Introduction

What the research says about the use of different technologies to enhance learning

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Discussions surrounding technology and education often take for granted that technologies can enhance learning and teaching. However, the research evidence behind such assumptions is rarely included in the discussions themselves, and the assumptions are rarely clarified with respect to key issues and questions (Kirkwood and Price, 2014). For example, the specification of what will be enhanced when technologies are used for teaching and learning, how enhancements can be achieved, and how enhancements can be evaluated. In fact, the question: 'do the technologies enhance learning?' is not even the right one to ask, because it implies that any technology regardless of the purpose of its design or the manner of its use can enhance learning and teaching. As Richard Noss argued (2013), the right question is 'how can we design technologies that enhance learning, and how can we measure that enhancement?'

In the previous chapters, Baume and Scanlon discussed how people learn. Here, we frame the chapters in this section of the book with a description of the learning activities that have been identified as occurring when people learn with technology. We then provide a series of case study chapters about how specific technologies and technology related activities have been evidenced as being used to support learning and teaching. We hope that these examples will provide sufficient support to reflect the potential of specific technologies to enhance learning and teaching when used appropriately. The nature of the evidence in this chapter varies broadly, yet focuses mainly on the improvement of student learning outcomes (quantitatively and/or qualitatively). Initially Lawrence Williams and Miroslava Černochová explore the research behind the new Computing curriculum, and the models that can help develop students' computer programming and literacy skills, in a creative way. Then Charlotte

Lærke Weitze shows that learning through game development may be an appropriate approach to support and evaluate students' learning processes and can lead to increased collaboration among students. The games-based learning discussion is followed by the use of technology in citizen science, in which Christothea Herodotou argues that citizen science projects have the potential to improve the public's knowledge of scientific content, their understanding of the scientific process and their attitudes towards science and scientists. In Chapter 2.4 Nageela Yusuf shows that video in learning may lead to an increased ability in learners to transfer knowledge, and in Chapter 2.5 Mark Gaved and Alice Peasgood present the results of two recent research projects to argue that learning at a relevant location, or in a context associated with a specified learning goal, is more likely to make the learning activity effective. Finally, Patricia Davies presents a chapter on the use of iPads in classrooms in which she shows that the investigation of student diaries about the use of their iPads revealed that students often use iPads in classrooms for tests and revision, and that the 'ownership' of an iPad is a key issue in their effective use for teaching and learning.

The acts of learning

Not all learning activities are the same. This is fairly obvious, for example watching a video about an earthquake is not the same activity as building a working simulation of an earthquake, even though both these activities may cover the same area of the curriculum. Table 1 illustrates the 19 Learning Acts that have been observed to occur when learning happens with digital media. These are grouped into four meta-categories (Manches *et al.,* 2010). A standard video would promote and support *Exposition* as a Learning Act. This Act is characterized as a private interaction with an author or speaker who is presenting a narrative account of knowledge to a learner. Knowledge is thereby 'exposed'.

This practice is well suited to situations where expertise can be transmitted in structured narrative form. The success of this form of learning depends on the depth of the private interaction elicited from the (otherwise passive) learner. Thus technology may support such depth of interaction by making material vivid or representationally rich. Interactive video is likely to also promote Learning Acts such as *Browsing, Ludic, Simulation and Problem Focused*. The effectiveness with which the range of different Learning Acts is supported through the interactive medium will impact upon its learning effectiveness.

Table 2.1: The Acts of Learning with technology

	Learning Act	**Learner's mediated interaction**
Personal	*Browsing*	Improvise an exploration of subject materials
	Annotation	Record elaborating commentary on subject materials
	Rehearsal	Recall and exercise relevant domain elements and processes
	Representing	Design and manipulate symbolic formats of subject matter
	Ludic	Un-directedly explore materials to generate positive affect
	Construction	Build artefacts, knowledge or representations relevant to some subject domain
	Reflection	Consciously systematize one's own evolving learning
Dialogic	*Exposition*	Implicit dialogue with authorial voice
	Tutorial	Engage in dialogue with more knowledgeable other
	Assessing	React to feedback from an authoritative other
Social	*Performative*	Publically present a domain-relevant construction
	Networked	Distributed and intermittent exchange of subject-related understandings
	Participative	Integrate with a community of learners who share knowledge-building ambitions
	Collaborative	Exchange to deliberately create shared knowledge
Scenarioed	*Cross-contextual*	Integrate and manage activities over multiple contexts
	Case-based	Engage with the components of a subject-relevant case
	Simulation	Manipulate a functional reproduction of subject-relevant system
	Problem-focused	Solve a specific problem defined as subject relevant
	Scripted inquiry	Execute a scaffold of investigation or articulation

