BUILDING ELECTRONIC PERFORMANCE SUPPORT SYSTEMS FOR FIRST-YEAR UNIVERSITY STUDENTS

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SUMMARY
This paper outlines the principles and theory of performance support (in general) and of electronic performance support (in particular). It explains why the design and creation of electronic performance support systems are so important as a mechanism for providing scaffolding environments for use in improving the learning experience for new (and established) students within a university environment. It goes on to explain and demonstrate our methodology by means of a case study involving the design of an electronic performance support system (EPSS) - called Epsilon - which was built to support students’ use of an academic library.

INTRODUCTION
For over a decade, we have been involved in building performance support systems to support learning activities in a wide range of academic communities (Barker, 1995). However, first-year students (who are newcomers to university study) pose special types of problem for university education. For example, in a recent article exploring the use of problem-based learning with a large first-year, undergraduate class at Edith Cowan University, Oliver (2007) suggests that:

‘Students entering university often need to develop a number of skills and capabilities to achieve success. First-year students come from a range of previous positions including school, the workplace and often unemployment. Students quickly need to assume responsibility for their
own learning, to undertake independent research and inquiry and to communicate their ideas in a succinct fashion.’

As we shall argue later in this paper, a fundamental and basic requirement for achieving the above requirements is for students to understand (1) the ways in which knowledge is acquired, (2) the mechanisms by which it is organised and stored in knowledge repositories, and (3) the techniques used to identify, specify and subsequently retrieve required items of knowledge from the vast array of conventional and electronic store-houses that now exist.

Some years ago we conducted a study of the importance of mental models as a psychological component within the cognitive development of undergraduate students who were exposed to electronic learning techniques (Barker and van Schaik, 1999). We also explored their importance and value in terms of the influence we believed they had on the uptake of lifelong learning opportunities (Barker, van Schaik and Hudson, 1998). In this latter paper we suggested that students entering university are often ill-equipped to cope with the demands placed upon them. We also outlined how we felt ‘performance support’ systems could be used as a change agent in order to motivate students and enhance their ability to learn independently.

Bearing in mind what has been said above, it seems quite a commonplace occurrence to use the first year of study at a university as a ‘foundation year’. Such a year is often used to ‘bridge the gap’ between where students are (academically speaking) and where they need to be - in terms of pre-requisite knowledge and required study skills. However, it is important to realise that ‘bridging the gap’ is a problem that exists at all levels of education. The phrase refers to the need to reduce the distance
that exists between what an individual is able to do and what he/she could achieve through the use of an appropriately designed supportive environment for study and/or work (Bezanson, 2002). In our recent research we have therefore been exploring how scaffolding environments can be used to improve the learning activities and the problem-solving abilities of university students. The particular approach that we have been using is based on performance support techniques (in general) and electronic performance support systems in particular. The importance of performance support methods within the broad range of tools available to an instructional-designer is illustrated schematically in Figure 1 (Carman, 2002).

PRINCIPLES OF PERFORMANCE SUPPORT

As is implied by Figure 1, much of the early work in performance support has been undertaken by Gery (1991). However, since her pioneering studies, considerable work in this area has been undertaken by other researchers. Our own work commenced in the early 90s (Barker and Banerji, 1995). It has been primarily concerned with identifying underlying models, theories and the principles of utilising performance support systems.

The rationale underlying the use of performance support is based on the fundamental belief that all aspects of human performance (both physical and cognitive) can be improved through the use of an appropriately designed performance intervention. Increasingly, computer-based systems are now being used as a basis for building the
necessary interventions for performance improvement. Such systems are therefore often referred to as ‘electronic performance support systems’ - or EPSS, for short.

In our previous research, which spans over a decade of activity, we have brought together a number of principles which underlie much of the design and development work that we have undertaken (van Schaik, Barker and Famakinwa, 2006). The principles are:

1. an EPSS should enhance human task performance;
2. it should make relevant data, information, knowledge and skills available at a particular point of need;
3. as is discussed in the next section, it could embed and/or may provide a scaffolding environment (this principle is optional);
4. it should provide explicit support for common tasks in the domain;
5. it should present task procedures in a step-by-step way;
6. it should present ‘just-in-time’ information;
7. designers should consider the issue of integration with the target application; and,
8. it is necessary to have simple and consistent navigation as well as consistent visual design.

