DESIGNING ELECTRONIC PERFORMANCE SUPPORT SYSTEMS TO ENHANCE COMPUTER-BASED LEARNING

Philip Barker, Paul van Schaik, Robert Pearson

ABSTRACT
An electronic performance support system (EPSS) is a computer-based environment that facilitates skill and knowledge acquisition within a particular domain of study. As well as its pedagogic utility, an EPSS can also be used to augment and enhance an individual's performance beyond those limits that are set by innate natural ability. EPSS techniques can also be embedded within computer-based learning systems in order to improve the efficiency and effectiveness by which students can acquire skills and knowledge. Our ongoing research programme in this area has been investigating the potential utility of our EPSS methodology within a range of different domains. This current paper describes an application of the technique within the domain of 'quantitative research methods' as taught within a psychology degree course. As well as describing the design and implementation of the system, this paper also outlines and discusses the results of an evaluative study of the prototype EPSS tool that has been created.

KEYWORDS
Electronic performance support, EPSS, computer-based learning, human-computer interaction, statistics, statistical methods, quantitative research methods, web-based delivery, system evaluation

INTRODUCTION

Virtually all cognate human behaviour is motivated by goal-seeking activity (van Merriënboer, 1997). Such activity is invariably mapped onto a sequence of tasks that allows an individual (or group of people) to move from some initial state of existence to some other sought after (and hopefully, more desirable) state of being.

Within an educational context, the 'more desirable' state referred to above is likely to involve the acquisition of 'richer' knowledge states and/or an improved skill set (within a given problem domain). Naturally, an important aspect of instructional design is therefore, either (a) the explicit formulation of task sets that can achieve these richer states (and which students can use directly), or (b) the identification of 'learning scenarios' that allow students to discover these task sets for themselves.

Despite the skills and knowledge that they have, most individuals (or groups) often find themselves in situations where a given goal is to be achieved, but yet they are not equipped, either intellectually or skill-wise, to achieve its realisation. It is therefore important to consider how the absent skills and/or knowledge can be acquired. One important approach to the realisation of this objective involves the use of an electronic performance support system (Gery, 1991; Barker, 1995; Reeves and Raven, 2002; Bezanson, 2002). Examples of the ways in which this approach can be used can be found in the work of McGraw (1994), Stevens and Stevens (1995), Wild (2000) and Flinders (2000).

In a previous paper (Barker and Hudson, 1998), we suggested that a fundamental requirement of an electronic performance support system (EPSS) is that it should increase a user's on-the-job performance within a given task domain. This can be achieved in two basic ways. First, through the provision of 'automated aids'; and, second, by providing various mechanisms to support 'on-the-job', 'just-in-time' training - which will enable users of any given system to 'learn as they do'. Naturally, within an educational context, the emphasis on teaching and learning activities will change the underlying design emphasis that is employed. Therefore, we believe that an EPSS facility that is designed to fulfil an educational need should accommodate the following three basic requirements. First, it should act as a pedagogic agent to assess skill and knowledge requirements for a given task sequence and 'fill in' the gaps relating to a user's capability. Second, it must function as a transfer agent to develop skills and knowledge using 'on-demand' and/or just-in-time mechanisms. Third, it should act as an augmentation aid to improve human performance - over and above an individual's (or a group's) innate natural ability.

Depending upon their scope and capability, support aids that are used to improve human performance can be classified according to a six-tier taxonomy (van Schaik, Pearson and Barker, 2002). The work described in this paper is based on the use of an *integrated electronic performance support system* for the facilitation of task execution within the domain of '*quantitative research methods*'. Our motivation for wanting to develop an EPSS for this domain stems from the current lack of availability of integrated systems for use in this area. Some approaches to the use of 'stand-alone' electronic teaching packages for specific techniques have been described in the literature - see, for example, Morris (2001). However, there is a growing need for more powerful integrated environments (Branford, 2001). Although online packages for supporting statistical tasks do exist (such as MINITAB and SPSS), these are not really regarded as integrated EPSS systems. Such an integrated environment should explicitly support the various tasks that a student or researcher encounters when conducting a research project.