Manches *et al.* (2010) describe each of these Learning Acts as follows:

BROWSING

An interaction with knowledge structures whereby the learner searches for relevant items. This search may be improvised and opportunistic (more traditional sense of 'browsing') or may be guided by principled rules ('strategic' search). Education should furnish an interest in exploration through unguided browsing but also the skills necessary to be more strategic.

ICT in the form of the internet access furnishes a rich context in which to exercise browsing, however, it also demands skills – while offering tools.

Examples

- search term technologies
- CiteULike and other data mining and collecting tools

ANNOTATION

An interaction with existing knowledge material (particularly text) such that tools allow the learner to construct a personal elaboration of that material. This might take the form of elaborative commentary closely attached to the original ('marginal notes') or it might be a form of personal précis or reflection ('summarizing', etc.). Knowledge is thereby elaborated or personalized.

This practice suits situations where a body of well-formed material is available for study. Its cognitive benefit arises from the effort of actively re-casting material and selectively linking it with existing knowledge. Clearly annotation is something that can be done more or less skilfully and demands practice and support.

ICT offers tools that can structure (such as notetaking) as well as an infrastructure of composition and storage tools for writing and filing the products of 'active study' pursued in this manner.

Examples

- web page annotation tools
- word processing functions adapted to structured note taking
- review features of word processors
- practices of organizing personal notes in personal computer filing systems

REHEARSAL

An interaction in which the learner is able to exercise key skills and knowledge relevant to the domain. For instance carry out arithmetical operations or practice language vocabulary.

Such activity supports the learner in building a robust database of knowledge relevant to some domain that can be recalled for processing in required contexts (e.g. solving arithmetic-based problems or conversations in a foreign language).

ICT can be a presentational tool for such problems that allow exercise of core skills and recovering of core facts.

Examples

- drill and practice software
- language pronunciation demonstrations

REPRESENTING

An interaction whereby some experience in the world (an artefact, event or process) is reproduced by invoking and manipulating some system of representation. Such activity allows the learner to make their understanding overt and explicit – as well as creating a space within which that understanding can be manipulated.

ICT provides representational tools that can be readily manipulated, stored and shared.

Example

- the concept map and other screen-based systems for constructing representations

LUDIC

An interaction allowing playful, relatively undirected engagement with domain-relevant material such that exploratory manipulation of that material is rewarded with positive affect.

Such activity allows the learning to *experiment* with knowledge and thereby explore properties and affordances of the domain.

ICT can provide microworlds in which such exploration is readily offered along with the possibility of playful creations.

Example
- Logo

CONSTRUCTION

An interaction with material that supports the building of artefacts, knowledge or representations.

Such activity allows the learner to exercise principles of some knowledge domain through the demands of constructing some end product calling upon that knowledge.

ICT may provide tools that allow creative development such as the construction of video, montage, narrative representations and so forth.

Examples
- Animoto
- Movie Maker
- PowerPoint

REFLECTIVE

An elaborating interaction with a record of one's own learning activities. This might take the form of some sort of diary with evaluative personal commentary. Personal knowledge building is thereby subjected to critical scrutiny and adjustment.

This practice cultivates the metacognitive skills necessary to refine and structure personal knowledge building activities.

ICT offers tools that assemble the achievements of learning and allow some form of (shareable) reflective commentary to be superimposed upon them ('annotation' where the object of annotation is a personal record).

Examples
- the e-portfolio

EXPOSITION

A private interaction with an author or speaker who is using some tool to present a narrative account of knowledge to a learner. This might take the form of a lecture, or a textbook or a multimedia presentation. Knowledge is thereby 'exposed'.

This practice is well suited to situations where expertise can be transmitted in structured narrative form. The cognitive benefit arises according to the depth of private interrogation and meaning-making encouraged in the listener/reader/viewer.