Related to our Principle 8, Hung and Chao (2007) have proposed a design framework, called Matrix Aided Performance System (MAPS). The framework uses principles of advance organisers (Ausubel, 1963) to both reduce the complexity of navigation and enhance the comprehension and synthesis of information in EPSS.
USING EPSS FOR PEDAGOGIC SCAFFOLDING

The basic principle underlying the application of ‘scaffolding’ (as a support tool) arises from the advantages that can be accrued through the provision of a temporary ‘assistive’ environment that is able to offer (a learner) help and assistance during some period of learning or familiarisation activity. Within teaching and learning environments there are a variety of ways in which scaffolding can be achieved - depending upon the particular aims and objectives that its application are intended to fulfil. For example, Harley et al (2007) and Stone (2004), amongst others, have described the use of SMS text messaging (based on mobile phone technology) to scaffold new students who are making the transition from school to university life.

We refer to this type of scaffolding as ‘global-generic’ because the techniques employed can be applied over a large area of application within any subject domain. More specific scaffolding relating to a particular learning task or a particular course of instruction can also be provided. This is often referred to as ‘local-specific’ scaffolding. Much of our work in relation to EPSS deals with this latter type of mechanism of support provision.

As a pedagogic technique, scaffolding is a well-known method for providing various forms of support to a learner while he/she is acquiring the skills and knowledge needed to become an expert performer in a given area of discourse. It is often used to provide help and rich feedback about problems that a learner may be experiencing. Cagiltay (2006), amongst others, has recently described how effectively EPSS can be used to provide scaffolding facilities within electronic learning environments. Our recent work in the area of pedagogic applications of electronic performance support has used this technique in a number of different areas. Some typical examples of the
projects in which we have employed this technique include the design of support for
electronic file transfer (Banerji, 1995), virtual study environments involving
distributed performance support (Beacham, 1998), information retrieval using search
ingines (Flinders, 2000) and quantitative research methods (Pearson, 2001; van
Schaik, Pearson and Barker, 2002).

Within an EPSS environment, the underlying rational for using a scaffolding facility
is that it can be used to monitor a student’s performance in a skill or knowledge-based
task. In situations where an under-performance is detected (and this is attributable to
a lack of experience, knowledge or practice), a learning scaffold can be created which
traps fundamental errors and mistakes (made by the student) and then advises him/her
on how to avoid or overcome these. In a similar way, under-performance as a result
of a lack of relevant knowledge can also be used to initiate a scaffolding process.

Normally, intervention by the scaffold is ‘faded out’ (that is, gradually decreased) as
the student’s performance approaches its ‘plateau region’ (see Figure 2) for the
task/skill that is involved - since further intervention would not achieve any
significant increases in performance (Famakinwa et al, 2007). However, if the EPSS
detects any noticeable deterioration in on-task performance, it can re-instate the
scaffold and use it in order to prevent further decline - again, fading it out when the
user’s performance again becomes optimal.

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Insert Figure 2 about here.
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We have incorporated the use of scaffolding techniques within our latest research into
the use of EPSS within academic library systems. Our research in this area has been
particularly directed (but not exclusively so) at first-year undergraduate students. This work is described in the following section.

**CASE STUDY - THE EPSILON SYSTEM**

Naturally, libraries are an important resource in the context of students’ information-seeking behaviour during their first year of study. Unfortunately, many students arrive at university without the necessary knowledge and skills needed to identify and locate the information they need to support their studies. Bearing this in mind, we have been using the techniques of performance support in order to enhance students’ knowledge of library processes and their ability to locate information - both in conventional paper-based and in electronic formats. The model that forms the basis for our work is depicted schematically in Figure 3. In this diagram, A, B and C represent the different channels of communication that the system interface needs to support. Channel A denotes a line of communication between the user and the EPSS through the system interface. Similarly, Channel B denotes communication between the user and library system (the target application) while C represents a dialogue between the system user and the scaffolding facilities provided by the EPSS.