Although our system has been designed primarily for use by students following psychology courses, the system can be used within other domains - both undergraduate and post-graduate. For example, students following courses in human-computer interaction (HCI) often have to design experiments to observe human behaviour (such as reading rates, typing speeds, reaction times, and so on). Such students therefore need to know how to design and conduct experiments. They also need to understand which statistical tests that they should use in order to analyse their data and make inferences based upon their observations. The EPSS environment described in this paper is designed to meet this need (Pearson, 2001).

In the remainder of this paper we describe the implementation of the prototype performance support system that we have built. Details are also given of the evaluative study that we have conducted with respect to undergraduate usage and opinions of the system.

SYSTEM DESIGN AND DEVELOPMENT

This section of the paper briefly discusses the various phases involved in the implementation of the EPSS facility. The following topics are described and discussed: the needs analysis, design considerations and the development phase. Short descriptions are also given of the various 'building blocks' that make up the prototype EPSS facility.

The Needs Analysis

In order to identify relevant content for the EPSS, a needs analysis was conducted. This took the form of a survey of psychology students at the University of Teesside. The needs analysis was undertaken in order to identify the most important topics (relevant to quantitative research methods and statistics) that the EPSS should contain. It also served to determine whether students would be likely to use an EPSS to support their studies. The results of the needs analysis were also used to identify the nature of the materials and learning aids that the students currently employ. It was found that the main statistical software used by the students was the '*Statistical Package for Social Scientists*' (SPSS). The EPSS facility therefore had to be designed 'around' the use of SPSS.

Before the prototype EPSS could be designed and built, the hardware and software requirements of the proposed system had to be identified. Based upon our previous studies of both stand-alone and distributed EPSS tools, it was decided that in order to meet both Banerji's and Beacham's design principles, an Internet-based system would be the most advantageous (Banerji, 1995; Beacham, 1998). The prototype system was therefore based upon the use of HTML and JavaScript technologies. In addition, because the EPSS had to be easily updateable, and also be capable of incorporating 'personal' performance support aids, it was decided that a 'database-driven' approach had to be used. This was achieved through the use of a software technology known as Active Server Pages (ASP).

In order to address the individual needs of potential users, the information that was gathered during the needs analysis was used to identify a number of different functions that had to be supported by the tools that were to be embedded in the prototype EPSS facility. These included: an '*Advisor*' system, a '*Help*' facility and a '*Personal Area*' - the latter being used for each individual user's '*Notes*' and personalised '*Performance Aids*'. The generic performance support facilities that were produced for the prototype EPSS environment were based upon tools for performing '*statistical power analysis*'.

DESIGN AND DEVELOPMENT

The Database

In order that the EPSS could be database-driven (using ASP techniques in conjunction with Microsoft Access) an appropriate database had to be designed and created. This had to contain information relating to the *Help* and the *Advisor* systems. It also had to store details of the users themselves, their personal notes and linkages (to various items in the EPSS and other sources on the Internet), and usage records. An important aspect of the database system was its use of the 'Structured Query Language' (SQL) in order to search for and retrieve information.

