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The use of an e-learning constructivist solution in workplace learning

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ABSTRACT

We wished to investigate whether an e-learning approach which uses constructivist principles can be successfully applied to train employees in a highly specialised skill thought to require expert individuals and extensive prolonged training. The approach involved the development of an e-learning package which included simulations and interactivity, then experimental testing in a case study workplace environment with the collection of both quantitative and qualitative data to assess the effectiveness of the package. Our study shows that this e-learning strategy improved the skills of the inexperienced operator significantly. We therefore propose that such programmes could be used as a work based training aid and used as a model system for the training of employees in complex skilled tasks in the workplace. This research demonstrates that the e-learning can be applied outside the traditional learning environment to train unskilled employees to undertake complex practical tasks which traditionally would involve prohibitively expensive instruction. This work also illustrates that simulations and interactivity are powerful tools in the design of successful e-learning packages in preparing learners for real world practical situations. Finally this study shows that workplace learners can be better served by e-learning environments rather than conventional training as they allow asynchronous learning and private study which are valued by employees who have other demands on their time and are more comfortable receiving tuition privately

Relevance to industry: E-learning using constructivist principles, and incorporating simulations and interactivity can be used successfully in the training of highly specialised and skilled tasks required in the modern workplace.

1. Introduction

In recent years workplace learning has embraced technology to meet the demands of continuing professional development and general training of employees. Little research however has been undertaken in this field to assess the effectiveness of the methods used and the reception to these styles of teaching by the learners. E-learning package designers often apply similar principles to these packages as those aimed at students or younger learners with no evidence of their success.

It has been debated at length whether andragogy (andragogy is the term given to the education of the more mature learner (often in the workplace)) and pedagogy differ, Knowles (1980) reached the conclusion that four of the five assumptions applicable to children and students were actually also appropriate to adults. It was apparent to him that the only major difference that distinguished these two sets of learners was that adults have gained a range of experiences, whereas students have a limited amount and therefore, rather than the learning being based on chronological age it should be based upon such experience.

In this study we suggest that since learning in the workplace should be based on experience not only of related topics to the one being instructed but also of the learners' knowledge of their own learning style, constructivism rather than behaviourism or cognitivism should be the theories of choice for these learners. Indeed research on how people learn in the workplace demonstrates that what is taking place is often constructivist, situated learning, often through cognitive apprenticeship. The constructivism theory of learning considers learning to be an active process where learners construct concepts based on their own current and past knowledge. Two common themes of constructivism have been identified by Duffy and Cunningham (1996). First, learning is an active process of constructing rather than acquiring knowledge and second, instruction is a process of supporting construction rather than communicating knowledge. This leads to the emphasis on the importance of the learner gaining practical experience in an

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authentic learning situation. Brown et al. (1989) argue that learning and cognition are fundamentally situated and are in part a product of the activity or setting in which they are developed, emphasising that the learning experience is enhanced if the subject matter is as close to being a real world situation as possible, i.e. the "Fidelity Principle" (van Merrienboer and Kester 2005). Studies of practitioners in several professions by Farmer et al. (1992) reveal that what helped them most in learning to deal with ill-defined, complex, or risky situations is having someone model how to understand and deal with the situations and guide their attempts to do so. Jonassen (1992) calls for e-learning to embrace a constructivist approach to e-learning systems. In e-learning this is often accomplished through the use of interactive games or simulations (for example, Rieber, 1990 and de Jong and van Joolingen, 1998). Therefore simulation and interactivity in e-learning, as we will show, is the method of choice for training of complex tasks in the workplace.

Boud and Feletti (1991) proposed that learning should be initiated with a posed problem such as a query or a puzzle to be solved. This will motivate learners to identify and research concepts which apply to these problems. Brown and King (2000) listed the common threads running through current literature on the principles of learning and components of problem based learning (PBL) instructional design as: 1, anchor all learning activities to a larger task or problem; 2, support the learner in developing ownership and control of the problem—also called activeness; 3, design an authentic task problem; 4, design the task and environment to reflect the complexity of the environment—also known as multiplicity; 5, give ownership of the solution process to the learner; 6, design the learning to challenge, as well as support, the learner's thinking; 7, encourage testing alternative views; and 8, ensure reflection on both the content and the learning process. The package tested here makes full use of the PBL approach allowing trainees to not only simulate the problem but to attempt to solve it in a "safe" environment where mistakes are not critical and costs of frequent attempts are not limiting. Such a principle was suggested by Kofman and Sange, 1993 insisting that learning arises through practice and performance and is a proven strategy in workplace learning as demonstrated by Wang (2002). Thus the package takes on the role of instructor entering into a mixed media "dialog" with the learner so that they can gauge their current level of performance on a task and be advised on possible areas that need improvement. This concept of dynamic assessment was suggested by Holt and Willard-Holt (2000) and we believe underpins constructivist learning. Furthermore the supportive feedback created by such assessment aids further development and encourages the learner to try further assessments and focus their development, stressed as good constructivist practice by Green and Gredler (2002). In addition the approach suggests that learners should be allowed repeated experience of different variations of the task adding to their index of knowledge (utilizing the "Variability Principle" van Merrienboer and Kester (2005)), with the active engagement reinforcing learning process.