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Insert Figure 3 about here.

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In the remainder of this paper we describe an EPSS facility (called *Epsilon*) that we have built based on the model depicted in Figure 3. The system is intended to help undergraduate and post-graduate students learn how to improve their ability to identify and locate information and knowledge resources within an academic library. Three basic themes are discussed: (1) the design and development of the system, (2)
its evaluation with a large group of first-year undergraduate psychology students and 
(3) the future work that we intend to undertake in this area.

System Design and Development

The design and development of the EPSS facility has been extensively discussed by 
Famakinwa (2004) and van Schaik, Barker and Famakinwa (2006; 2007). This paper 
therefore emphasises the integration of the EPSS with the online evaluation system 
for use with large groups of users.

When building computer-based instructional material, designers have a large variety 
of media types at their disposal. Traditional paper-based instructional materials are 
limited (in most cases to text and static pictures); they also lack interaction and 
immediate feedback is often not feasible when a human tutor is not available. On the 
other hand, computer-based instructional materials go beyond these basic media types 
and can encompass video, animation and sound. More importantly, computer-based 
instructional materials can provide better integration of the different media types and 
can offer interaction with immediate feedback - without human intervention. Another 
advantage of computer-based instructional materials is that they can be delivered 
remotely in situations where it would be difficult or impossible to provide skilled staff 
at the time they are needed.

A major tenet of EPSS systems is the need to support on-the-job skill development 
and training when it is needed and at the location where it is required. During the 
development of the Epsilon EPSS facility, World Wide Web (WWW) technologies
were used extensively. This was done in order to make the system readily available where it was needed most.

A tutorial component for knowledge development and a gaming component for skill development were developed as additional items to the previous version of the Epsilon system (van Schaik, Barker and Famakinwa, 2006). The tutorial component was developed using Microsoft PowerPoint and Macromedia Flash while the gaming components were implemented using Hypertext Mark-up Language (HTML), Cascading Style Sheets (CSS) and client-side JavaScript. These components were stored on a local web server provided by the University of Teesside. For the evaluation environment, PHP technology (Ullman, 2001) was used to build the scripts that integrated the Epsilon components, the survey management tool and the evaluation instructions. The survey management tool (phpESP) was available as a collection of PHP scripts that could be used to create, manage and administer online surveys. Details of this package can be found at the following URL: http://sourceforge.net/projects/phpesp. The MySQL database was used to store the captured information. The database was also used to capture data that could be used to track each participant’s progress through the evaluation process - such as, the start and end times for the various activities that the users performed.

**Evaluation**

Evaluation sessions took place over a period of one week. Participants were divided into three groups and each user was given a unique code for the evaluation. Based on this code, the evaluation system could identify the group that each participant was in; it could then administer (in addition to the pre- and post-tests) only the appropriate
Epsilon components and relevant questionnaire items. At the start of the evaluation each participant had to log on to the system using his or her assigned code. At the end of the evaluation period, all the information that was collected was exported to Microsoft Excel. This was necessary because the data had to be pre-processed before it could be used in SPSS for analysis.

Method

Research design. A three-group, pre-test/post-test design was used to establish the effect of using the two EPSS components. Group 1 only studied the tutorial component, Group 2 only played the game component and Group 3 studied both the tutorial component and played the game component. Each participant was randomly allocated to one of the groups. Outcome measures included knowledge of the library classification system and confidence in knowledge.

Participants. First-year psychology students took part (N = 99; n = 32 in Group 1, n = 39 in Group 2 and n = 28 in Group 3) in the evaluation, as part of a taught practical class in research methods. Mean age was 21 (SD = 6.36) and 21 participants were male. Mean years of computer experience was 10.78 (SD = 3.67), mean computer use per week was 16.01 hrs (SD = 13.38) and mean web use per week was 8.28 hrs (SD = 8.15).

