Towards a Brain-Compatible Approach for Web-Based, Information Security Education

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Abstract

Information Security is becoming a necessity for all information users. Suitable delivery and presentation of information security education to these users is therefore becoming increasingly important. Online learning may be a suitable mechanism. It has become a widely used, extensive education format that uses information and communication technology as well as the many resources available on the web. In order to ensure an effective and enjoyable learning experience online education should emulate real-world 'classroom education' and be designed in compliance with pedagogy. Brain-compatible education (BCE) is such a pedagogy. BCE has primarily been used in real-world classrooms. This paper examines how generic, online, information security education can be developed in compliance with BCE principles in the Moodle environment.

Keywords

Information Security Education, Brain-compatible Education, E-learning, Moodle, Case study

1. Introduction

Information security education had long been an acknowledged need in an organisational context (NIST 800-16 1998). However due to recent changes in and the creation of new national legislation and cyber security initiatives, this need has now been assigned to the organisation and the general public. The educational target audience therefore includes individuals from all age groups, education levels and social standings. The current generation would be the most affected by this change.

The current generation of learners has grown up in a media-rich environment. This environment has predisposed them to prefer information presented in an entertaining and interactive manner. Consequently, this generation will be the first capable of benefiting from the educational aspects of the web and interactive web technologies.

Educational approaches which use computer network technologies, primarily over an intranet or the Internet, to deliver information and instruction to individuals are fast becoming a popular education method (Welsh et al. 2003). It has many advantages such as easy accessibility, target audience diversity and development versatility. Unfortunately web-based learning courses often mirror real classrooms. Therefore in many educational fields including information security, the problems that exist in real classrooms also exist in web-based learning environments.

Educational researchers are continuously searching for pedagogies that can improve the learning experience in any real classroom. Many of these pedagogies could potentially also be applied in online environments. Brain-compatible education (BCE) is one such pedagogy that has been successfully used in real classrooms.

Brain-compatible education is designed to take advantage of the relationship between an educational environment and the natural complexities of the human brain (Jensen 2008). Several BCE principles, methods and techniques have thus developed. These techniques endeavour to teach subject matter in a manner and format which is naturally complimentary to the brain's physical and psychological processing functions (R. N. Caine & G. Caine 1991). BCE's application to the design of online learning environments has been proposed by Clemons (2005), this paper will apply and test it on an online information security course.

This paper aims to show that BCE principles *can* be applied in the Moodle 2.0 environment when developing an information security course to be appealing and effective for a learner's information security education experience. The methodology which was used is presented in the next section.

2. Methodology

This paper takes the form and structure of a case study, as described by Creswell (2007). The structure is as follows: an entry vignette, introduction, description of the case and its context, development of issues, detail about the selected issues, assertions, and closing vignette.

The research itself was conducted as a case study wherein material from an existing information security course was selected and modified to comply with BCE principles in the Moodle environment. Some of the changes made where previously theorised possible by Reid, Van Niekerk and Von Solms (2011). This paper focuses on the lessons learned during the actual implementation of the design guidelines which could be applicable in future online, BCE cyber security courses.

3. Context of Case study

SEAT was the course selected for modification during the case study. SEAT is a security education and training course at the Nelson Mandela Metropolitan University (NMMU) which targets students and the general public. Its objectives are: to improve awareness of the need to protect system resources and an organizations end users; to develop the skills and knowledge of computer users so they may securely perform their computer activities; to allow online access to a rich source of security related best practices; to help end users understand why security is part of their responsibilities, and how they impact their organizational employers security.

The original SEAT consisted of nine modules. Each module consisted of a single flash lesson and a related multiple choice quiz. The lessons content presentation consisted of text and related clipart images. An evaluation of the original SEAT showed that it lacked usability, which necessitated the redevelopment of the course.

Two major additional considerations during redevelopment included the need for it to be as appealing and easily accessible as possible for a diverse, dispersed target audience. Thus it was decided that the course would be modified to be presented in a BCE compliant manner, and made accessible as an e-learning course via Moodle.

4. Case study Background

This section will provide a brief background to the primary fields of study which influenced the choices in the redesign of SEAT as presented later in this paper.

4.1. Online Learning

Many communications, collaboration and education enabling technologies have developed alongside the Internet, computer-based multimedia, and the World Wide Web. These technologies have become an enabler of a new variety of e-learning called "web-based" or "online" learning (Zhang 2003).

Online education has delivered many benefits to education experiences including: improved quality of the learning, improved accessibility to education and training, improved cost-effectiveness of education (Alexander 2001), promotion lifelong learning, enhancement of an educators ability to address different audiences and diversify their teaching style, and use of innovative teaching methods in order to maintain students' interest (Bates 2001).

