How can ‘scaffolding’ be used as an instructional design technique in corporate e-learning?

Self-paced e-learning has become a common feature of corporate training around the world, with an estimated global market value of USD 12 billion in 2015 (Business Wire, 2016). This type of e-learning tends to be provided via a central library, or Learning Management System, that employees can access whenever they want to update their skills or are asked to complete mandatory training. However, the ease of measuring cost savings and difficulty of measuring educational outcomes raises questions about how well corporate e-learning is designed for how people learn (see Strother, 2002), and may have contributed to some commentators arguing that:

> ‘most instructional procedures were developed without any consideration or knowledge of the structure of information or cognitive architecture’ (Paas, Renkl and Sweller, 2003, p 2).

It is easy for the e-learning developers and instructional designers involved in the development of such ‘instructional procedures’ to make false assumptions about the way that human memory works. The oft repeated comparison between human memory and computer memory could lead one to believe that if information is presented to a learner, they will be able to recall it just as a computer can do. Yet Roszak (1994, p 96) points out that the metaphor of ‘computer memory’ can only loosely be applied to the way that the human brain works. Where a computer can ‘regurgitate everything it has stored exactly as it was entered’ (*Ibid.*), human ‘working memory’ can hold only a few pieces of information at any one time (Paas, Renkl and Sweller, 2003, p 2).

If corporate e-learning is to have educational outcomes, rather than simply reducing costs or ‘ticking a box’ for regulation (see Strother, 2002), it needs to be designed to work *with* learners’ cognitive architecture so that they actually learn from the experience. One way to do this is to make use of a range of techniques that can broadly be described as ‘scaffolding’, whereby the learner is provided with ‘a support structure that aids them in attaining a higher level of achievement’ than they would be able to attain unassisted (Shapiro, 2008, p 30).

Practical considerations for the implementation of these techniques, and questions raised for e-learning design, are considered below.

Defining ‘e-learning’

Before it is possible to explore the application of scaffolding to corporate ‘e-learning’, it is important to note that there is no universally recognised definition of this term. A survey looking at usage of the terms ‘distance learning’, ‘e-Learning’, and ‘online learning’ found that ‘expectations and perceptions of learning environment labels’ varied enormously (Moore, Dickson-Deane and Galyen, 2011) and often overlapped. Indeed, even the spelling of the term ‘elearning’ and use of the term ‘course’ were found to vary between those surveyed.

For this discussion, then, I take ‘e-learning’ to mean the same as Moore, Dickson-Deane and Galyen’s scenario example:

> 'A learning experience where the material is provided in a course management system (e.g. Blackboard, Sakai, etc.) which must be accessed via the Internet. You cannot interact with an instructor or class mates' (2011, Table 3).

This definition has been selected because it most closely resembles the e-learning that I am responsible for producing at work, and because it seems analogous to the description used by *Business Wire* (2016). However, it is problematic. In the author's survey, only 19% of respondents identified it as 'e-learning' (Moore, Dickson-Deane and Galyen, 2011, p 133). Additionally, if that same experience featured a facility to add comments, would this count as interaction with class mates?

Ultimately, there is no correct answer to this question. For the purposes of exploring 'scaffolding' as an educational technique in e-learning, it is enough to state that I will be focusing on courses that are self-paced, in that the student can complete them on their own, but are not self-directed, in that an instructor has created the content for the learner to follow.

Examples from outside of corporate e-learning might include Lynda.com or Codecademy.

Introducing 'scaffolding'

'Scaffolding' is a metaphor for tutor-led problem solving first described by Wood, Bruner and Ross (1976, p 89), but building somewhat on Vygotsky's 'Zone of Proximal Development' or 'ZPD' (1962, cited in Black, 2000; Sanders and Welk, 2005).

Put simply, a learner can either complete a task on their own or they can't. The ZPD exists between these two binary states, where the learner can complete a task if they have the support of a tutor. The concept of 'scaffolding' was introduced to describe this tutor support.

Wood, Bruner and Ross (1976, p 90) suggested that by controlling certain elements of a given task, a tutor helps the learner focus only on 'those elements that are within his range of competence'. As the learner then completes these elements, they develop comprehension of the overall solution and can eventually complete the whole task unassisted, learning to do so more quickly than they would have done without scaffolding.

