Technology enhanced learning:

The good, the bad, and the ugly

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Training (whether traditional, e-learning, or blended learning) is intimately connected with and dependent on the human cognitive system. Learning means that the cognitive system acquires information and stores it for further use. If these processes do not occur properly, then the learners will not initially acquire the information, and even if they do, then they will not be able to recall it later, or/and the information will not be utilised and behaviour will not be modified. Regardless whether the objective is learning new information (e.g., compliance regulations, product specifications, etc.), acquiring new skills (e.g., operating a new apparatus, customer service, time management, etc.), or knowledge sharing and transfer within or across organisations — the processes of acquiring, storing and applying the information are critical. The question is how to achieve these cornerstones of learning and whether technology can enhance them. The answer is clear: The learning must fit human cognition. There is a lot of scientific knowledge and research on human cognition and learning. The difficult and tricky challenge is how to translate this theoretical and academic research into practical ways to utilise technology so as to enhance learning. By bridging basic research about learning and the brain into ways of using learning technologies, one is able to create sophisticated learning programs. These take into account and build on the architecture of cognition, and as a consequence produce effective and efficient technology enhanced learning.

Keywords: behavioural impact of learning, cognitive architecture, cognitively optimising learning, e-learning, gaming, learning and cognition, remembering acquired information.

'Learning' is not new; it has existed for millions of years. In fact, it is a cornerstone characteristic of intelligence and of being human. In contrast, technology, and its application to learning, is a very new endeavour. A few decades ago, only a handful of people experienced technological applications in the domain of learning. Back in 1992, only 16 years ago, while working with the US Air Force on a cognitive

Pragmatics & Cognition 16:2 (2008), **215–223**. DOI 10.1075/p&c.16.2.02dro
ISSN 0929–0907 / E-ISSN 1569–9943

learning project, I experienced an air-to-air combat simulator; it cost 50 million US Dollars to buy, and had an operating cost of a $1,000 an hour! Nowadays, technology has expanded so much that almost anyone, anywhere, uses it on a daily basis. It is so intertwined with our lives that it is sometimes hard to imagine life without it. Indeed, we are so intimately connected and reliant on technology that it is an increasing part of our cognitive processes and affects our very nature.

What is Technology Enhanced Learning (TEL)? Obviously not all technologies relate to learning. It is not simple to define which technologies are 'learning technologies' or 'e-learning'. If we try to construct a list of learning technologies we will definitely need to include all those technologies that are developed and intentionally deployed for formal learning. Even this segment of the list is not short; it includes complex gaming and mobile learning platforms, interactive videos and immersive technologies, as well as rudimentary devices such as electronic blackboards and software for presenting information such as PowerPoint. Such technologies are critical to a list of learning technologies. However, much of learning is informal. The WWW is a technology that revolutionised the way we access, share, and encode information, and clearly plays a role in learning. E-mail and mobile phones have affected how we communicate information and learn. Therefore, the list of learning technologies is quite long and continuously expanding, and it is not simple to define which technologies are learning technologies and which are not.

What, if anything, unifies learning technologies? And can they substantially, qualitatively, change the face of learning? Technology Enhanced Learning (TEL) has a quantitative impact. It can offer efficiency and cost-effective learning (although many times it merely transcribes learning from one medium to another). Obviously, different technologies, different learning materials, and different learners are important parameters in the TEL equation. However, regardless of the technology, the learning material, and the learners, can we use technologies to enhance learning, and if so, how? Furthermore, how does TEL affect what learning is, and how does it affect us as learners? These are the questions at hand. Before I attempt to deal with them, I must first clarify, briefly, what learning is.

Too often 'learning' is reduced and limited to acquisition of information. When learning is evaluated and measured (if at all), this is usually done immediately following the 'learning'. However, learning often comprises additional elements. Only the first element is the acquisition of information. Another component of learning is memory. Do the learners remember what they have learned? Much, in fact most, of the learning material is often forgotten within 24 hours of acquisition. We cannot really evaluate and discuss learning without considering whether the learned material is acquired and encoded in a way that forms long lasting mental representations. We need to consider what TEL can offer, not only to the acquisition of information, but also to its long term retention. Another critical aspect of learning

that is too often ignored is whether it has had any impact. Even if information is acquired and remembered, it might be stored in isolation and thus fail to make an impact or to be applied so as to modify behaviour and attitudes. Examining TEL (or traditional learning) without considering these additional elements overlooks very important components of learning and results in "tunnel vision".