The Help System

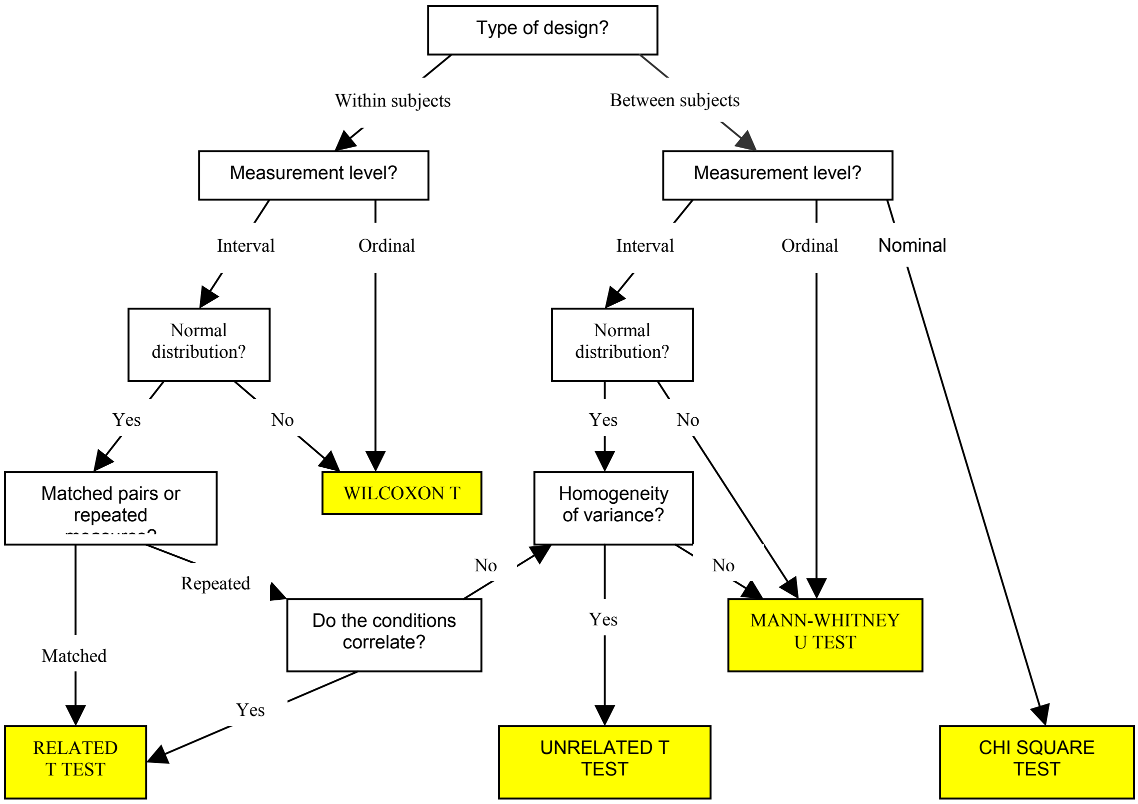
The aim of the Help facility was to allow users to obtain easy access to any available information relating to quantitative research methods and statistical concepts that happened to be stored within the Help table of the database. This could be achieved in either of two basic ways. First, by allowing a user to submit a word or term (describing his/her help requirement) which could then be used as a search criterion to locate and return any relevant information contained in the Help table. Second, by displaying the whole contents of the Help table (on the computer screen) and allowing users to search through it manually.

When constructing the help system, the needs analysis was used to highlight potential areas in which users might need support. The analysis results were therefore used to identify the content areas that the help system should attempt to cover.

The Advisor System

The aim of this tool was to guide users towards information about procedures that they wanted to carry out or towards concepts that they wished to learn about. When the system guides users towards appropriate information, they are given a number of optional choices at each level of the hierarchical decision tree that is used to navigate through the EPSS content pages. As users proceed through the navigation tree for any given topic, each of these options is explained; users can then choose either the option that represents the data that is being examined or an option that corresponds to the procedure that they wish to carry out on their data.

The major part of the content of the basic web pages that make up the *Advisor* system is 'hard coded'. However, each of these pages is partially database-driven because any content that is used on a number of different pages (for example, '*nominal*', '*ordinal*' and '*interval*' descriptions) and the definitions of key statistical terms (such as '*related t-test*' and '*correlation*') is always retrieved from the Help table in the database.



