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Electronic performance support system (EPSS) technology provides a powerful mechanism for helping end-users operate complex systems. This article describes and discusses some research we have undertaken to explore their potential within academic library systems. Based on a needs analysis, an EPSS for supporting library users was designed and implemented. An evaluation of the system showed that an experimental group of EPSS users was more successful than a control group in performing library tasks, showing that aided task performance was better than unaided. Implications of the results and future work are discussed.

Nowadays, most people are familiar with the concept of a “library.” As can be seen schematically in Figure 1, we can use General Systems Theory to represent (in a generic way) the notion of a library as a discrete individual entity serving the needs of its user community.

In Figure 1, the term “artefact” is used to refer, in a general way, to any of the different types of information products that a library houses within its collection. Examples of such artefacts include books, newspapers, journals, CDs, audio tapes, DVDs, data archives, software items, and so on. In principle, any of the items within a library’s collection will be “borrowable.” However, many library users will not necessarily wish to borrow items, they may wish only to consult some of the artefacts to become more knowledgeable about particular topics that interest them.

Naturally, a very important issue that has to be addressed when making use of any form of library is making sure that users can retrieve the details of (and can locate) the various items that are of interest to them. A range of
different retrieval tools is available for achieving sought-after items. However, considerable skills are usually needed to use these tools in an effective way. As we discuss later, it is therefore important to consider how people gain the skills needed to use these tools.

Although individual libraries can often meet the general information requirements of most of their users, there will always be situations in which a library’s stock of items will not fulfil particular specialist needs. Furthermore, the range of any given library’s stock of items may be severely constrained by the financial budget within which it has to operate. The sharing of items between libraries would therefore seem a useful strategy to adopt to overcome problems of this sort. It would therefore seem reasonable to want to build a “networked library” facility in which items held in one library can be shared by other libraries. This concept of sharing is depicted schematically in Figure 2.

With the advent of global electronic communication networks (e.g., the Internet), the task of interconnecting individual libraries with one another is becoming increasingly easy. This is particularly so when an individual library holds some (or all) of its resource collection in digital format – for example, http://www.aace.org/dl

Naturally, for an end-user of a system such as that depicted in Figure 2, there is a number of additional problems that he/she is confronted with – over and above those associated with using a particular individual library (as depicted in Figure 1). For example, each of the resource centres (libraries L1, L2, L3, L4, and so on) depicted in the diagram is likely to have a wide range of different resources, and services available. Gaining familiarity with what is available at each location is therefore an important issue that has to be addressed. Another important problem that has to be considered is the fact
that each individual library may use different tools, protocols, and procedures for allowing users to access its resource collection. This again, adds to the growing complexity of an end-user’s interaction with a library facility.

With the increased use of digital technology within library systems, these organisations are undergoing a fundamental paradigm shift (Barker, 1997). They are moving away from being just “storehouses of human endeavour” towards becoming “centres of learning and knowledge sharing.” This is particularly so in the case of academic libraries within schools, colleges, and universities. Secker (2004) has discussed, at some length, the impact that this paradigm shift is having on university libraries. Of course, as nonacademic, traditional libraries change their brief, to become centres for lifelong learning, they too are likely to undergo this paradigm shift.

Bearing in mind what has been said previously, it is important to realise that end-user interaction with a library system – be this in a face-to-face context, through a personal computer or a workstation facility – is likely to become more and more complex as time progresses. It is therefore imperative that we devise and provide library users with appropriate tools to help them overcome the problems that they are likely to encounter. The types of tool that we advocate in this article are based on the application of electron-
ic performance support technology (Gery, 1991; McGraw, 1994; Stevens & Stevens, 1995; Bezanson, 2002; Reeves & Raven, 2002).

Over the last decade we have had substantial experience in designing and applying the theory and practice of electronic performance support systems (EPSSs) to the problems of helping users of advanced technological systems. In some typical examples of the projects that we have undertaken we have derived theoretical foundations (Barker, 1995) and applied the principles of EPSS to the design of support for electronic file transfer (Banerji, 1995), virtual study environments involving distributed performance support (Beacham, 1998), information retrieval using search engines (Flinders, 2000) and quantitative research methods (Pearson, 2001; van Schaik, Pearson, & Barker, 2002).