Materials and equipment. During the evaluation process, participants were required to enter information into data-collection software that was running alongside the tutorial and the games components. This software included instructions for using the tutorial component and playing the games, a pre-test and post-test for measuring
knowledge (and their confidence in this knowledge) and pages for recording task performance on the games. A questionnaire was also included in the data-collection software, which requested demographic information and measured system acceptance and participants’ experience of using the EPSS components.

**Procedure.** Once participants were each seated at an individual personal computer they were given a consent form to read and complete. After logging onto the system, they worked through the computer-based evaluation. This included studying the tutorial and/or playing the games, and completing appropriate sections of the data-collection software. Students progressed through the tutorial by studying the slides contained in three *PowerPoint* presentations. In the first game, students had to find a book with a particular shelf-mark in the library. In the second game they had to place a number of books with particular shelf-marks in the right (numerical) order. Although students were allocated to different groups, those who did not study the tutorial or did not play the games were given the opportunity to do this after they had finished the evaluation. However, this was not part of the formal evaluation and depended purely on students’ own interest.

**Results**

*Knowledge.* Mean knowledge scores (pre-test and post-test) were around 60% (see Table 1). Analysis of co-variance (ANCOVA) was used to establish the effect of EPSS component (tutorial, game, tutorial and game) on post-test knowledge after statistically controlling for pre-test knowledge. The co-variate, pre-test knowledge, was significantly related to post-test knowledge, $F(1, 95) = 43.11, p < .001, r = .57$. There was no effect of EPSS component on post-test knowledge after controlling for pre-test knowledge, $F(2, 95) = 1.72, p > .05$. 

*Barker, van Schaik and Famakinwa*
Confidence in own knowledge. Mean confidence scores (pre-test and post-test) varied widely from 71% to 88% (see Table 2). The co-variate, pre-test confidence, was significantly related to post-test confidence, $F(1, 95) = 69.36, p < .05, r = .63$. The effect of EPSS component on post-test confidence after controlling for pre-test confidence was significant, $F(2, 95) = 7.28$, medium effect size $\epsilon^2 = .08, p < .005$. This result reflects the relatively high increase in confidence in Group 1 compared to Group 2, $t(69) = 3.74, r = .41, p < .001$, and Group 3 compared to Group 2, $t(65) = 2.39, r = .28, p < .05$.

Correlations of demographics with task performance and confidence. The correlation of mathematics self-efficacy with the following outcomes was significant: mean confidence pre-use, $r = .38, p < .001$, mean confidence post-use, $r = .25, p < .05$ and total correctness post-use, $r = .23, p < .05$. The correlation of gender with mean confidence post-use, $r = .22, p < .05$, and total correctness post-use, $r = .25, p < .05$, was also significant. The correlation of gender with maths self-efficacy was not significant, $r = -.07, p >> .05$. These results show that mathematics self-efficacy and gender were to some extent related to students’ knowledge and confidence, but these variables explained only a relatively small amount of variability in outcomes.
Acceptance. Reliability analysis was conducted on the acceptance measures included in the questionnaire. The items for perceived usefulness of the tutorial component (Cronbach’s alpha = .95) and the game component (alpha = .95) formed reliable scales as well as the items for intention to use for the game component (alpha = .78) and to a lesser extent for the tutorial (alpha = .67). Overall scores were calculated by averaging over items. With possible scale values ranging from -3 through +3, the 95% confidence intervals of perceived usefulness were [0.34; 1.57] with mean = 0.96 and [0.24; 1.48] with mean = 0.86 for the tutorial and games, respectively. The 95% confidence intervals of intention to use were [0.44; 1.38] with mean = 0.91 and [0.58; 1.50] with mean = 1.04 for the tutorial and games, respectively.