Some of the pages within the system also offer links to other pages that contain further information to support the concepts and ideas being explained in the *Advisor* system. All of the bottom-level pages within this facility have links to further pages that explain the steps that have to be performed in order to carry out the relevant statistical procedure using SPSS.

The idea of teaching users how to carry out tasks in SPSS was also explored. For example, in the case of the '*related t-test*' a simulated SPSS environment was used. This environment enabled users to learn the steps required in order to carry out this procedure by actually executing them within the EPSS environment. This facility was implemented by displaying screen shots of SPSS along with menu options and buttons that could be used as 'hot-spots' - which when clicked would allow a user to proceed to the next step in the task sequence being executed.

As was mentioned earlier, the needs analysis highlighted areas where potential users might need support - and therefore suggested the content areas which the *Advisor* system should attempt to cover. Bearing this in mind, the domain knowledge of the EPSS was organised into two broad areas that dealt with *descriptive statistics* and *inferential statistics*, respectively. These areas could be displayed in the form of tree diagrams representing how users would be guided towards relevant information. Figure 1 shows the tree diagram for the *Descriptive Statistics* unit and Figure 2 presents the diagram for the *Inferential Statistics* section. In each diagram, the rectangles represent web pages within the *Advisor* system and the arrows denote hypertext links. A link on each web page also allows access to a map of the descriptive or the inferential statistics *Advisor* - depending upon which part of the system a user happens to be in. Each map includes links to the relevant pages in the *Advisor* system.

The Personal Area and Notes

The aim of the personal area and personal notes was to allow the incorporation of personal performance aids and tools. In order to access their personal area and their personal 'sticky notes' users must log into the system. Once logged in, a user is able to add, edit and remove their notes from the host pages that they relate to. When within their individual personal areas, users are also able to add links to personal performance aids and tools on the Internet as well as edit and remove all of the 'sticky notes' that they have added to pages.