ICT offers tools that package and make accessible such structured accounts. However, the success of this form of learning practice depends on the depth of the private interaction elicited from the (otherwise passive) learner. Thus technology my support such depth of interaction by making material vivid or representationally rich.

Examples

- podcasts of lectures
- YouTube explanatory videos
- eBooks
- Wikipedia and other reference materials online

TUTORIAL

An interaction in which the learner takes part in a dialogue with a more informed other. The quality of the interaction depends upon the manner in which the dialogue is orchestrated towards building and interrogating knowledge.

This practice externalizes process of scrutiny and questioning as well as furnishing a context for more explicitly interrogated exposition (see above, under 'exposition').

ICT can support dialogues in text or voice, particularly where partners are not co-present. Technology may also blend that conversation with forms of visual representation on associated whiteboards etc. It may simulate the human partner in such dialogues.

Examples

- intelligent tutoring systems
- chat-based discussion forums
- Skype exchanges

ASSESSING

An interaction that optimizes opportunities for one person to feedback on the knowledge-building product of a learner. This practice equips the learner to recognize and respond to a critical voice applied to their own efforts.

ICT provides tools to traffic in assessment interactions – potentially making them more prompt, representationally rich and interactive.

Examples

- VLE structures that support online submission and commentary on student work
- tools for embedding voice or images as feedback to submitted files

PERFORMATIVE

An interaction with an (implicit or explicit) audience. Personal knowledge is shaped in such a way that it is actively disseminated – made the object of attention (and critique perhaps) by others.

This practice encourages an awareness of personal knowledge in terms of how it may be seen by, and how it influences others. This requires engaging with those alternative perspectives and considering how knowledge allows itself to be shaped to come into relationship with them.

ICT offers tools for dissemination and audience reaction.

Examples

- blogs
- expository videos on YouTube
- wikis

NETWORKED

An interaction in which learners make intermittent contact with others for data co-ordination of interrogation, although usually separated in time and space. Knowledge patterns are thereby established for navigation and querying.

This practice cultivates a model of knowledge as distributed and facilitates patterns of engagement that support creative questioning of such structures.

ICT provides an infrastructure for assembling and managing networked knowledge and for navigating to nodes where informants may be interrogated.

Examples

- topic-centred mailing lists, discussion forums or ning.com sites
- personal databases of contacts for one-to-one or one-to-many querying
- Delicious and other shared bookmarking tools

PARTICIPATIVE

A structure of interaction that creates circumstances for fostering integration among a group of individuals who have an evolving history of shared understanding and practice, and a motive to work towards elaborating this. The cognitive gain of this concerns the confidence and identity of the individual as a 'member' of some learning community/discipline. It also creates a knowledge structure within which the individual learner can seek other learner relations.

ICT can provide infrastructures that establish and shape the felt sense of communication and community and which create tools for individuals to become participants rather than mere communicants.

Example

- The Knowledge Forum and other networked designs for shaping and making visible corporate identity and products

COLLABORATIVE

An interaction in which two or more individuals deliberately strive to create shared knowledge.

This practice allows an individual to acquire interest, skills and confidence in knowledge construction activities that take advantage of the expertise of others and which gives an affective motive for that knowledge building.

ICT can provide a context at which collaborators may assemble and share representations.

Examples

- classroom arrangements within which small groups may work together at a shared site of representation and recording
- internet communications may support collaborative knowledge building at a distance and synchronously

CROSS-CONTEXTUAL

An interaction in which learners integrate meaning across different contexts of representation or activity. The cognitive benefits arise from positioning the same ideas in more than one setting or by simply extending the range of knowledge searching and integration.

ICT equips the learner with tools to capture, store, compare and integrate material from multiple contexts.

Example

- mobile recording and communication tools such as PDAs, cameras, phones and GPS enabled devices

CASE-BASED

An interaction in which the structure and working of a disciplinary 'case' is pursued. This allows the learner to understand knowledge in the context of an authentic example, providing an integrated and meaningful context for disciplinary content.

ICT can provide a structuring and exploratory context for the presentation of case material. It offers a condensed form of representation with interactive possibilities – allowing the case to be viewed and explored in an economical manner.