Comments from staff. Comments from staff teaching the module indicated that students “enjoyed it, they really liked it, and it really challenged them. It appeared that they appreciated it more”. Another comment was that “the students felt this was great and they want to do it again; look at it again”. Subsequently, we provided them with links to the tutorial and gaming components so that students could use both whenever they wanted for further developing their knowledge and skills or for performance support. Another comment was that students had come back to say they had been able to find books in the library. However, staff also felt that the EPSS was too generic, particularly for first year students, and the exercise should be more specific to their library needs. These comments confirmed some of the findings from an evaluation of the same EPSS system with non-first-year students reported by van Schaik, Barker and Famakinwa (2006).
Follow-up evaluation. After three months, a brief follow-up evaluation was conducted, in which a subset (N = 43) of the same groups of students took part. The same test was administered again and demographics and training in use of the library were measured. Test results showed that knowledge of the library classification system, $t(140) = 3.22, r = .26, p < .01$, and confidence in knowledge, $t(140) = 3.76, r = .30, p < .001$, had improved from pre-use to after three months (see also Table 3). Further test results demonstrated that knowledge had not changed from post-use to after three months, $t < 1$, but confidence had decreased, $t(140) = 2.36, r = .20, p < .05$. Informal questioning of psychology lecturing staff indicated that students had not been given assignments explicitly requiring students to use the library classification system over the three months period up to the follow-up evaluation. Therefore, the knowledge gained from using the EPSS appeared to remain stable without further ‘reinforcement’.

Another finding was that the correlation between knowledge of the classification system and confidence in knowledge was significant after three months, $r = .41, p < .05$, but the correlation was not significant immediately before use, $r = .04, p >> .05$, and immediately after use, $r = .18, p > .05$. These findings indicate that students’ awareness of their knowledge of the classification system (‘meta-cognition’) may have increased over time.

Summary of results. The type of EPSS component studied did not have a significant effect on students’ knowledge. However, the type of component studied did
significantly influence students’ confidence in their knowledge; those who had not studied the tutorial were less confident. Confidence was weakly associated with mathematics self-efficacy and gender. System acceptance by students was high and staff’s response was positive overall. Both confidence and knowledge appeared to be stable over time after EPSS use.

Discussion. Overall, the evaluation results from van Schaik, Barker and Famakinwa (2006) with a small sample of non-first-year students were confirmed. However, the effect of EPSS components on students’ confidence was significant this time. The EPSS was well received by student-users and staff. Users found both EPSS components useful. The tutorial component enhanced users’ confidence in their own knowledge.

Future Work

Following on from the study described in this paper, we have identified three types of work which we will pursue in our future research:

- First, future work on the EPSS for library classification should focus on the inclusion of sound, speech audio, video tutorials and the integration of the system with existing library facilities, services and VLEs (Secker, 2004; Catherall, 2005). We also need to be able to make the EPSS more adaptable to the individual needs of specific libraries and academic disciplines by making the content adaptable by its target user-groups. Some of our future work thus has to be orientated towards allowing modification of our system by its end-users (this is called ‘modding’- a technique which is often used in the computer-games industry). Modding is the practice of modifying a piece of
software or hardware to perform a function not originally included in its
design (El-Nasr and Smith, 2006). Within the context of EPSS, modifications
could be made to an application in order to personalize the support provided
by the system for specific groups of users. For example, in our Epsilon
system, the gaming components could be modified to support specifically, say,
first-year psychology students, or in a different modification, the needs of
third-year geography students. This would ensure that the software used only
the relevant shelf-marks which psychology students (or geography students,
respectively) typically encounter during their course of study. This should
provide more realistic and relevant simulations than could otherwise have
been achieved.

- Second, the favourable reactions that we have received to our work from our
colleagues have made us aware of the need for performance support to be
provided for students at ‘remote’ locations. That is, students who are away
from the university on job-placement or work-study activities. This need was
also reflected in a needs analysis study that we recently undertook with a
sample group of students. We are therefore currently pursuing this avenue,
starting with an investigation of the utility and efficacy of using a mobile
phone system to access the Epsilon EPSS facility using a WAP Internet server
(Onibokun, 2006; Famakinwa et al, 2007). Although we observed some
limitations in what could be achieved, the initial results of the experiments
were sufficiently encouraging to suggest that this would be a very useful
approach to adopt.