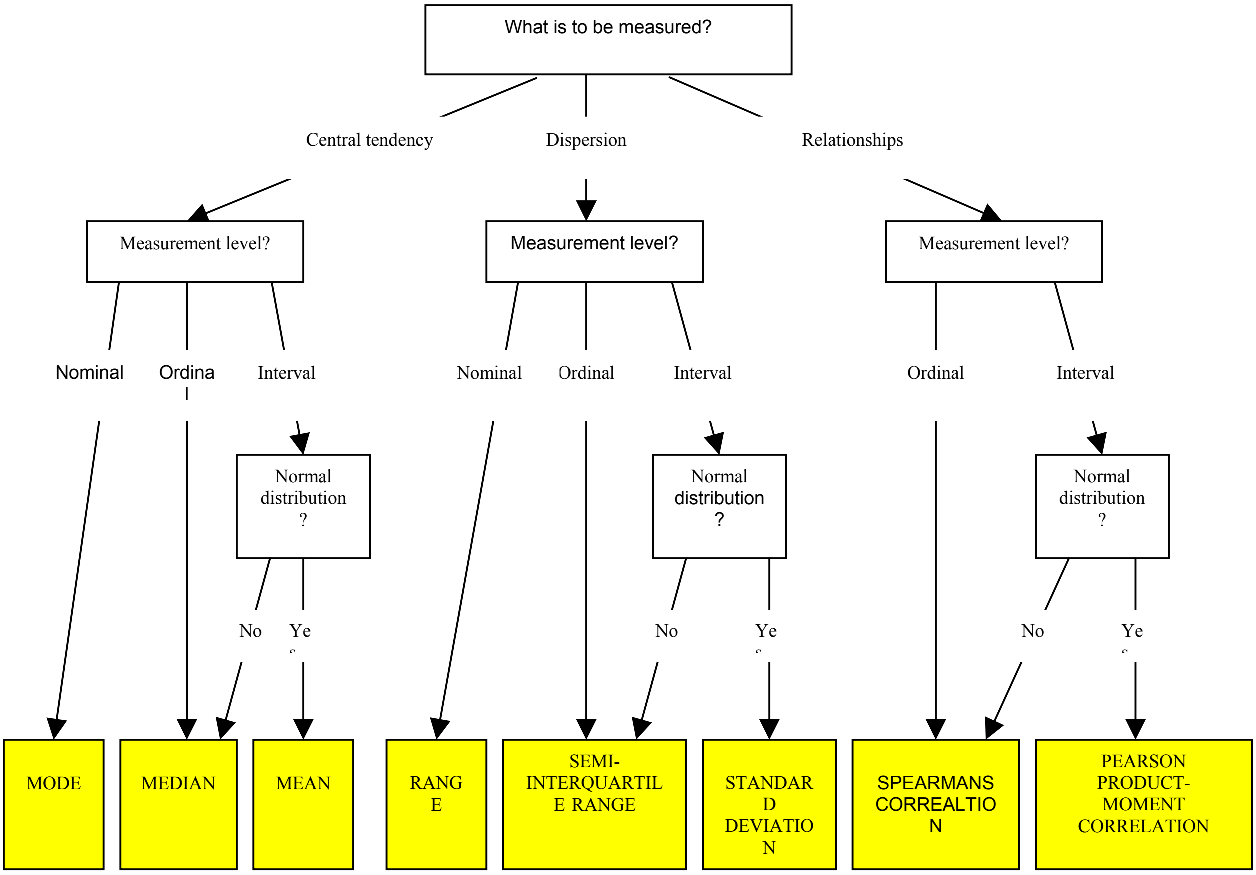


Figure 1. Tree diagram for Descriptive Statistics

In addition to the user's notes and personal area, a '*usage record*' is also kept of all the EPSS pages that individual users view. A usage record starts as soon as a user has logged onto the system. The *page-id* of each web page that a user visits is then concatenated to the root entry for the usage record. When a user leaves the system (by logging off), the usage record is stored in the Usage Record table of the database. Some of the other data that is also stored in the usage record include - the user's *user-id*, the *date* and the *time* at which the user logs off. The usage records enable the system administrator to monitor and analyse EPSS usage. In order to provide the sticky notes facility and the audit trail that is held within a usage record, every page of information in the EPSS system has to have its own unique identifier associated with it. For this purpose, within the current implementation of the system, we use the actual file name in which a web page is stored.

