# HUMAN COMPUTER INTERACTION (HCI) FACTORS IN TECHNOLOGY ENHANCED LEARNING

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## Abstract

Today there is an increasing emphasis on technology in the learning process. There may therefore be benefit in considering how lessons from Human Computer Interaction (HCI) can be applied to improve student engagement in learning. HCI provides many relevant theories that are significant in the context of learning and retrieval of knowledge as well as influences that are significant in relation to pedagogies. Research, including work on making training and technology interactive, suggests that when users are properly cognitively involved, engaged, and challenged the outcomes are better. Challenges include creating memorable learning experiences to encourage long lasting mental representations that enhance learning.

## Human Computer Interaction (HCI) and Learning

Throughout history there have been many noteworthy influences on the development of understanding learning. From the *Age of Enlightenment* there are the contributions of the influential philosopher, John Locke (as cited in Stanford Encyclopedia of Philosophy, 2012) who believed, "Humans are born as a 'blank slate' and acquire knowledge through experience and sense perception." From my perspective, Human Computer Interaction (HCI) can be defined as:

> A discipline concerned with the study, design, construction and implementation of human-centred interactive computer systems. HCI goes beyond designing screens and menus that are easier to use and studies the reasoning behind building specific functionality into computers and the long-term effects that systems will have on humans.

This paper examines the importance of HCI in learning through a discussion on the role of HCI in learning, links HCI with educational theories and finally provides examples to illustrate the important lessons that can be learned by taking account of currently knowledge and research in this field.

Advances in technology in recent years has meant that a wide variety of technology such as PCs, laptops, the Internet, mobile devices, tablets, smart phones are becoming embedded into our everyday lives and the modern society today. Web 2.0 has brought not just technological advances but social changes. Student experience with mobile devices such as smart phones, tablet devices and laptops means that they are often familiar with instant access to online resources and expect to be able to use them as part of their own individual learning.

Recently, there has been increased interest in the importance of HCI in learning sciences. In his keynote at the International Conference of the Learning Sciences ICLS 2012, Pierre Dillenbourg made the case that many of the important problems of learning / education are not primarily addressed through innovations in learning theory but by addressing important problems through useful, usable, perhaps innovative designs (a particular emphasis in HCI).

HCI is very much a multi-disciplinary study of how humans interact with technology. Many of these disciplines, such as cognitive psychology, sociology, computing, artificial intelligence and linguistics all have a direct bearing on learning. HCI provides a number of relevant theories of *memory, attention, perception*, and *knowledge* that are particularly significant when it comes to the acquisition, storage and retrieval of knowledge – particularly heuristic knowledge gained through experience – learning by doing.

The ***learning society*** is often referred to a society that is "founded on the *acquisition, renewal* and use of *knowledge*" (emphasis by author) moving the focus from teaching/teacher to learning/learner and from formal to a much more self-directed form of "learning throughout life experiences" (Ku Pearce, & Smith, 2010, p.329). In this context, acquiring knowledge is not the same as acquiring information. The role of computing technology in a knowledge-based society has become increasingly important by providing easy access to data, facts, and information as well as helping the learner transform information into knowledge. The individual is becoming much more responsible for developing his/her own skills. Knowledge about facts is becoming less important than learning how to access, analyse and exploit information and transform it into new knowledge.

HCI has long been concerned with accessibility and principles for designing interactive technologies for diverse users. Aspirations of overcoming the Digital Divide, through providing universality and accessibility for all, have become major concerns in HCI (Shneiderman, 2002).

Many tools we are familiar with today may be enhanced to provide advanced data services. A good example of this is the newspaper, which in the future may have flexible content which can present data, information and knowledge in many innovative forms, for example, virtual reality, 3D, 4D and multiple dimensions of visualization. These advanced capabilities will have the power to transform the way we currently view teaching and learning into a much more flexible, tailored, customizable set of tools to improve the engagement of students. The more "fun" an interface is the more likely the student is to engage successfully with their own learning (Raymer, 2011).

There are many opportunities to investigate this area further with HCI principles in mind. The way humans use memory and how this further influences learning is crucial when researching how students might gather and store new facts, information and knowledge. The active learning approach is

based to a large extent on a social constructionist view of learning and in particular much of the work of Biggs (1996) on *constructive alignment.*

According to Biggs, "The teacher's task is not to transmit correct understandings but to help students construct understandings that are more or less acceptable"(1996, p.148). Geoff Petty (Petty, 2004) described this as learning by doing. He stated, "Research shows that active learning is much better recalled, enjoyed and understood. Active methods require us to 'make our own meaning', that is, develop our own conceptualizations of what we are learning" (2004, p.239). During this process we physically make neural connections in our brain, the process we call learning. Passive methods such as listening do not require us to make these neural connections or conceptualizations. Active methods also develop thinking skills such as analysis, problem solving, and evaluation and are more fun.