Figure 3 shows the generic relationship that exists between a system and its user(s), a supporting EPSS and a possible scaffolding environment.

An EPSS should be regarded as a support tool that enhances a user’s ability to interact with and use a given system. In addition, an EPSS can provide a scaffolding mechanism that provides support for both novice and/or experienced users who want to learn new things. As a novice’s familiarity with the system increases, the influence of the scaffolding environment can be reduced and, ultimately, fade away.

The theoretical basis for performance support is rooted within the belief that many innate human limitations can be overcome through the appropriate design and use of performance aids. These may be of a cognitive, intellectual,
physical, mechanical, electronic or bio-technical nature. One important approach to the effective use of EPSS technology is its application to the development of “scaffolding environments” (Cagiltay, 2006). Such an environment is essentially a supportive infrastructure that people can use while they are learning about and acquiring new skills and competencies – for example, learning how to use a specialised search tool for locating particular items of interest within a digital resource repository.

As has been mentioned previously in this section, our current EPSS research has been oriented towards studying how we can use performance support technology to provide a supportive infrastructure for library users (Famakinwa, 2004). We have therefore designed, tested, and evaluated a prototype EPSS facility to help library users overcome some of the difficulties that they encounter when using academic libraries. The functional role of this EPSS facility is depicted schematically in Figure 4.

The setting for the research and development work that we have undertaken was provided by the academic library facility at the University of

![Figure 4. Using an EPSS to provide a scaffolding facility for library users](image)
Teesside (http://www.tees.ac.uk/lis). This is a very modern, highly computerised library environment that provides access to a large range of resources—both conventional and electronic. In addition to the range of resources that it provides access to, there is an equally broad spectrum of users that it has to serve. It has to cater for undergraduate students from a variety of disciplines (studying for degrees and diplomas), research students, and staff from six different schools.

In the remainder of this article we discuss some of the important issues underlying the design and implementation of our prototype EPSS facility (called “EPSILON”). We then outline the nature of the system evaluation that we conducted to assess the effectiveness of the performance aids that were embedded within the system. The final part of the article discusses the implications of our findings and outlines a future programme of work that we intend to undertake to move the system from its prototype stage into a completed operational product. We hope to share the final implementation of this product on a national basis with other university libraries within the United Kingdom.

**SYSTEM DESIGN AND IMPLEMENTATION**

**System Requirements and User-Needs Analysis**

At the commencement of the project a focus group session was conducted with the University of Teesside library personnel. This was done to identify problems that users encountered while using library services. The findings from this session indicated that students experienced difficulties with:

(a) searching for journal articles and books within the library’s electronic catalogue, (b) understanding and using journal citations, (c) using the online databases, and (d) locating books and journals within the library. Discussions were also held with 19 students to further identify users’ needs. These discussions took the form of one-to-one interviews.

The results from the sessions with the library personnel and students led to the specification of the tasks that the prototype system should support. The tasks which were therefore selected for support in the prototype included (in decreasing order of importance): (a) searching for information on subjects of interest; (b) locating books and journal articles within the library stock, and (c) managing the process of borrowing books. These high-level tasks were each broken down into smaller sub-tasks.

The findings from the interviews with students echoed the beliefs of the library staff. However, a common problem expressed by the students was the lack of awareness of the full range of library services available to them. Even in organised library sessions the students complained that too much information was given to them. In addition, library-prepared documentation was not readily accessible when it was actually needed.
Prototype Design

Based on the system requirements and user-needs analysis, the design specifications for the prototype were produced. The prototype was designed and implemented and extensive formative usability testing was conducted. This was especially important for this project, as it was necessary to interface with several external applications and there were no prior examples on which to base the initial designs.