So, how do we use technology to enhance learning (acquisition, memory, and impact)? To achieve objectives in learning and to maximise its potential one must consider the workings of the human cognitive system. At the end of the day, it is the learners' cognitive system that acquires the information, stores it, and retrieves it later for use. Thus, understanding the human cognitive mechanisms involved in learning should underpin any and every aspect of learning and TEL. A good fit between the learning and the learners is critical for success and promotes efficient and effective learning. The efficiency and effectiveness of learning depends mainly on whether — and how well — the learning conforms to the mechanisms and constraints of the cognitive system. Understanding these mechanisms that underlie learning is critical for all aspects of learning. But the complicated and tricky step is how to connect and translate this understanding to practical implications in learning and in utilising technologies. It is also important to beware of TEL, as too often it drives the learning rather than supports it. The fact that we can use technologies does not mean we should. To determine if (and what) technology is suitable for learning, and how to use it to maximise learning, we need to examine if and how it works with the human cognitive system. Of interest is also if and how using TEL may affect the learners. This brings to the forefront the need to emphasise and focus on the learner and not the learning materials and technology.

Can TEL help the learning to better fit the cognitive system, and if so, how? An example of this would be issues pertaining to cognitive load. The cognitive system has limited capacity for processing, acquiring, and storing information. Understanding and acknowledging this constraint means that any learning program must carefully consider issues of cognitive load. Dealing with cognitive load at a rudimentary and superficial (but still important) level requires minimising the amount of information the learners are exposed to and are expected to acquire at any one time. This quantitative approach entails eliminating any information that is not needed, so as to enable the learners to focus their limited cognitive resources on the most important and relevant material. One should consider not only excluding all irrelevant information, but really focusing the learners on the most critical information by also excluding relevant information that is not actually that important. But for this we do not need technology, although technology can aid in pacing the learning. TEL can deal with cognitive load through a qualitative approach.

The qualitative approach, in contrast to the quantitative approach, deals with the efficiency with which information is conveyed rather than the amount of

information per se. Thus, using this approach, limited cognitive capacity does not necessitate reducing the amount of information the learners are exposed to and are expected to learn at any one time. One can considerably reduce cognitive load by tailoring the learning to the architecture of cognition. For example, due to limited cognitive capacity, the cognitive system has developed attention and selection mechanisms which focus processing on a subset of the information available. Using TEL, one can more easily determine what information is most critical and make this information more salient so as to aid the cognitive system to direct resources to the most valuable and critical cognitive relevant information. This can be accomplished by emphasising this information, for example, through correct use of colour, animation, and enhancing distinctiveness and uniqueness of critical features. We have used this TEL methodology to improve learning of aircraft identification. There are other sophisticated cognitive ways of using technology to achieve this qualitative approach, such as making the information more meaningful, cognitively engaging, involving deeper cognitive processing, and making it 'pop-out'.

Thus, using TEL enables more easily to construct learning materials in ways that are less cognitively demanding and taxing on the cognitive system. This can optimise the efficiency and effectiveness of how information is conveyed to the learner, which in turn enables the learners to acquire and memorise more. There are many ways technology can facilitate and enhance learning, both in terms of the efficient acquisition of information and in terms of the effective retention and use of the information. However, to achieve such efficiency and effectiveness the technology must be tailored to utilise and take advantage (as well as take into account the constraints and limits) of the way humans learn, remember, and use information: The human cognitive system. As stated above, the questions we ask in TEL should not focus on the technologies, but on the learners: For example, what does the learner take from the learning? What knowledge will be acquired? What will be remembered? And what will be used? It is naïve and would be a mistake to think, let alone take for granted, that using technology per se will enhance learning. In fact, using technology often hinders learning because it does not match and fit well the cognitive system. It is not the actual technology that is critical as much as when and how it is used. First, learning objectives need to be clear; not in order to justify the learning within the organisation hierarchy, nor in order to present these objectives to the learners themselves. Understanding the learning objectives in a deep way is critical so as to guide and constrain the use of technology so it actually promotes achieving these goals.