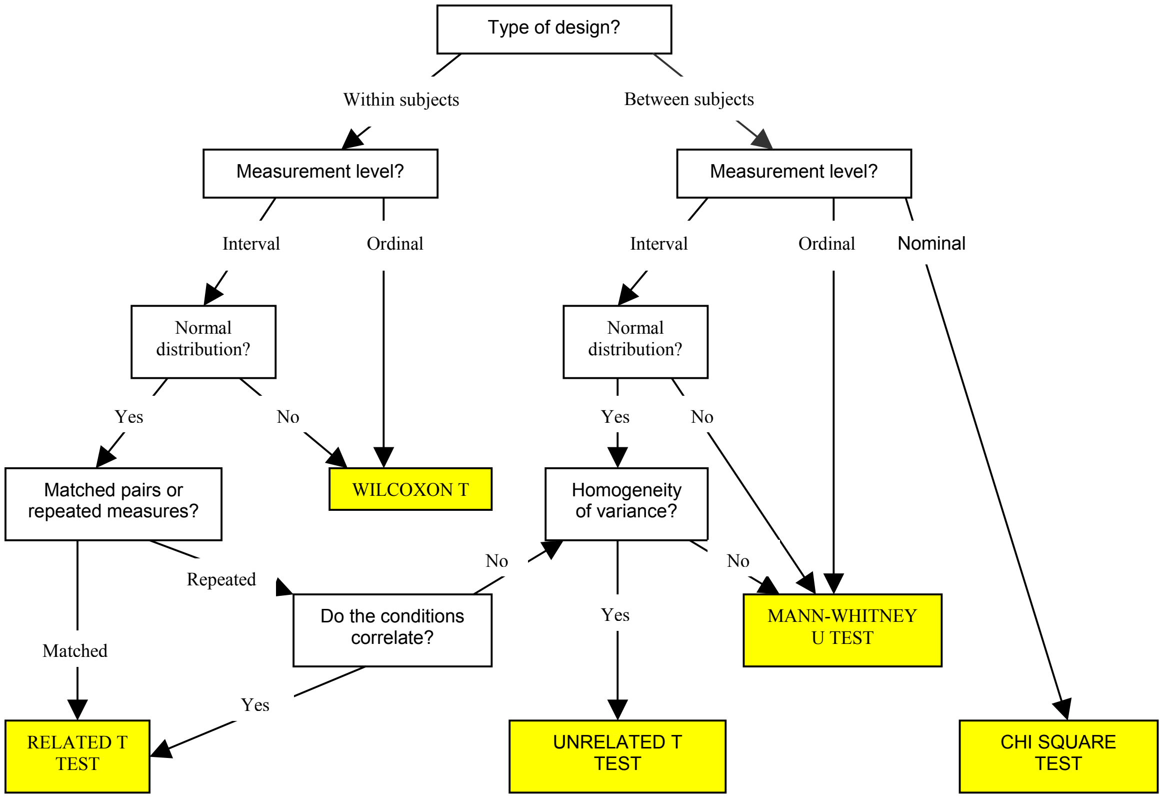


Figure 2. Tree diagram for Inferential Statistics

The Performance Aids

The performance aids that were developed were intended to provide special purpose tools to execute tasks that students would normally carry out 'by hand'. Within the prototype EPSS, one of the generic skill areas that have been implemented involves '*power analysis table look-up*'. The EPSS is able to cater for two possible situations. First, it could be used for '*within subjects tests'* (using the *related t* and *Wilcoxon's T* standard statistical tests). Second, it could be applied to '*between subjects tests*' (based on the use of the *unrelated t* and the *Mann-Whitney U* statistical procedures). Each of these could be applied in both a 'prospective' and a 'retrospective' way.

As different variables are required to carry out *prospective* and *retrospective power analysis* two separate tools were designed. For each of these tools a web page was constructed that allowed a user to choose and submit the *research design* for a given experiment. This could be based on either an '*independent measures*' approach or a '*repeated measures*' technique. In addition, the following information was needed: the directionality of the test (either *one-* or *two-tailed*), the statistical test to be used, (the *related t*, *Wilcoxon's T*, *unrelated t*, or *Mann-Whitney U*) and the effect size (*d*). For the prospective power analysis the power was also required and for the retrospective power analysis the sample size also had to be specified.

In order to implement the performance aids for the power analysis tools, four 'look-up' tables were required. These were created dynamically (in JavaScript) using two-dimensional arrays. Appropriate JavaScript code was then developed in order to populate the arrays, display them on the user's computer screen and search through them in order to locate the required entries - carrying out interpolation if this was deemed necessary. Once relevant entries in the JavaScript tables have been located the corresponding values in the displayed tables can be highlighted on the user's screen.

EVALUATION

Method

An evaluation of the prototype EPSS for quantitative research methods was conducted in order to establish students' performance with the system and their overall acceptance of it as a teaching and learning aid. In addition, students' level of knowledge of concepts in quantitative research methods was also analysed.

Design and participants

The EPSS was evaluated as part of revision lab classes (class sizes of 15 to 20) at the start of the second academic year of an undergraduate Psychology programme. The evaluation employed a single sample of 89 Psychology students (75 females, 13 males and 1 not stated) who had taken two research modules in their first year of study; the quantitative research methods content of these modules was included in the EPSS. The students' mean age was 24.6 with a standard deviation of 8.4. Students rated themselves as possessing relatively little experience with regard to quantitative research methods (median = 2.5 with semi-interquartile range (siqr) = 0.9 on a 5-point Likert scale) and SPSS (median = 2 with siqr = 0.9 on a 5-point Likert scale). They rated themselves as moderately experienced in the use of computers (median = 3 with siqr = 0.5 on a 5-point Likert scale).