### HCI influences on Pedagogies Relevant to Online Learning

Two pedagogies influential in online teaching and learning that are relevant to this discussion are social constructivism and connectivism. Social constructivism, particularly based on the work of Vygotsky (Vygotsky, 1978) emphasises the social aspects of learning. Put simply, this involves students constructing their own knowledge through discussion or collaboration and ideas being constructed from experience to have a personal meaning for the student. Vygotsky's theory involves learning contexts in which students play an active role in learning. Siemen's theory of connectivism (Siemens, 2004) on the other hand, is concerned with learning through our connections and by making connections, tapping into networks, accessing resources, connecting ideas. This leads logically to knowing where to find information being more important than what we know. This is particularly relevant in the Internet age. Today, Siemens suggested, "The pipe is more important than the content within the pipe" (2004, p. 6). These pedagogies require supporting opportunities for collaboration, interaction, discussion and finding resources.

## Learning and Technological Changes

Over the past twenty years or so, technology has transformed how we live our lives, how we communicate, and how we learn. Advances in technology in recent years has meant that a wide variety of technology such as PCs, laptops, the Internet, mobile devices, tablets, smart phones are becoming embedded into our everyday lives and the modern society today. These technologies have become so embedded that changes to the technology results in changes to society. The move from Web 1.0 to Web 2.0 has changed the way many users interact with technology. They are no longer merely passive recipients but have become active content creators. Web 2.0 has brought not just technological advances but social changes. These changes present challenges for Web-based education, including how, where, and when learning happens. Student experiences with these types of devices means that they are often familiar with instant access to online resources and expect to be able to use them as part of their own individual learning. It is reasonable therefore that learning needs and theories that describe learning principles and processes should reflect those of underlying social environments.

In a 2010 Cisco Report called *The Learning Society* (Halkett, 2010) the author suggested,

> The future of education is networked. Using the full power of video and mobility, people can collaborate to create and share knowledge as well as develop new ways of teaching and learning that captures the attention and imagination of learners anywhere, anytime on any device. (Halkett, 2010, p.12)

The report goes on to highlight significant developments in learning research:

- Learning is an active, social process. - Learners learn new knowledge, principles, and concepts for themselves through dialogue and interaction with others, such as teachers and peers, as well as interacting with their learning environment.
- Motivation is critical to effective learning. - Levels of motivation and emotional states, positive or negative, can be critical in effective learning.
- Learners bring different knowledge to a new learning challenge. - Learners have prior knowledge no matter how inaccurate or narrow. Effective learning builds on this, engages with it and progressively moves towards new understanding, step-by-step. This highlights the role of formative assessment in establishing current levels of understanding in order to be able to monitor progress.
- Learners start from different places and take different routes to the learning outcome.
- To be effective, knowledge should be discovered as an authentic, integrated whole.

## Technology Enhanced Learning

JISC (2010) defined a ***technology enhanced learning*** culture where a wide range of learners (e.g., full-time, part-time, professionals, overseas) is provided with a robust technology environment that provides the learning opportunities wherever the learner chooses.

Goodyear and Retalis (Goodyear, 2010) used the term to cover all those circumstances where technology plays a significant role in making learning more effective, efficient or enjoyable. They included both hardware – such as interactive whiteboards, smart tables, handheld technologies, tangible objects – and software, e.g., computer-supported collaborative learning systems, learning management systems, simulation modelling tools, online repositories of learning content and scientific data, educational games, web 2.0 social applications, 3D virtual reality, etc.

## Learning, Technology and Cognitive Aspects

There have been many innovative philosophies such as those proposed by Maria Montessori in the late 20$^{th}$ century. Her educational approach encourages experimentation and independent thinking rather than the more

mainstream pre-determined textbook curriculum (Scicluna, 2012). HCI can contribute greatly in this area since there is a recognition and acceptance of human differences and diversity that education needs to take account of.

Dror (2008) said:

> Learning means that the cognitive system acquires information and stores it for future 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 utilized and behaviour modified. (215)

He described how training (whether traditional, e-learning, or blended learning) is inextricably linked to connections and dependence on the human cognitive system. Research, including work on making training and technology interactive, has found that when users are properly-cognitively involved, engaged, and challenged the outcomes are better.