Educators have focused on extending traditional learning method and techniques through electronic and web technologies into new dynamic education models and environments (Eckert et al. 1997). Many web-based learning environments complete with material have already been successfully created using a variety of tools. Selecting such a tool was the first consideration.

Many popular, open-source and proprietary learning system tools such as Blackboard, Sakai, aTutor, Schoology and many others exist. Moodle is one such environment which is used at Nelson Mandela Metropolitan University (NMMU). Therefore, due to convenience and availability of this platform, it was chosen for the case study. However the similarities which exist between the various online learning management systems and their supporting web-technologies, may mean that this case studies assertions may be applicable to other platforms. The next consideration was engaging the learners.

The aim of any educational experience is to ensure learners accept, retain, and process information which is presented to them during a learning experience. To fulfil this goal the learners should be interested, engaged and motivated to participate in the learning experience. Learning principles and conditions should therefore be used to present material in a manner which meets learner needs (Clemons 2005). The application of pedagogy to e-learning courses is therefore recommended.

4.2. Brain-compatible Education

Brain-compatible education (BCE) is defined as learning based on principles, methods and techniques which endeavour to teach content in a manner and format which is naturally complimentary to the brains physical and psychological processing function for incorporating information into its schema (Jensen 2005).

Brain-based education involves teaching through the designing and orchestrating life-like, enriching, and appropriate experiences for learners (R. N. Caine & G. Caine 1991). It is a pedagogy which addresses multiple modes of learning, acknowledge outlets for creative presentation of learning, provide enough contrast to preclude boredom, and contribute to a motivating context (Rogers & Renard 1999). It accomplishes this by using effective teaching methods, techniques and approaches from all educational disciplines to enhance subject matter to be as appealing and learnable as possible for the brains of the target students (Jensen 2008).

Target audiences for classroom-based BCE learners have ranged from primary school to university students. The application of this pedagogy has been proven to positively affect students' learning (Jensen 2005). Clemons (2005) suggested the application of the pedagogy to online, but did not provide any technical details on how this could be done. This paper aims to explain **how** the pedagogy can be implemented in a Moodle context for an information security course.

4.3. Moodle

"Moodle is an Open Source Course Management System (CMS), also known as a Learning Management System (LMS) or a Virtual Learning Environment (VLE)" developed in compliance with a "social constructionist pedagogy" (Moodle.org 2012). It is a tool used by educators to create dynamic, online websites for the delivery of their course to their students.

Moodle courses consist of an educator's chosen activities and resources. An activity is something that a student will do that interacts with other students and or the teacher (Moodle.org 2012). There are thirteen standard Moodle some examples being assignments, forums, wikis, quizzes and lessons (Moodle.org 2012). A resource is an item that an educator can use to support learning (Moodle.org 2012). Standard resources included by Moodle are files, folders, IMS content packages, labels, HTML pages and URLs. All courses can be augmented through the use of plug-ins.

Moodle can be used to conduct entirely online courses or it can be used as an augmentation tool for their interpersonal classes (Moodle.org 2012). NNMU has mainly used it as an augmenter tool; however with the creation of SEAT it is also being used as the sole material provider for an entirely online effort.

For the purposes of the case study presented in this paper, Moodle was the chosen LMS for the implementation of a BCE compatible version of SEAT. The next section will identify the issues which were addressed in the case study.

5. Identification of Issues

This section will briefly outline a few issues addressed by the redevelopment of the SEAT course. The problems are separated into two categories: Learner-related and Educational-Material Related.

5.1. Learner-Material Issues

Many issues/factors required addressing so as to improve the learners education experience. The first issue is that the target audience is the general public. Therefore the material has to cater for a large variety of learning style preferences. Furthermore because the audience is so varied in age, abilities, background and culture etc. the material had to be as appealing as possible to as many people as possible.

The second issue is that in traditional, 'compulsory learning' schools or organisations are able to "force" the completion of an activity or course through cohesion of various forms; in a *voluntary* online education scenario this cannot be replicated. Therefore alternative measures must be used to motivate a learner to learn. Thirdly the existing SEAT material encouraged learning by rote. This an issue because remembering material by rote is the lowest level of Blooms taxonomy of the cognitive domains (Van Niekerk 2010). Cyber Security Education learners need to understand the material so as to be able to apply it.