Materials and apparatus

The EPSS was mounted on an intranet server. A questionnaire was used as an evaluation instrument and was divided into four sections. The first section measured students' prior knowledge of concepts in quantitative research methods; it employed twenty multiple-choice questions. The answer sheet required respondents to write down as their answer: (a) one of four answer alternatives presented for each question and (b) their level of confidence (percentage) in the answer given. Section Two measured the demographic details of respondents. The third section of the questionnaire measured the students' task performance when using the EPSS - through the answers that they gave in response to tasks they were asked to conduct. Finally, Section Four was used to measure the respondents' acceptance of the system, including the key concepts of perceived usefulness and intention to use - as identified in technology acceptance research (Davis and Venkatesh, 1996). Five-point Likert scale items were used in Sections Two and Four of the questionnaire.

Procedure

Students first filled in Section One of the Questionnaire. Next, they were instructed to use and explore the EPSS for 10 minutes. Following this they were asked to answer the questions in Sections Two, Three and Four and use the EPSS as needed when completing Section Three.

RESULTS

Knowledge of concepts in quantitative research methods

Over the twenty knowledge questions, the mean percentage of correct answers was 53.1 with a standard deviation of 12.2. The mean confidence in answers was 48.2 percent with a standard deviation of 18.3. The percentages of correct answers for individual questions are presented in Table 1.

Questions relating to the following concepts had fewer than 40% of correct answers: *variability*, *bi-variate correlation*, *errors in statistical testing*, *degrees of freedom*, *linear regression* and *binomial distribution*; questions related to other concepts had more than 50% correct answers. Over all the twenty questions, the percentage of correct answers had a significant correlation with confidence, $r = 0.25$, $p < 0.05$.

Use of the EPSS

The percentages of correct answers for the four questions requiring the use of the *Advisor* system showed good performance on three questions (see Table 2). *Advisor* Question 4 suffered from poorer performance because many respondents answered the question in terms of difference rather than relationship as stated in the question. Percentages of correct answers for two questions requiring the use of *Tools* showed good performance (see Table 2). Furthermore, performance was good on the questions requiring the use of the *Help* facility - showing high percentages for successfully finding concepts within *Help* (see Table 2). An overall score for EPSS performance was calculated as the total number of correctly answered questions and items found in the *Help* system. The mean percentage score was 84.6 with a standard deviation of 13.9. Pearson's correlation between EPSS success and percentage of correctly answered knowledge questions was non-significant ($r = 0.067$, $p >> 0.05$). An unrelated t test showed that those scoring below the median and those scoring equal to or higher than the median on the knowledge questions did not significantly differ in their overall EPSS performance ($t(71) = -0.366$, $p >> 0.05$).

Table 1. Percentages of answers to knowledge questions

Q	**Concept**	*Percentage correct*	*Confidence - mean (sd)*
1	Central tendency	99	78 (25)
2	Variability	**21**	**48** (23)
3	Normal distribution	65	**49** (25)
4	Bi-variate correlation	**32**	**34** (21)
5	Significance testing with two groups	61	53 (27)
6	Descriptive statistics	63	**47** (26)
7	Parametric test for two unrelated samples	57	**45** (28)
8	Level of measurement	63	**43** (28)
9	Validity	81	60 (27)
10	Correlation	74	**45** (31)
11	Sampling	76	67 (24)
12	Causation	78	58 (25)
13	Errors in statistical testing	**17**	**43** (28)
14	Degrees of freedom	**39**	**37** (25)
15	Parametric test for two related samples	62	**41** (25)
16	Design when using two related samples	84	56 (29)
17	Linear regression	**2**	**37** (26)
18	Graphical representation of interval level data	83	**48** (29)
19	Binomial distribution	**18**	**38** (26)
20	Homogeneity of variance	52	**37** (29)