Ultimately, it is not what technology you use that counts, but what the learner takes from it that really matters. How the learners interpret, understand and internalise the learning material via technology is what the focus should be on. There are many factors that affect what the learners gain from TEL. To consider these issues a real transformation of our approach is needed: Rather than focusing on the

technologies in a vacuum isolated from the learners, to considering TEL from the learner's cognitive viewpoint. This is important because once the learning material is provided to the learner, the learning process does not end; it just begins. The learner is active in how (and if) the information is taken on board, remembered and used. Too many TEL are over focused on the technology rather than on the learners' cognition.

When considering the learners, we need to note that when the learning material is simply presented to the learners, they are passive and so learning is minimal. In contrast, when learners are active and motivated, when they are involved, participating, engaged, and interacting with the material, then learning is maximised. It is maximised because it activates and correctly taps the cognitive mechanisms of learning, such as attention, depth of processing, and other cognitive processes. Given the great importance of achieving the active participation of the learners, can TEL help accomplish this? The answer depends on utilising technology so as to promote what I call the three C's of learning: Control, Challenge, and Commitment. Each of these is not easily achieved, but if technology can support them, then it can offer great gains and benefits that make TEL worthwhile. The shift from merely exposing the learners to the material to utilising the three C's transforms the learning, leading it to a higher level and quality. This new level of learning is more sophisticated, superior, and can achieve short and long term objectives that otherwise are not possible. In what follows, I discuss each of the three C's, not only pointing out why they are crucial, but also elaborating on how technology can be constructed to incorporate them.

The learners' control can take many forms and can be viewed as a continuum. At one extreme, control is totally surrendered to the learners, giving them full freedom to do (or not do) as they please. At the other extreme of the continuum, the learners have no control at all; they blindly (and passively) follow what is determined and dictated by the learning program. Since giving the learners control supports and promotes learning, it follows that TEL should maximise the learners' control. However, giving them control can also be detrimental to learning. Thus, it is important to understand why and how it fits (or not) your learning program and carefully consider this issue. Before explicating practical ways in which technologies can help shift control from the learning developers to the learners, I want to draw attention to some potential problems in giving the learners more control. If the learners control the learning (or even part of it), this adds another cognitive task to their system. In addition to actually acquiring the learning material and encoding it properly so it is easily retained and used, the learners will need to exercise control over the learning itself. This control may involve understanding and considering alternatives, making decisions (and sometimes needing to remember them), taking actions, and so forth. These processes are an additional burden

on the cognitive system, which is (should be) involved and focused on the actual learning material; the result is an increase of the overall cognitive load. Furthermore, the learning material may have an inner structure, a logical way and flow in which it can be best learned. Therefore, giving the learners control may also interfere and even conflict with the optimum way of delivering the learning. Nevertheless, shifting control to the learners is an excellent way to enhance learning and should always be maximised, whenever possible. However, as discussed above, one must achieve the correct balance, and consider when, where, and how it can have the greatest benefit, and how technologies can play a role. This brings me to examine some of the practical ways in which control can be given to the learners via technologies.

The ultimate way of giving the learners control is letting them determine if and what they need to learn via a LMS (learning management system). This enables them to decide which learning modules will be learned from a variety of available programs, or to decide within a single module which elements will be covered. Such freedom may result in material not being studied and hence not learned at all; however, the learning that is chosen will be learned more effectively. Furthermore, if the learners are forced to 'learn' things that they do not need (or that they think they do not need), then they may 'shut down' and disengage, thereby not learning any of the material well. If control is given to such a major extent, it is important to provide the learners with help so that they are able to use this freedom wisely. This entails a clear understanding of the options and what is offered within each alternative. More important and critical is helping the learners 'know what they know' and 'know what they need to know'. Such knowledge about knowledge falls within the area of meta-cognition, and is an inherent part of learning.

At a more basic level, rather than giving learners control of what they learn, technology can more easily give the learners control over the order in which topics are covered. Sometimes this order is rigid because of inter-dependencies whereby one concept/content must be covered before the other. However, many times there are degrees of freedom that allow different sequences of learning. This flexibility can be used to increase the scope of control that is provided to the learners. The learners can also receive more control, via technology, over the presentation format of the material. Because learners have different experiences, cognitive styles, etc., they may have preferences for the way the material is delivered (for example, visual vs. auditory, text vs. diagrams, etc.). Giving them control over the format of presentation not only gives them control, but also optimises and tailors the learning to the individual learner. Finally, at the most basic level, learners can control the pace of learning (e.g., when to move on to the next item/page, and whether to repeat a section before moving on to the next).

