databases Video-tapes	Print based documents On-line documents Internet-based databases
Discursive	Discussions with tutor, fellow students, colleagues, patients.	Tutorials, Workshops	Video-conferencing Audio-conferencing Web-conferencing	Web conferencing
Adaptive	Individualised clinical question Individualised literature work and learning outcomes	Clinical problem presentations	Paper-based "case studies" Multimedia "case studies"	E-mail and/or telephone contact with facilitator Paper-based or multimedia case studies (later development)
Interactive	Apply knowledge and skills to individual patients Discuss/modify approach to learning	Tutorials Discussion with tutor	Multimedia/Computer-based tutorials	Web conferencing
Reflective	Feedback and reflection on current and future practice	Tutorials Reflective diaries Feedback sessions	Web conferencing Videoconferencing	Web conferencing Evaluation (on-line or paper) Videoconference

Table 3: Selecting technologies for flexible delivery of a module in evidence-based medicine (EBM) - current, potential and proposed learning activities and teaching delivery methods. Further details of the proposed activities are given in the text.

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