Content. The major components of an EPSS normally include online help, an expert system, online learning and text retrieval (Barker & Banerji, 1995). Each component is usually designed to accomplish a particular goal. The characteristics of the type of information or support each provides are therefore different. For this project only the online help and expert system components were implemented. The content characteristics of the online help component had to be designed to provide context-sensitive information (such as basic facts, definitions, procedures, and their expected results) in small manageable “chunks of information.” The expert/advisor system had to provide more dynamic and interactive support for users while they were completing a task. The content for the EPSILON system (which was designed as a series of web pages) was taken mainly from the University of Teesside’s Library and Information Services web site.

Navigation. Simplicity and consistency are important factors that can have considerable impact on a user’s navigation through a web site. Simple and consistent user interfaces will therefore help novice users quickly become accustomed to an application and allow easy movement between the different sections of the web site. Bearing this in mind, the global menu system for the EPSILON system was located at the top of the screen (in the title panel), where users could readily access the home page and various “personalised services” (see Figure 5). From the home page, users could access all the features and services of the system by judicious use of menu items that had collapsible submenu items (these were intended to reduce screen clutter).

Visual design. The page layout design for the web site was based on the use of a template that contained three panes: (a) a title pane, (b) an information pane, and (c) a help pane. The title pane was located at the top of the browser window. As previously mentioned, it contained the global menu system for the application and also gave users access to the home page and their individual personal areas. In the information pane, users could receive specific help in performing any task that they had selected to perform. The help pane was used to provide additional information to assist users with the current task (or subtask) that was being performed. Clicking on the Help Assistant links (found within the information pane) would also update the Help
The Help pane was collapsible and could thus be hidden from view when not in use.

The advisor component of the system was responsible for providing advice and support for users while performing certain tasks that would require interfacing with external services. The External Applications User Interface was the mechanism that enabled the support of external software applications that could not be readily integrated into the system because their source code could not be accessed. It opened up in another browser window containing two panes (Figure 6). The external service or application was loaded in the lower pane – the application pane - while assistance and support information was presented in the upper pane – the support pane.

**Testing the Design**

Throughout the design of the user interface, informal usability tests were carried out with people not connected with the project. Test users were three fellow members of the Master of Science (MSc) Information Technology cohort of which the third author (Oladeji Famakinwa) was a member. Two females and a male took part in the informal usability tests; their ages were in the range 23-25 years. For the tests they were given library-related tasks.
Making a Case for Using Electronic Performance Support Systems

These tasks were further expanded on and used in the final evaluation of the prototype. While using the system, the participants were constantly observed; they were also encouraged to think aloud. This testing allowed the identification of usability issues at an early stage and enabled them to be addressed before too much work had already been committed to the project (therefore making changes difficult). This section documents some of the test results obtained while designing and building the prototype.

**Page layout.** The first drafts of the user interface involved using a display with four-panes. However, early testing of this arrangement established that it was too cluttered and therefore it was reduced to a three-pane display – with the Help pane being collapsible. This greatly enhanced the overall look and feel of the screen. The home page was also redesigned as the initial designs suffered from too many links on the page, which confused users. The final design resulted in the use of collapsible menus that hid their sub-menu items until they were clicked. The frequently-used menu items were therefore made visible while less frequently-used ones were initially hidden.

Even though the Help pane was collapsible, the default state was to have it displayed. Informal usability tests showed that this decision to keep the help pane visible was flawed. All users ignored the help pane while performing tasks – even as far as not being aware of its existence. Thus, when
they did make a request for help by clicking on help topics in the Information pane, they were unaware that the Help pane had been updated with this new information request.

**External applications interface.** The Advisor component of the system implemented the External Applications User Interface. When activated, a new browser window was opened containing two panes (Internet Explorer frames). The external service or application was loaded in the lower pane while assistance and support information was presented in the upper pane. This design was mandated by the need to interface with an external application with the EPSS system. However, users experienced difficulties with using this system.

Opening a new browser window while performing a task often disoriented and confused users. When they were finished with the use of the Advisor component, they often forgot to close the window to continue with the main task at hand. The size of the upper pane was fixed and so the size of the lower pane was determined by the size of the window. This, however, also meant that on low-resolution screens the window opened was small and so the application pane was often too small to use without excessive scrolling. Users failed to realise that the pane divider could be adjusted.