In encompassing these features, designers of e-learning packages also need to be mindful of the usability of the software. Since the learners are using the package autonomously and asynchronously the interactive features need to be intuitive and kept relevant to the learning process. Designers must employ all the principles of user centred design. Greitzer (2002) reported that many e-learning applications employ state of the art multimedia and interactive technology but fail to meet their expected training potential. This can be the result of poor design, organisation of the content or usability, leading to the cognitive ability of the learner being compromised. Cognitive theories state that human memory is comprised of very limited working memory (Miller 1956) yet unlimited long term memory (Atkinson and Shiffrin 1968), however associated and organisational processes play an important role with the exploitation of relationships between items being used to assist learning (Anderson and Bower 1973). If knowledge is presented in an unordered or confusing way or the e-learning package is difficult to use cognitive load will be high. Thus e-learning systems must constantly strive to provide learners with interfaces that keep cognitive load low as well as engage the learner relevant material. Thus Carroll suggested that the most effective approach is to encourage learners to work immediately on meaningful, realistic tasks within a user friendly environment; to reduce reading time and passive activity; take advantage of prior knowledge and allow mistakes to be pedagogically productive (Carroll, 1987, 1990).

This study examines the use of simulation embedded in constructivist learning theory to empower computer interaction in assisting cognition. We assess both the effectiveness of the approach as well as the learners' perceptions of the usefulness of the package.

1.1. The problem

Meat from the domestic pig (*Sus scrofa*) accounts for 42% of consumption worldwide and thus improvement of prolificacy in pigs is a critical objective of the meat producing industry. There is a pyramidal structure to pig breeding in most developed countries, in that most or all piglets are the direct descendants of a small number of boars. Therefore fertility problems in individual sires are likely to have significant, adverse effects on pig production. Pig semen is analysed at artificial insemination centres for concentration, morphology and motility however these parameters show only a weak correlation with prolificacy. Boar fertility is usually deduced from "none-return rates" i.e. the proportion of sows that do not return to heat divided by the total number of sows served by a particular boar. These figures are often only gathered towards the end of a boar's reproductive life by which time they may have already passed on any fertility defect to their sons (Sygen International, personal communication; Popescu et al., 1984; Quilter et al. 2003; http://www.pig-genetics.co.uk/breeding.htm).

The weight of evidence suggests that the most common cause of reduced fertility in boars is chromosomal abnormality, i.e. a gross rearrangement of the genome (chromosomes) that can be picked up by microscopy analysis. In a series of studies, Ducos and colleagues (e.g. Ducos et al., 1996, 1997, 1998a, b; Pinton et al., 2000) using strictly determined criteria for none-return rates suggested that around 10% of boars are hypoprolific and that approximately half of these carry such an abnormality emphasizing the need to screen for it beforehand. Such analysis however has a number of drawbacks in that it is perceived to require highly skilled individuals and relatively few people therefore take the time to learn it. Further the cost of training is very high due to the cost of laboratory materials and the infrequency of specialist courses and instructors. Alternatives include sending samples to specialist laboratories for analysis; however, this can have both cost and ethical implications. Moreover we are aware of only one laboratory (in France) that specialises in such analysis in pigs (Ducos, personal communication). In our view the solution lies in the education of individuals in performing analysis of pig chromosomes (so-called "karyotpying") which involves sorting the chromosomes into recognised pairs and then assessing if any of the chromosomes look different from normal by comparing the chromosomes in each pair with each other, using computer-based simulations. These have gained in popularity in many fields of education including the replacement of "wet" student practical classes (e.g. Dewhurst et al., 1994; Gibbons et al., 2004; Heerman and Fuhrmann, 2000; Hughes, 2000;