***Technology can be made more effective by making it interactive***.

The challenge is to create mental representations that are long lasting and effect behaviour, something best done by creating memorable learning experiences targeting specific brain structures. Patricia Chalmers (Chalmers, 2003) described the difficulty of learning and remembering information merely presented on a computer screen, for example, on a website, asking ‘‘Where am I?’’ or ‘‘Where was I?’’ or ‘‘Where am I going?’’ She explained this as understanding where new knowledge fits into ‘‘the big picture.’’

## Interfaces

Online teaching requires particular attention to the interface. Improvements to the interface can directly benefit the student learning experience. Virginia Commonwealth University has published a white paper on Online Teaching and Learning (VCU, 2009), which stressed the recent changes on the Web toward a more social and interconnected space making it necessary to examine online teaching and learning and the implications of the social web for learning online. There is reference to research carried out by Chickering and Gamson (Chickering & Gamson, 1987) that discussed Seven Principles for Good Practice in Undergraduate Education viewed as central to effective teaching. This can be summarised as encouraging student-faculty contact, cooperation among students, active learning, giving prompt feedback, emphasizing timings, communicating high expectations and respecting diverse talents and ways of learning. The white paper also presents a number of scenarios, e.g., Myers-Brigg Personality Inventory to decide how to allocate teams, podcasts, screencasts, wikis, and YouTube.

## Technologies: An example - Clickers

Clickers are an example of how I have recently used innovative technologies in an attempt to improve student engagement in some classes. Clickers are small hand-held devices that allow students/audiences to answer questions by pressing buttons on the handset in a “Who

Wants to be a Millionaire" style of participation. There are many researchers who have contributed to this field. Bruff (2009) found that Clickers were less effective if merely used for tracking and evaluation, but were of particular benefit for use in class as well as small group discussions making classes more fun and providing opportunities for "teachable moments."

Other researchers (Mayer et al., 2009; Yourstone, Kraye, & Albaum, 2008) have focused on the quality of class interaction and cognitive processing. Duncan (2007), Plant (2007) and Stowell and Nelson (2007) have researched student satisfaction, and Pileggi and O'Neill (2008) looked at teamwork.

## HCI experiment: Memory enhancement using visualisation

One example taken from a recent HCI class is to investigate improving memory. Students are asked to supply ten objects from their possessions. These ten objects are then visualised interacting with objects linked to the numbers 1 to 10. One links with bun (visualise any form of bun, e.g., burger bun or sticky bun with white icing), two is shoe, three is tree, four is door, five is hive, six is sticks, and so on for all ten numbers. Students then visualise one of the volunteered objects interacting with one of these items. Particularly memorable examples include: lip gloss interacting with eight (gate) – in this case a student suggested a cow looking over the gate with sticky, glossy lips – the lip gloss – an unforgettable image. Another student suggested handbag as the item interacting with two (shoe) – their comment was girls always carry spare shoes in their handbag. Ten weeks later the class could remember all ten random items.

The expression, "A picture is worth a thousand stories," refers to the concept that a complex idea can be simplified with an image. This method takes advantage of a fact about human memory: most people remember images better than verbal or written information. Images are concrete, while raw information is often abstract. The goal of visualisation is to present large amounts of data easily and understandable. This has implications for online learning since there are many innovative, creative ways of using visualisation to assist in the learning process by providing opportunities for improving memorability. HCI provides much research on memory and how we use it. With advances in human-focused technology and design, memory aids are progressing from simple strategies, such as mnemonics and visual associations, towards workstations and wearable computer systems that actively augment the user's memory.

## Lessons from gaming and HCI

Lessons can be learned from the computer games community. There is great learning potential in the virtual environments of gaming. Computer games such as *World of Warcraft* and *Grand Theft Auto* are problem-solving spaces described as ***situated learning*** since the player is situated in an actual problem-solving space. Education can learn a lot from computer games about effective ways to teach. For example, games provide information when it is needed, instead of all at once in the beginning, when it is usually forgotten by the time it is needed. *Assessment* is another area for improvement. In games,