Even the more basic levels of control give the learners some ownership of the learning process. This significantly improves learning, both in terms of achieving the learning objectives and in terms of the learners' positive affect. Even the mere illusion of control (i.e., giving the learners a feeling that they control the learning when in fact they do not) can be a step in improving the learning outcomes. TEL can be an aid in this area.

For the learners to be further motivated, engaged, involved, participating, and interacting, the learning must be challenging. If the learning is deemed boring, as simply going through the motions, then learning is minimised. Learning is drastically enhanced when the learners find it challenging. Challenging does not mean making it unduly complicated and complex. Learning can be made challenging in a number of ways and on different fronts. First, regarding the learning material itself, the learning material can be made challenging if it is presented in an interesting way that requires the learners to think about it, to reflect and figure things out. If the learning feels more like a puzzle, a mystery that the learners solve, then it is challenging. If the learners feel that they have accomplished something, if they feel good about themselves, if they are proud, then the learning is challenging. Can technology enhance this? Yes, of course, but only if used properly. For example, using gaming technology can really make the learning fun, challenging, and interactive. Many times, getting people to take formal learning courses is like 'beating a dead horse'; however, when you introduce a computer game the 'dead horse' transforms itself to a 'racing horse'.

TEL can present learning via a gaming framework, which offers a wide range of benefits. For instance, learning can be made challenging not only by modifying how the material is presented and the role of the learners, but also by providing clear signs, measurements, and feedback about the learners' advancement and progression. These should be clearly laid out throughout the learning game so the learners can see how well they are doing. As they advance and progress, they should be provided with a clear measurement of their success and receive positive self-enhancing feedback. The learners should not merely be provided with a progression measurement (e.g., how much they have gone through or/and how much they still need to do), but they should be given challenges to achieve certain levels of performance, or they should be encouraged to generate their own goals. These types of challenges can be further encouraged and supported by external recognition and awards. Furthermore, depending on the context and the organisational culture, this type of challenge can also be extended across learners whereby different learners compete for the best performance achieved. If the learners are not committed to the learning, then it is an uphill struggle (or a lost battle…). Commitment to the learning underpins many aspects of learning; however, getting the learners to commit is not easy. As discussed, control and challenge contribute to

commitment, but commitment is elusive and difficult to achieve. Some learners come committed, others are only loosely committed, if at all. Although commitment is a personal trait to some extent, it can be enhanced by using TEL. Our example of gaming is one way to help achieve this.

The three C's of learning: Control, Challenge, and Commitment, help to establish active and motivated learners. They bring about engagement, involvement, participation, and interaction. These are all critical ingredients for achieving effective and efficient learning because they maximise many cognitive mechanisms. Otherwise, passively exposing the learners to the material undermines the very objectives of learning. Technology can enhance learning by helping to promote and achieve them. The three C's are not independent or exclusive, they affect one another and there are additional ways to support active learning. The three C's are an illustration of a way of thinking, of an approach to how technologies can be utilised to enhance learning. Having active and motivated learners will better achieve learning objectives and learning technologies should be constructed to incorporate them as much as possible.

As I have tried to illustrate, the issues surrounding the use of technology for learning are complex. They are intertwined with human cognition, how people learn, store information and use it. Thus, we must consider TEL in light of, and subservient to, the human cognitive system. Only then can we construct effective TEL and start to consider the effects it has on the cognitive system itself. It is a broad issue, but one of significant practical, as well as psychological and cognitive importance. The title of this paper is TEL: The good, the bad, and the ugly. I have provided material and thoughts for the readers themselves to determine what the good, bad, and ugly aspects of TEL are. It should be clear that technologies offer a great and powerful tool which can enhance learning. This good aspect needs to be considered and understood in light of the limitations of TEL, and the potential bad outcomes that are possible by incorrectly using this tool. Using technologies just for the sake of using them, and thus transcribing the learning material from one medium to another, is not a matter of bad vs. good use, but an inappropriate, and if you want, an ugly, use (misuse) of learning technologies. New horizons and opportunities are now presented by learning technologies, but let us use them wisely, based on scientific knowledge. Otherwise, these technologies are doomed to failure, taking with them those who use them.

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