Both Vygotsky and Wood, Bruner and Ross were describing the support provided by a human tutor, but the concept of 'scaffolding' has since been expanded to 'describe any number of support mechanisms, whether human, programmatic, or technological' (Shapiro, 2008, p 30).

Examples used in e-learning might include procedural support like a flowchart or checklist, feedback prompts triggered by particular behaviours, leading questions and partly-worked solutions (Van Merriënboer, Kirschner and Kester, 2003). More discrete scaffolding might take the form of what Shapiro (2008, p 30) calls 'embedded scaffolding': this being any design choice that supports learner understanding. For example, site maps or annotated links give some indication of the relationship between seemingly disparate information, supporting learner understanding and therefore acting as a scaffold.

Much of this embedded scaffolding provides a layer of meaning to content at such a basic level that the learner may not even consider them to be part of the instructional design (Shapiro, 2008, p 30). However, their inclusion reduces the metacognitive effort required on the part of the learner so that they do not need to think deeply about where to 'click next'.

In all of these examples, the purpose of the scaffold is to limit the task's cognitive load (CL), this being the total mental effort required to perform the task using the limited resources of working memory (Paas, Renkl and Sweller, 2003, p 2). This mental effort can be reduced by performing a simpler version of the task (reducing intrinsic CL) or through well-designed instructional materials (reducing extraneous CL).

For example, creating a complex spreadsheet in Microsoft Excel using a hard copy instruction manual might exceed a novice's ability, while creating a simple spreadsheet by following on-screen annotations might not.

Crucially, in this example, the scaffold is *integrated with the task* to avoid the 'split attention effect', whereby shifting focus from the computer-based task to the hard copy instructions increases extraneous cognitive load (Van Merriënboer, Kirschner and Kester, 2003, p 6). This effect is posited as one possible reason that learners who need the most support are least likely to use instructions (Carroll and Rosson, 1987, cited by Van Merriënboer, Kirschner and Kester, 2003, p 6).

Another consideration here is that this Microsoft Excel example relies on a *simplified version of the whole task* rather than learning part of the task separately. There is evidence that, although breaking a complex task into component parts can reduce cognitive load, this approach is either: a) not considered by learners (Papert, 1996, p 12) or b) results in difficulty transferring those skills learned separately to the whole task (Van Merriënboer, Kirschner and Kester, 2003, p 6).

The suggestion posited here is to use a scaffold to help the learner complete the simplified task, and to keep scaffolding as the task is made increasingly difficult so that the learner remains within the ZPD.

The need for these caveats, however, highlights a concern for anyone applying scaffolding to the design of self-paced e-learning: that careful consideration should be given to the sometimes counter-intuitive cognitive impact of design decisions.

This difficulty is further compounded by the difference in the impact that scaffolding can have on novices and experts.

Differences between novices and experts

The difference in perception of novices and experts has long been established. Chase and Simon (1973) showed that expert chess players are able to memorise the position of far more pieces on a chessboard than novices, when those chess pieces are arranged as if a game is in progress. That is to say, *when there is a logical relationship between those pieces* and they are not simply positioned at random.

This is consistent with the concept of *schemas*, 'cognitive constructs that incorporate multiple elements of information into a single element with a specific function' (Paas, Renkl and Sweller, 2003, p 2).

Essentially, a novice will look at the positions of chess pieces and perceive them as unrelated. They try to remember the position of each piece individually, resulting in a cognitive load that exceeds their capacity. An expert, on the other hand, will look at a chess board and see the two competing strategies of the players, such that they only have to remember those two strategies and their relationship to each other (for more on the impact of relationships on memory see: Norman, 2002, and Papert, 1996).

One common feature of many scaffolding devices is that they help to bridge this gap between novice and expert by demonstrating the relationships between seemingly unrelated pieces of information.

Shapiro (1998, cited in Shapiro, 2003, p 32) demonstrated this by exposing subjects with limited knowledge about ecosystems to a training system on the topic. Subjects who were supported by an interactive map (a scaffold) performed better on the post test than those who had no such support.