- Third, because of the growing importance of digital library facilities within
conventional library environments (Dahl, Banerjee and Spalti, 2006), it is
We would hope to report our findings in relation to the above developments in a future communication.

CONCLUSIONS

Electronic performance support provides a powerful mechanism for helping students (in general) and first-year students (in particular) to acquire new skills and knowledge to facilitate their study plans. In the work that we have undertaken with first-year psychology students, the Epsilon EPSS tool was enthusiastically received - both by students and by the tutors involved with the course in which it was used. Naturally, bearing in mind the increasingly broad range of study spaces and locations that students currently use, it is important to be able to provide access to this type of
facility in both on-campus and off-campus learning spaces. We therefore intend to explore various ways in which this latter requirement can be accommodated using different sorts of mobile computing technology - such as laptops, PDAs, iPods and mobile phones.

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BIOGRAPHICAL NOTES

Philip Barker is the Eyetech Professor of Applied Computing within the School of Computing at the University of Teesside in the UK. He undertakes research in the broad area of ‘human-computer interaction’ (HCI) and is particularly interested in the effects of computer-based technology on both the cognitive and the physical behaviour of users of this technology. He is particularly interested in electronic learning and the interplay between organic and electronic knowledge structures in relation to problem solving activities.
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<http://www.knowledgenet.com/pdf/Blended%20Learning%20Design_1028.PDF>


Figure 1: Blended learning theory as proposed by Carman (2002).
Figure 2: Performance plateaus and bands.
Figure 3: Use of an EPSS support tool for use in an academic library.
Table 1: Knowledge as a function of EPSS component.

<table>
<thead>
<tr>
<th>Group (Gp)</th>
<th>Tutorial (Gp1)</th>
<th>Game (Gp 2)</th>
<th>Tutorial and Game (Gp 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test</td>
<td>52.50</td>
<td>53.85</td>
<td>57.14</td>
</tr>
<tr>
<td></td>
<td>(15.24)</td>
<td>(13.69)</td>
<td>(15.60)</td>
</tr>
<tr>
<td>Post-test</td>
<td>62.50</td>
<td>61.03</td>
<td>68.57</td>
</tr>
<tr>
<td></td>
<td>(14.59)</td>
<td>(14.10)</td>
<td>(16.04)</td>
</tr>
</tbody>
</table>

Note. Mean values with SD in ().
Table 2: Confidence in knowledge as a function of EPSS component.

<table>
<thead>
<tr>
<th></th>
<th>Group (Gp)</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Tutorial (Gp 1)</td>
<td>Game (Gp 2)</td>
<td>Tutorial and Game (Gp 3)</td>
</tr>
<tr>
<td>Pre-test</td>
<td>64.47</td>
<td>67.97</td>
<td>71.15</td>
</tr>
<tr>
<td></td>
<td>(14.74)</td>
<td>(14.45)</td>
<td>(15.50)</td>
</tr>
<tr>
<td>Post-test</td>
<td>83.81</td>
<td>77.28</td>
<td>87.90</td>
</tr>
<tr>
<td></td>
<td>(13.15)</td>
<td>(15.67)</td>
<td>(14.13)</td>
</tr>
</tbody>
</table>

Note. Mean values with SD in ().
Table 3: Knowledge of and confidence in knowledge of the library classification system.

<table>
<thead>
<tr>
<th>Group (Gp)</th>
<th>Pre-use</th>
<th>Post-use</th>
<th>Three-month's follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>54.34</td>
<td>64.42</td>
<td>63.64</td>
</tr>
<tr>
<td></td>
<td>(14.72)</td>
<td>(14.52)</td>
<td>(15.01)</td>
</tr>
<tr>
<td>Confidence</td>
<td>67.74</td>
<td>82.39</td>
<td>76.19</td>
</tr>
<tr>
<td></td>
<td>(14.92)</td>
<td>(14.99)</td>
<td>(12.97)</td>
</tr>
</tbody>
</table>

Notes. Mean values with SD in (). Pre-use and post-use results have been collapsed over groups because in the follow-up evaluation it was not possible to determine which groups students were assigned to in the initial evaluation.