assessment and learning are tightly aligned; games constantly assess player performance and provide feedback. Most games are engaging and addictive with every success bringing another new challenge. Once you start playing, it is difficult to stop.
*Engagement* is an important concept in HCI, not only for informing the design and implementation of interfaces, but also for enabling more sophisticated interfaces capable of adapting to users. Engagement has often been described as occurring when the brain is rewarded, and that for something to be perceived as rewarding, it must evoke positive emotions. Two essential components to the perception of something being rewarding are wanting and liking. Dix, Finlay, Abowd and Beale (2004) in their HCI textbook, describe ***reward*** as essentially positive reinforcement of desired or good behaviour. This could be through providing explicit praise (used frequently in educational systems when a correct answer is given) or through more implicit elements that engage or entertain the user. Novelty, social interaction, feedback and surprise are all potentially rewarding to the user. For example, seeing a direct relationship between action and effect (feedback) can be rewarding.
Rodgers, Sharp, and Preece (2011) in *Interaction Design: Beyond Human-Computer Interaction* discuss *affective learning* as a way to design systems to elicit positive responses from users (feeling at ease, being comfortable, enjoying the experience) and topics such as user frustration caused by an interface and how interface agents (anthropomorphism) and synthetic characters affect us. Brave and Nass (2002) also examine the effects of emotions during HCI and how emotions tend to alter attention and memory, bias judgment and motivate behaviour.

HCI is often focused on software interfaces; however, the principles of good interface design can be applied in many situations, for example, creating a website, a mobile phone, or an intelligent fridge. Intuitive design relies on understanding human psychology. ***Usability*** is a measure of the effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in a particular environment. By following these principles, it is possible to create systems where the relationships between the user's goals, the required actions, and the results are sensible, meaningful and not arbitrary. *Feedback* is deemed to be essential in HCI in a useable interactive interface. Donald Norman defines three principles of interactive design in his book *The Design of Everyday Things* (Norman, 2002, pp. 4-10) . These are:

1. **Visibility**: It should be obvious what a control is used for. Good visibility allows the user to easily translate goals into actions.
2. **Affordance**: It should be obvious how a control is used. A button affords (suggests) pushing, a lever affords pulling, etc. The user should know how to operate a control just by looking at it.
3. **Feedback**: It should be obvious when a control has been used. This relates to the information sent back to the user about what has been achieved, e.g., sound, highlighting, animation etc.

Another feature of gaming that could apply to education is the practice of modification or *customisation*. Many game developers encourage players to modify their products and encourage users to create things like new maps or

scenarios. In HCI it is recognised that users are different, hence a diverse, inclusive, individualised environment will have many benefits. Dyck, Pinelle, Brown, and Gutwin (2003) analysed several current game interfaces looking for ideas that could be applied more widely including the suggestion that games allow:

- **Effortless community** – easy to form, join, and participate in communities of users;
- **Learning by watching** – 'over the shoulder' of more experienced users as they work;
- **Deep customizability** – allow users to modify interfaces and share these with others; and
- **Fluid system-human interaction** –communicate information to users in ways that do not demand the user's attention and do not interrupt the flow of work.

These ideas have arisen in games because of their focus on user performance and user satisfaction, and we believe that they can help to improve the usability of other types of applications.

## Conclusion

Undoubtedly, technology is going to play a significant part in education in the future. The way we learn today has changed significantly over time and the pace of technological change has been a significant contributory factor. Today students can access information in a variety of different methods that they can choose to best suit their own individual learning styles. Studies have shown that attention spans of the average student have decreased as we become more used to expecting instantaneous access to information online. The "instant gratification" effect which students have come to expect from the latest technologies such as computers, Internet, mobile and tablet devices, gesture and speech recognition, and intelligent search engine capabilities have enabled virtual libraries of knowledge to be available at the click of a finger.

In a well-designed technology-enhanced learning environment learners should be able to engage in the process of manipulating information and critical thinking as well as expressing and sharing their knowledge to peer-learners.

By working together, many disciplines such as HCI, Learning, and Games can hopefully make this a much more enjoyable and engaging experience. These are exciting times for education and there is little doubt that educational practice will evolve as technological innovations continue to evolve.
HCI has much to contribute.

## References

Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher Education 32,* 347-364.

Brave, S., & Nass, C. (2002). Emotion in human-computer interaction. In J. Jacko, & A. Sears (Eds.), *The human-computer interaction handbook:*

*Fundamentals, evolving technologies and emerging applications.* Retrieved from:http://lrcm.com.umontreal.ca/dufresne/COM7162/EmotionHumanInteraction.pdf

Bruff, D. (2009). *Teaching with classroom response systems: Creating active learning environments*. San Francisco: Jossey-Bass.

Chalmers, P.A. (2003). The role of cognitive theory in human–computer interface. *Computers in Human Behaviour, 19*, 593–607.

Chickering, A. W., & Gamson, Z. F. (1987). Seven principles for good practice in undergraduate education. *American Association of Higher Education Bulletin*. *39* (7) pp.3-7.

Dix, A., Finlay, J., Abowd, G., & Beale, R. (2004). *Human-computer interaction* (3rd ed.). London: Prentice Hall. ISBN 0-13-239864-8.