**IMPLEMENTATION**

To allow for a tighter and more seamless integration with preexisting web-based library software services (such as the library’s electronic catalogue), the system was designed to be web-based. The basic tools used were Hypertext Markup Language (HTML), a client-side scripting language (JavaScript), and Active Server Pages (ASP) – or server-side programming.

**Book Locator**

In the implementation of the library’s electronic catalogue, after a user had found the details of a book and its associated shelf mark, there was no further information available to show the location within the library where the book could be found. The Book Locator was an EPSS advisor component of the system that provided this information. Using the book’s shelf mark, a user could determine the floor of the library on which a book was located and also the location on that floor at which it should be shelved. During the testing of the system this was the feature that students liked most.

**Personalised Area**

ASP technology is used for producing dynamic web pages. A server generates these as a browser requests them. The personalised area of the system was implemented using ASP technology in combination with the Microsoft
Access relational database management system. By logging into the system using an appropriate user account, users could access their own personal areas of the system. The account information consisted of a username and a corresponding password. This information was stored in the system’s database. If a user did not have an account then one could be created by visiting the account registration page. The personalised area of the EPSS provided the following services to users: creating notes, saving documents, opening previously created notes, and opening previously saved documents.

EVALUATION

An evaluation of the EPSILON system was conducted to establish levels of task performance, efficiency, speed and acceptance, and usability problems, by comparing aided task performance (using EPSILON) with unaided performance (using the LIS web site).

Method

Experimental design. Using an independent measures design, the independent variable was task support (aided using EPSILON, unaided using the LIS web site). Dependent variables were task completion, efficiency and speed of task performance, intention to use the system and usefulness of the system as measured by psychometric scales.

Participants. The sample size and selection procedure of participants were restricted by budgetary constraints. A sample of 20 was used for an initial test of the effectiveness of EPSILON. Participants had to be university library users. Fifteen of these were postgraduate students (10 studying various computing programmes and the remaining 5 studying courses in marketing, engineering, social sciences, health, and sports). The other five were studying an undergraduate programme or had completed such a programme in computing, graphics design or law. Half of the participants were recruited from the MSc Information Technology cohort and the other half from visitors to the university library at the time the evaluation was conducted.

All participants had some experience of using the World Wide Web (WWW or Web). Participants had been using the Web from more than a month to more than a year and the majority (95%) had been using the Web for more than one year. In terms of frequency, many participants (75%) used the Web more than once a day, with the remaining 25% of participants using the Web more than once a week but less than once a day.

The majority of the participants (95%) had some experience with the LIS web site. Participants had been using the web site from less than a month to more than a year and the majority (65%) had been using the web site for more than one year. In terms of frequency, many participants (50%) used the...
web site more than once a week, with the remaining 45% of participants using the web site less than once a month.

**Materials and apparatus.** The experimental group used EPSILON and the control group the LIS web site and the tools and services hosted on it. Although the sites differed in various ways, both made it possible to complete all the tasks that participants were asked to perform. The experiment was carried out on personal computers connected to the Internet in the university’s library. The questionnaire was divided into two sections: Section 1 measured demographic details and computer self-efficacy (Hill, Smith, & Mann, 1987) and was answered by both groups. Section 2 was exclusively designed for and answered by the experimental group and measured intention to use, and perceived usefulness of EPSILON, using 7-point Likert scale items based on Davis and Venkatesh (1996). This section also included open-ended questions on the usability of EPSILON. Reliability analysis showed that Cronbach’s alpha for the computer 4-item self-efficacy scale was close to the criterion value of 0.70 (alpha = 0.65 for Items 1, 2, 3, 4, and alpha 0.69 for Items 1, 2, 3). When deleting Items 3 and 4, the scale became reliable with alpha = 0.80. Therefore, a mean value over Items 3 and 4 was calculated and used in subsequent analyses. The 4-item perceived usefulness score was reliable with alpha = 0.93. Therefore, a mean value over the four items was calculated and used in subsequent analyses. A single item was used as an indicator of intention to use.

**Procedure.** Both groups were given an introduction on the features and services available on the site that they would be using. For each of six tasks, a description of the task was first handed out to each participant. Then, after reading the task, participants performed the task using the site available to them. Accuracy of task performance (correct or incorrect), number of links followed before the end of the task and time-on-task were noted. After the last task, participants were asked to fill out a copy of the questionnaire.