The fourth issue is that the current standard material is presented in a non-explanatory manner. As a result of this presentation style, the learners are often distracted by other activities. The fifth issue is that the modules are currently presented as isolated segments of the course with no tie into the overall concept of what is being taught. The context in which the material is taught is also not always relevant for a student. Finally in the original material no feedback was provided to the learners. This is problematic, as formative feedback is necessary in any education approach. This concludes the learner –material issues, the next section will identify the material-creation issues.

5.2. Material-Creation Issues

In addition to the learner related factors; discussed above; factors such as how the material is developed, hosted and accessed also needed to be addressed. Firstly the original application was difficult to maintain. This is because code maintenance, over a number of years, was poorly documented. This is further aggravated by the fact that the development language and development environment used to create the original SEAT is outdated and no longer functions well on current computers. Thirdly the material was not very accessible. Learners required access to an installation of a desktop application, this limited a learner's ability to access the material to traditional class and lab time. Finally there was no automated control over who could enrol in the course and therefore the course "graduate" was tracked manually. Therefore this system was vulnerable to human error.

The issues identified in each category will each be elaborated upon in the next section. The solutions applied in the redevelopment of the material will be provided.

6. Detail of selected Issues

This section elaborates upon the previously discussed issues which will be further explained and related to the brain-compatible pedagogical principles. For additional brain-compatible principle explanations refer to Reid et al. (2011). The brain-compatible principles which will be addressed are listed in Table 1. Each principle has been assigned a non-meaningful number which, for the sake of convenience, will be used for all further references to the same principle within the paper.

	Principle
1	A learning experience should be as multifaceted as possible; catering for many learning styles and providing as many opportunities for each learner to develop as possible.
2	Positive emotions should be used to aid recognition and recall.
3	It is necessary to repetitively review material to solidify recall and recognition.
4	Both focused and peripheral attention of a learner should be involved in the learning process.
5	Every brain simultaneously perceives and creates parts and wholes during the learning process.
6	Relate all new material back to old material and thereby build new knowledge on old knowledge
7	Allow learners to progress through the course at their own pace.

Table 2: Brain-compatible education principles

The original material of the SEAT course was moved to the Moodle environment. Once it had migrated the authors began the process of updating the material and course to solve the various issues. The redevelopment of the course will now be explained.

6.1. Learner-Material Issues

Firstly it was determined that to implement Principle 5 learners had to understand how material exiting as an isolated concept and as a part of an overall cyber security approach. To do this Moodle's ability to separate course material into modules and blocks was used. Each lesson from the seat course was assigned to a module. Within each module a lesson activity, a quiz and additional resources were included.

Modules were structured in a progressive sequence. Initially only the first module was accessible. To progress through the course the learners had to achieve a minimum required mark in each modules quiz. This progressive design was it ensured the material was viewed in a particular order. This aided principles 5 and 6. The content could relate material back to the previous modules material, ensured that learners had the required "old" knowledge and provided perspective as to how the concept fitted into the whole subject.

Within the module itself the learners were free to navigate through the lesson material and the additional resources according to their own preferences. The grouping of the activities and resources complied with Clemons' (2005) suggestion of "chunking" activities together to help them relate and make sense. By allowing learners to review the modules material in any particular order they were allowed to progress as a self-determined pace. This combined with the allowance for the active modules quiz to be completed at any time promotes Principle 7.

Schools or organisations can insure the completion of traditional compulsory learning activities through cohesion of various forms. In a voluntary online education scenario this cannot be replicated. Therefore alternative measures must be used to motivate a learner to learn. Learning requires motivation and engagement this is particularly important since online learning is a self-managed endeavour.

The next aspect of the redevelopment dealt with the redevelopment of the material itself. This redevelopment had to aid compliance with the Brain-compatible principles 1, 2, 3, 4 and 6.

Initially, the Moodle lesson activity was considered for the SEAT lessons. Moodle lessons allow navigation between question pages and content pages, and it has adaptive ability to navigate between pages based on the learner's response. However because the lessons consist of basic HTML it was determined that they were not dynamic enough for our needs. Instead, Microsoft's Sketchflow Silverlight application was used to create lessons which were then hosted on a server as a webpage. This webpage was then embedded in the Moodle module as a URL resource. The aim was to create interactive, media-rich and engaging lesson material.

The Moodle course targets the general public. This means that the learner audience consisted of individuals who varied their age group, culture, experiences, abilities and learning-style preferences. The course material had to appeal to as many of these individuals as possible to ensure successful learning experience. To enable the brain-compatible principles 1 and 2 were applied to the redevelopment of the material.