When this same experiment had been run on a topic that subjects were familiar with, animal families, the impact of the scaffold was reduced. As in the chess experiment, the experts had looked at the animal families and recognised the relationships between them, suggesting that as a foundation-level of knowledge or skill is established, the need for a scaffold decreases.

For the designer of self-paced e-learning, this raises a fresh consideration and, to an extent, marks the point where the 'scaffolding' metaphor breaks down. In the construction of a building, further physical scaffolding is required as the building gets taller. In learning, the use of scaffolding seems at times to be best suited to 'getting the learner started'. Once the learner has developed a foundational level of understanding, or *schema*, the impact of scaffolding devices is reduced unless the task is made more difficult. That is to say, an expert in animal families will benefit less from a scaffold than a novice, but a scaffold is likely to be useful if the task were expanded to include plant life.

Fading the scaffold

In a previous example, it was suggested that scaffolding could be used to support learners as they attempt increasingly difficult challenges in Microsoft Excel. Shapiro's experiment on the impact of scaffolding on learners who already have a foundation level of understanding suggests that, in some cases at least, better educational outcomes might be attained by 'fading' the scaffold (2008, p 38).

She points out that, for these learners, scaffolds can reduce the need for crucial metacognitive tasks like critical-thinking, questioning, and self-monitoring that would advance learner understanding. Applying this approach to the Microsoft Excel example might involve starting with on screen annotations, but gradually removing them until such a point that the learner is forced to think more deeply about what their next step will be.

For Shapiro (2008, p 41), too many people involved in the design of learning experiences focus on usability rather than evidence about how learners respond to scaffolds. Structuring information in such a way that it conveys a sense of order is a useful scaffold for novices and is likely to create an easy user experience. However, the ultimate aim of e-learning is to support learning, and making the user experience *more difficult* for the learner may be one way to do this.

One writer likely to balk at this idea is Donald Norman, whose book *Design of Everyday Things* (2002) has become a touchstone for designing user experiences. According to Norman, knowledge in the world like the labelling of computer keys removes the need for novices to go through the effort of learning how to type (p 56). However, if they are to increase their typing speed, they need to be able to type without looking at the keys.

Norman doesn't use the term 'scaffolding', but the labelling of computer keys performs this role. As the learner then masters typing, the scaffold starts to fade. Not because the labels have been removed, but because the learner no longer needs to look at them. The scaffolding has served its purpose and the learner has reached the logical endpoint of Shapiro's 'fading' suggestion: task mastery.

Learner control

This typing example is of course a specific context, but in one respect it leads into a final consideration for scaffolding e-learning: that of *learner control*. If better educational outcomes are sometimes possible by fading the scaffold, then who should decide when this happens?

As this essay refers specifically to e-learning with no learner-instructor interaction, it seems sensible to accept that the designer will have to make some decisions regarding scaffolding during the development. However, there are good reasons to include mechanisms that give the learner some control over this.

Bruning, Schraw and Ronning (1999, p 128) point out that the learning experiences that are most satisfying for learners are those that are moderately difficult[1]. That is to say, they take place within the Zone of Proximal Development. If they are too easy (excessively scaffolded), or too difficult (not scaffolded enough), this can have a detrimental impact on learner motivation.

Teachers in a classroom setting often struggle to find this balance because a heterogeneous group of learners will advance at different speeds (*Ibid.* p 128). When it comes to e-learning, this problem is compounded by a lack of contact between instructor and learner, by each individual learner's objectives, by the varying experience levels of learners and, in the case of mandatory compliance training, by the fact that some e-learning courses may be completed many times over.

One solution posited by Bruning, Schraw and Ronning is:

> 'to use individual mastery programs in which students work at a pace that is comfortable for them until each has mastered the core material included in a unit.' (1999, p. 129)

Rather than the instructional designer making decisions about whether scaffolding should be added or removed, good practice for the design of self-paced e-learning would be to give the learner control. For example, problem-solving exercises might include an option to view hints or demonstrations, or the learner might simply be given the opportunity to skip material altogether. Including scaffolding in this manner increases learner control and reduces the likelihood that their motivation to continue the e-learning will be reduced by content that is too fast, too slow, too difficult or too easy.