Dror, I. E. (2008). Technology enhanced learning: The good, the bad, and the ugly. *Pragmatics & Cognition, 16*(2), 215–223.

Duncan, D. (2007). Clickers: A new teaching aid with exceptional promise. *Astronomy Education Review, 1*(5), 70-88.

Dyck, J., Pinelle, D., Brown, B., & Gutwin, C. (2003). Learning from games: HCI design innovations in entertainment software. In *Proceedings of Graphics Interface 2003* (pp.237-246). Accessed at: http://hci.usask.ca/publications/2003/games-gi03.pdf.

Goodyear, P., Retalis, S. (Eds.). (2010). *Technology-enhanced learning: Design patterns and pattern languages.* Rotterdam: Sense Publishers.

Halkett, R. (2010). *The learning society*. San Jose, CA: Cisco Systems. 12-14. Retrieved from http://www.cisco.com/web/about/citizenship/socio-economic/docs/LearningSociety_WhitePaper.pdf

JISC. (2009). JISC Strategy 2010 - 2012. Retrieved from http://www.jisc.ac.uk/publications.aspx

Ku, D., Pearce, J., & Smith, W. (2010). Can traditional HCI principles be applied to computing technology in learning contexts? *Proceedings of the 2010 Australasian Computer Human Interaction Conference* (OzCHI 2010) (pp. 328-331) Brisbane, Queensland: IEEE . Retrieved from http://people. eng.unimelb .edu.au/jonmp/pubs/OzCHI%202010/p328-ku.pdf

Mayer, R. E., Stull, A., DeLeeuw, K., Almeroth, K., Bimber, B, Chun, D., Bugler, M., Campbell, J., Knight, A., & Zhang, H. (2009). Clickers in college classrooms: Fostering learning with questioning methods in large lecture classes. *Contemporary Educational Psychology, 34*(1), 51-57.

Norman D. (2002) *The design of everyday things*. New York: Basic Books. (Reprint from Norman, D. [1988] *Psychology of everyday things*. New York: Basic Books.)

Petty, G. (2004). *Teaching today: A practical guide* (3rd ed.). Cheltenham, UK: Nelson Thornes Ltd. 239-241. Accessed 26th May 2013 at: http://www.geoffpetty.com/activelearning.html

Pileggi, R., & O'Neill, P. N. (2008). Team-based learning using an audience response system: An innovative method of teaching diagnosis to undergraduate dental students. *Journal of Dental Education, 72*, 1182-1188.

Plant, J. D. (2007). Incorporating an audience response system into a veterinary dermatology lecture: Effect on student knowledge retention and satisfaction. *Journal of Veterinary Medicine Education, 34* (5), 674-676.

Raymer R. (2011). Gamification: Using game mechanics to enhance elearning. *e-Learn Magazine*.. Accessed May 7, 2013 at http://elearnmag.acm.org/featured.cfm?aid=2031772

Rodgers, Y., Sharp, H., & Preece, J. (2011). *Interaction design: Beyond human-computer interaction*. Chichester, UK: John Wiley & Sons Ltd.

Shneiderman, B. (2002). *Leonardo's laptop.* Cambridge, MA: MIT Press.

Scicluna, L. (2007, May). Philosophy of education. *Everything Philosophy* Accessed 3rd May 2012 at .http://www.everythingphilosophy.com/philosophy-of-education/

Stanford Encyclopaedia of Philosophy (SEP). (2012). John Locke. Accessed May 7, 2013 at http://plato.stanford.edu/entries/locke /

Siemens, G. (2004). Connectivism: A learning theory for the digital age. *elearnspace everything elearning*. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.87.3793&rep=rep1&type=pdf

Stowell, J. R., & Nelson, J. M. (2007). Benefits of electronic audience response systems on student participation, learning and emotion. *Teaching of Psychology, 34*(4), 253-258.

Virginia Commonwealth University (VCU). (2009). Building from content to community: (Re) Thinking the transition to online teaching and learning. Watwood B., Nugent j., Deihl W. Accessed 26th May 2013 at http://www.vcu.edu/cte/pdfs/OnlineTeachingWhitePaper.pdf

Vygotsky, L.S. (1978). *Mind and society: The development of higher mental processes*. Cambridge, MA: Harvard University Press.

Yourstone, S. A., Kraye, H.S., & Albaum, G. (2008). Classroom questioning with immediate electronic response: Do clickers improve learning? *Decision Sciences Journal of Innovative Education, 6*(1), 75-88.

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