Examples

- semantic technologies that support investigation of cases
- self-contained case realizations in virtual format

SIMULATION

An interaction allowing control over some model system representing domain-relevant processes. The learner is allowed to manipulate qualitative or quantitative parameters in order to investigate functioning or construct desired outcomes.

The activity benefits learners by allowing the functional properties of some system to be experienced directly such as to support experiment.

ICT can provide self-contained environments in which such systems are modelled and which allow active manipulation.

Examples

- Civilization
- Astroversity
- Racing academy
- Savannah

PROBLEM-FOCUSED

An interaction in which the learner is challenged and resourced to solve domain-relevant problems. The learner thereby encounters domain knowledge in the context of authentic problems and is motivated to exercise that knowledge.

ICT can be a presentation resource for encountering problems designed by others. That presentation may include tools for the exploration of the problems made available.

Example

- presentational contexts for defining a problem and offering solution and dissemination tools

SCRIPTED INQUIRY

An interaction in which the route through an inquiry space is defined and guided by a script of steps. The learner thereby is scaffolded in the relevant problem solving strategy.

ICT can offer tools that guide the learner though some process of enquiry by specifying a succession of moves relevant to approaching some agreed goal. These scripts may scaffold a conversation in collaborative contexts or drive a pathway for individuals.

Example

- LMS and other learning design scaffolds

It can be very useful to bear these 19 different Learning Acts in mind when thinking about and designing activities that use technology to support learning. It is worth bearing these in mind as you read through the next six chapters in Part 2.

Key findings summary

What the research says about the use of different technologies to enhance learning

- The ideas behind the new Computing curriculum in England can easily be linked back to constructivist and constructionist approaches to teaching and learning.
- As exemplified with the 'Literacy from Scratch' project, successful Computing curriculum models can help students develop computer programming skills, as well as literacy skills, in a creative way. Computing can also support cross-curricular approaches to teaching and learning, including literacy, Computing, ICT, art, music and bilingual work.
- There is evidence to support the value of developing computational thinking and coding skills through teaching programming languages.
- Learning through game development, as opposed to game playing, can be an appropriate approach to support and evaluate students' learning processes, and it can lead to increased collaboration among students. The evidence reported in Chapter 2.2 shows that students can learn from making games as much as they can from conventional teaching.
- Citizen science projects have the potential to improve the public's knowledge of scientific content, their understanding of the scientific process and their attitudes towards science and scientists. To achieve this potential, public participation must be appropriately guided, and must include reflection about the public's role and how it relates to the processes of science.
- Evidence about the impact of various citizen science approaches is just emerging and it has multiple challenges such as the creation of scientifically robust investigations, the validity of the collected data, the need for moderation and advice from experts and long-term

engagement in citizen science projects to develop skills to conduct reliable research.

- Research about the use of video in learning is rarely conclusive due to the methodological challenges of controlling potential variables, which can impact on student performance. However, there is some evidence that video in learning may lead to an increased ability to transfer knowledge, as it provides opportunities to view visual material at a comfortable pace for learners. This has the potential to help learners to internalize knowledge, and thereby recall it at a later time.
- Learning at a relevant location, or in a context associated with the learning goal, is more likely to make the learning activity effective.
- Initial evaluations of the potential of urban environments with high-tech infrastructures to support learning with location and context associated learning activities are promising. However, research mostly relies on self-declarations of participants, and further investigations are required to interpret the potential of these approaches.
- The requirement for learners to make obvious use of smart tools to trigger learning resources (such as taking a photo of a sign in a public place or scanning QR codes) may deter potential users from taking advantage of potential learning opportunities in location-based learning approaches.
- iPads are nowadays commonly used in educational settings with the purpose of enhancing student engagement and learning. Students' feedback on the use of iPads in schools evidences that these new digital technologies have the potential to contribute to teaching and learning. However, the value of these educational technologies is to be found in the way they are implemented rather than the technologies themselves.
- Evidence from student diaries about the use of iPads illustrated that the two main ways in which students used School iPads in the classroom were for revising and testing. Students stated that tests on the iPad were easier because they mainly involved multiple-choice type questions and little writing. The majority of the participants enjoyed being given a choice about when and how to use their iPads during lessons. The consensus of the participants in the project was that using School iPads during lessons 'makes learning fun'. They also reported enjoying the experience of 'being in charge' of their own learning.

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