Conclusion

In this essay, scaffolding has been posited as a technique used in the design of corporate e-learning to limit cognitive load and work with what Paas, Renkl and Sweller (2003, p 2) refer to as 'cognitive architecture' to advance educational outcomes.

---

[1] It should be noted that Bruning, Schraw and Ronning are writing about the school classroom experience, but their observations are broadly applicable to adult learning when considered in light of Vygotsky's work on ZPD.

Of course, while the principles discussed go some way towards achieving this goal, it should be noted that designing any kind of learning experience will be heavily context-specific. For example, the level of scaffolding required will vary depending on whether learners are novices or experts. If the learner group consists of both novices and experts, the designer may want to give more control over the fading of scaffolding to the learners than they would do if designing entirely for novices.

After all, just as Alexander and Boud (2001, p 6) argue that there are good lectures and bad lectures, so too is there good e-learning and bad e-learning. The techniques described in this essay represent just some of the considerations that instructional designers may want to take into account on future projects to make sure that educational concerns are incorporated into design, and not just cost savings or compliance.

References

Alexander, S. and D. Boud (2001). Learners still learn from experience when online. In *Teaching and learning online; pedagogies for new technologies.* J. Stephenson (ed) (London, Kogan): pp. 3-15.

Business Wire, 2016. 'Global Corporate E-Learning Market to Reach over USD 31 Billion by 2020, says Technavio'. Available at: http://www.businesswire.com/news/home/20160129005032/en/Global-Corporate-E-learning-Market-Reach-USD-31. Retrieved: 6 April 2017.

Barzilai, S., & Blau, I. (2014). Scaffolding game-based learning: Impact on learning achievements, perceived learning, and game experiences. *Computers & Education*, *70*, 65-79.

Black, P. (2000). Research and the development of educational assessment. *Oxford Review of Education*, *26*(3-4), 407-419.

Bruning, R. H., G. J. Schraw and R. R. Ronning (1999). Beliefs about self. In *Cognitive psychology and instruction*. (Upper Saddle River, N.J., Merrill): pp. 110-136.

Chase, W. G., & Simon, H. A. (1973). Perception in chess. *Cognitive psychology*, *4*(1), 55-81.

Moore, J. L., Dickson-Deane, C., & Galyen, K. (2011). e-Learning, online learning, and distance learning environments: Are they the same?. *The Internet and Higher Education*, *14*(2), 129-135.

Morrison, G. R. and G. J. Anglin (2005) Research on Cognitive Load Theory: Application to E-Learning. *Educational Technology Research and Development 53:* 94-104.

Norman, D. A. (2002). Knowledge in the head and in the world. In *The design of everyday things.* (New York, Basic Books): pp. 54-80.

Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive load theory and instructional design: Recent developments. *Educational psychologist*, *38*(1): pp 1-4.

Papert, S. (1996) A word for learning. In *Constructionism in practice: designing, thinking, and learning in a digital world*. Y. B. Kafai and M. Resnick. Mahwah, N.J., Lawrence Erlbaum Associates: pp 9-24.

Phillips, J. A. (2015). Replacing traditional live lectures with online learning modules: Effects on learning and student perceptions. *Currents in Pharmacy Teaching and Learning*, *7*(6), 738-744.

Piaget, J. (1952). The origins of intelligence in children. (New York, NY: International Universities Press).

Roszak, T. (1994). Of Ideas and Data**.** In *The cult of information: a neo-Luddite treatise on high tech, artificial intelligence, and the true art of thinking*. (Berkeley, University of California Press).

Sanders, D., & Welk, D. S. (2005). Strategies to scaffold student learning: Applying Vygotsky's zone of proximal development. *Nurse Educator*, *30*(5), 203-207.

Shapiro, A. M. (2008). Hypermedia design as learner scaffolding. *Educational technology research and development*, *56*(1), 29-44.

Strother, J. B. (2002). An assessment of the effectiveness of e-learning in corporate training programs. *The International Review of Research in Open and Distributed Learning*, *3*(1).

Van Merriënboer, J. J., Kirschner, P. A., & Kester, L. (2003). Taking the load off a learner's mind: Instructional design for complex learning. *Educational psychologist*, *38*(1), 5-13.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of child psychology and psychiatry, 17*(2): pp. 89-100.