**Results**

The two sites were compared in terms of computer self-efficacy, level of task performance, efficiency and speed. Because of the small sample size, a significance level of 0.10 was adopted.

Mean computer self-efficacy was high in both groups (mean = -1.75, SD = 1.27 and mean = -1.80, SD = 1.62 for the control and the experimental group respectively) with an effect size $d = -0.04$ and a Mann-Whitney U test showed that the two groups did not differ significantly on this outcome measure, $z = -0.70$, $p > 0.10$. Furthermore, correlations of computer self-efficacy with measures of task performance, efficiency, and speed were not significant. Therefore, subsequently analyses comparing the two groups on
Mean overall correctness of task completion was 75% (SD = 23) for the experimental group, compared to 40% (SD = 18) for the control group with an effect size $d = 1.94$ and a Mann-Whitney U test revealed that the difference was significant, $z = -2.93$, $p < 0.005$. Figure 7 shows the completion rates for each task, with the most dramatic differences in favour of the experimental group for Tasks 2 (8 times more successful), 3 (60% successful compared to 0% for the control group), and 5 (> 3 times more successful).

Efficiency was measured as the ratio of the optimal number of links followed to the page that contained the correct answer to a task and the actual number of links followed by the participant to perform the task. Mean overall efficiency over correctly performed tasks was 0.86 (SD = 0.12) for the experimental group, compared to 0.68 (SD = 0.20) for the control group with an effect size $d = 0.90$ and a Mann-Whitney U test established that the difference was significant, $z = -2.27$, $p < 0.05$. Figure 8 shows efficiency per task, with the most dramatic differences in favour of the experimental group for Tasks 2 (almost 4 times more efficient), and 5 (> twice more efficient).

Mean time-on-task over correctly performed tasks was 1.35 minutes (SD = 0.42) for the experimental group, compared to 1.43 (SD = 0.99) for the control group with an effect size $d = -0.08$ and a Mann-Whitney U test showed that the difference was not significant, $z = -0.07$, $p > 0.10$. Figure 9 shows efficiency per task, with the most dramatic difference in favour of the experimental group for Task 5 (> 4 times more efficient).
In summary, improvements when using EPSILON occurred with very large and large effect sizes for successful task completion and efficiency with correct answers respectively, with exceptional improvement in Tasks 2, 3, and 5. However, speed of task performance was not improved.

Levels of intention to use (mean = 0.60, SD = 1.35) and perceived usefulness of EPSILON (mean = 1.00, SD = 1.31) indicated positive perceptions of the system. Wilcoxon matched-pairs signed-ranks tests, comparing mean scores against a neutral value of 0, showed that perceived usefulness
was higher than a neutral perception (represented by a value of 0), \( z = -1.69, \) \( p < 0.10 \), but intention to use was not different from a neutral value, \( z = -1.28, p > 0.10. \)

Participants’ answers to open-ended questions about the usability of the EPSS revealed the following positive aspects: ease of use, breakdown of tasks into clearly defined steps, clear description of available facilities and services, help system, user interface, and navigation system. Further answers indicated the following negative aspects: inadequacy of help system, colour scheme, look and feel, use of frames, navigation system, windowing system, and causing difficulty in using the EPSS. However, 30% of participants identified no negative aspects of the system.

The EPSILON user interface opened up too many windows during a typical task activity, thus disrupting task flow. This often disoriented participants as they frequently forgot they had to close the most recently opened windows before they could continue with the task. The help panel also posed an important usability problem. This panel was designed to be constantly visible thereby providing context-sensitive help to participants as tasks were being completed. However, most participants found this distracting and confusing; their view was that too many information windows were open at the same time. Other participants simply ignored the help panel and, even when help was needed, did not realise that this panel provided assistance. Participants had to resize both windows (the application window and the help panel) manually to view them simultaneously, an option many chose not to use. Furthermore, it was not possible to provide context-sensitive help with the window for the external applications interface due to security constraints.