Clemons (2005) suggested the inclusion of "elaborate rehearsal" and interactivity in an online course to aid compliance with these principles. Activities which Clemons theorised complied with her suggestions were audio-,video- and animation clips, role plays, debates, voice-overs lectures, use of colour, diagrams, charts, pictures, interactive models and drawing activities.

In the redeveloped SEAT we included video clips, music, and lesson materials containing text, contextual pictures and clarifying animations. Colour was used to influence the learner's emotional state.

The background of the lesson material was styled yellow; this elicits positive moods and aimed to attract the learner's attention. This aspect of the material also related to Principle 4 and the enhancement of the; learners attentive ness. Future modifications of the material will incorporate green into the colour scheme as it encourages productivity and long-term energy are good in classrooms (Taylor 2007). Because of

NMMU policy, the Moodle environment itself was styled to conform to the NMMU, colour branding which is not necessarily brain-compatible. This will be tested in future research.

Clemons (2005) suggested that interaction would enhance attentiveness in online courses. The use of techniques to stimulate emotions such as excitement, fun, curiosity and anticipation to enhance learning (Clemons 2005). All this aids compliance with principles 1,2,3 and 5. Role-playing and scenario simulations and thought provoking games, videos and animations were suggested by Clemons as suitable techniques. Unfortunately role-playing and scenario simulations are currently only planned features of Moodle (Moodle.org 2012). To resolve this issue we included video resources and animations which illustrated the concepts in an interactive manner in the material. These additions also aimed to focus the learner's attention on the material and prevent distractions (principle 4).

Principle 3 was reinforced multiple time since the material was provided in many formats and included many elements which repeated the concepts in different contexts while appealing to principle 1 by catering for all learning styles.

Finally the courses and its quizzes and exams were modified to provide formative feedback. This modification complied with Clemons (2005) suggestion of providing encouraging, positive feedback and avoid penalizing mistakes that come from the learning curve associated with technology.

6.2. Material-Creation Issues

There are many ways the brain-compatible principles can be applied in the Moodle environment. The applications used in this case study to aid the learners in their interaction with course material are only a few examples of this. The next section will address how the issues relating to the materials creation and hosting were dealt with.

The Technology Acceptance Model (TAM) indicates that when users are presented with a new technology the perceived usefulness and ease-of-use will influence their decision about how and when they will use it (Venkatesh & Davis 2000).

Since the online material was designed for Moodle, the material had to be hosted on a Moodle server. NMMU has an internal campus-wide Moodle server. The use of Moodle addressed most of the issues in this category.

The issue of accessibility was partially solved because Moodle can be accessed online. Learners are able to access their Learn sites anywhere at any time. However currently the NMMU Moodle server only allows registered NMMU students to log in and register for courses. Internal policies have issued a practice of disabling manual registration procedures. Therefore a lecturer cannot register a student who is not physically studying at NMMU. This issue will be addressed by moving the SEAT course to an external server.

The material is now maintainable as the Moodle platform is constantly be updated by its developers and all the changes are well documented. The actual lesson material used in the SEAT case study is also updateable and editable via Microsoft tools e.g. Expression blend and Visual Studio 2010. All Microsoft projects are backwards compatible.

Moodle's multitude of features are very useful in the creation and design of an education experience. However the default, online creation methods of various activities are not always ideal, and can be tedious or time consuming e.g. the quiz development feature. The native Moodle quiz interface was time consuming and not ideal for the development of many questions simultaneously. We used a third-party tool called Respondus as an alternative.

7. Assertions/Lesson Learned

Firstly based on a preliminary evaluation of the learner's reactions to the redeveloped material we have found the following: 100% of the learners liked the look and feel of the material; 85% of the learners like the variety of educational material provided; and 80% of the learners felt motivated and engaged during the learning experience.

Secondly the authors wish to assert that based on the case study's course redevelopment and subsequent launch that it **is** possible to create brain-compatible, online information security material. Furthermore it has been well demonstrated that Moodle enables the development of brain-compatible information material even though it is created to enable a different pedagogy. It should however be noted that the creation process is not always easy, and the built-in development tools are not always very usable or suitable for mass development. The authors recommend the employment of third-party tools when necessary.

Finally, it is the opinion of the authors that there is a requirement for the development of tools which cater specifically for information security educators who wish to create brain-compatible education material.

8. Conclusion

Moodle is an education platform which can be used in compliance with BCE principles to create online, information security. However some of its creation features are not as comprehensive or usable as they could be. In these cases the use of third-party party tools is recommended. To further enable information security educators to create online, brain-compatible, information security education material, both using and independent of Moodle, a layer of applications and tools which cater specifically for the needs of material creating educators needs to be developed.

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