**DISCUSSION**

The results show that task performance as well as efficiency and speed were improved when aided (using EPSILON), compared to unaided performance. In particular, tasks that capitalised on the performance enhancing facility of the system benefited from an enormous improvement.

The control group had a low completion rate on Task 2 because the LIS web site, although having information on the location of books in the library, did not integrate it into the library catalogue facility. It was found during the test that 95% of the participants were not aware of its existence. In this group, Task 3 also suffered because participants did not know where (in the web site) to find information about what to do in the event they were unable to locate the book or journal article they were looking for within the LRC. Related to Task 5, none of the participants considered making an inter-library loan request as an option. They were not aware of the inter-library loan service, even though they had heard about it. Therefore, in the control group, Task 5 completion rate also suffered as the LIS web site did not read-
ily make available information on how to use this service.

Although our findings demonstrate the performance-enhancing function of EPSILON, various usability problems with the first version of this system were identified. This means that the true potential of aided performance using the system (with improved system usability) is conceivably markedly greater than was achieved in this evaluation. In particular, the usability of the help system, navigation system and windowing will be considered in future design and development work to enable the full potential to be unlocked.

CONCLUSIONS AND FUTURE WORK

Previous work has focused on the theory of electronic performance support (Barker, 1995; Cagiltay, 2006) and its application of EPSS to business and commercial settings (Gery, 1991; Bezanson, 2002). We have extended the work to academic settings (Banerji, 1995; Beacham, 1998; van Schaik et al., 2002). As far as we are aware, the current study is the first of its kind to address the relevance and the application of EPSS to academic libraries and to assess end users’ acceptance of EPSS in this context.

In this research we identified two types of principles: generic and specific. Our first generic principle of performance support is that it should enhance human task performance. Our second principle is that an EPSS should make available data, information, knowledge, and skills at a particular point of need. A further optional principle is that an EPSS could embed and/or may provide a scaffolding environment. From the project described in this article, we have identified the following specific guidelines for EPSS:

1. an EPSS should provide explicit support for common tasks in the domain; this was implemented in the current project by presenting some common tasks as a starting point for using the library site;
2. it should present task procedures in a step-by-step way; this guideline was followed by breaking down the common tasks into individual steps;
3. it should present “just-in-time” information; in the current project this principle was illustrated by context-sensitive help that was available at each step of a task procedure and task procedures for common tasks were available just-in-time without having to learn or remember the details of procedures;
4. designers should consider the issue of integration with the target application; in the current project the target application (a library site) was launched separately to be used side-by-side with the EPSS – this being the most realistic option given budgetary constraints and the technical challenges of integration; however, in other projects, in particular where the application is developed simultane-
ously with EPSS components, integration may be possible and
desirable; this could improve users’ interaction with the target sys-
tem by avoiding having to switch between applications (the target
system and the EPSS); and

5. it is necessary to have simple and consistent navigation as well as
consistent visual design; both are general design principles for user
interfaces, but apply equally well to EPSS in particular.

In conclusion this project has demonstrated the viability of the applica-
tion of EPSS to library services. However, there is still an unfulfilled need
in terms integrating the many external tools and services already in existence
in library web sites. A user interface which seamlessly blends the EPSS and
library tools and services would assist in addressing and alleviating the
usability problems that were identified. Future research should test the effec-
tiveness of the EPSS with a larger sample of different types of library user.
The current study employed relatively experienced library users. However,
our current research investigates the use of our EPSS (for library work) with
new students who have not been previously exposed to an academic library.
Further work should also increase the scope of support in the library task
domain. For example, our current work investigates support for basic library
skills, in particular the use of a classification system for library resources,
such as books. We have identified two fundamental types of support: (a) for
developing basic knowledge of the library classification system as a basis
for developing skills in using this system; and (b) for task support in using
the classification system; with repeated use of this task support, users will -
as a side-effect - develop the required skills and will then not need task sup-
port in the future. Given the ongoing shift from paper-based resources to
electronic resources within library systems (Curtis, 2005; McMenemy &
Poulter, 2005), a further topic for future research would involve identifying
support for the use of a collection of different electronic journals and other
electronic resources.

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