Notes: Q = question; sd = standard deviation

Table 2. Percentages of answers to questions requiring use of the EPSS

EPSS Sub-system	Question topic		Percentage correct or found
Advisor	1	Measure of central tendency for parametric data	95
	2	Parametric test of independent measures design	76
	3	SPSS menu selections for parametric test of independent measures design	77
	4	Test for relationship in ordinal data	47
Tools	1	Prospective power analysis	94
	2	Retrospective power analysis	90
Help	1	Mode	100
	2	Interpolation	100
	3	Effect size	97
	4	t test	79

System acceptance

The usefulness of the EPSS for learning, revision and completing assignments each had a median score of 5 (with siqr 0.25, 0.25 and 0.5 respectively). The perceived likelihood of using the EPSS, if it was made available through the university's intranet, had a median score of 5 with siqr 0.25. A Wilcoxon's paired signed-rank test showed that median scores on all four measures were significantly higher than a neutral score (represented by a value of 3 on a five-point Likert scale), all $z < -5.9$, $p < 0.001$. Using Kendall's tau it was established that all four system-acceptance questions were significantly correlated.

DISCUSSION

Overall, knowledge levels indicated that there was scope for improving students' performance. Specific areas of poorer performance were *variability*, *bi-variate correlation*, *errors in statistical testing*, *degrees of freedom*, *linear regression* and *binomial distribution*. Further development of the EPSS could address these areas in more detail within the *Advisor* system and *Help* facility.

Overall students' performance using the EPSS was high (mean = 84.6% correct). This indicates that the EPSS was successful in supporting students when performing tasks related to quantitative research methods. Although outcome measures of knowledge and EPSS use were not designed for comparison, overall, students' performance using the EPSS was higher than unaided performance on knowledge questions (mean = 53.1% correct). Comparing students' level of knowledge and their success on tasks with the EPSS more directly, it was found that in the area of *parametric test* for *independent measures* design (knowledge question 7 and *Advisor* question 2) students' performance improved by 33%. These results suggest that the EPSS can be used as a means to improve students' performance.

There was a non-significant correlation between students' performance in terms of (a) knowledge of concepts and (b) success in using the EPSS. This correlation together with the non-significant difference in aided performance between the better and poorer students in terms of unaided performance indicates that students with different levels of knowledge benefit equally from using the EPSS for revision.

The correlation between performance and confidence when using the EPSS was not examined in this study. However, the significant correlation between confidence and performance on the knowledge questions indicates that use of the EPSS may not only result in increased student performance but might also produce an increase in confidence as well.

Regarding perceived usefulness, students expected that the EPSS would be useful to them for learning, revision and completing assignments. Relating to intention to use, students believed that it was likely that they would use the system if it was made available to them through the university's intranet. The significant correlations between acceptance measures confirmed the association between intention to use and perceived usefulness found in previous research (Davis and Venkatesh, 1996; van Schaik, Bettany-Saltikov and Warren, 2002).

CONCLUSIONS AND FUTURE WORK

The EPSS that we have developed has extended the range of electronically supported domains to the area of quantitative research methods using a web-based implementation. This implementation makes it possible to support a global user community of learners and researchers with regularly updated support. The global scope of our system is in line with developments towards global educational and training systems such as virtual universities (Hazemi and Hailes, 2001). Further details of our ongoing work in this area are given elsewhere (Moukadem, Barker and van Schaik, 2002).

The evaluation results of the EPSS in the context of revision are encouraging. However, the value of the EPSS should also be assessed in other situations such as learning and completing assignments.

The scope of the EPSS can be extended in various ways in order to make it more widely applicable. In particular, the range of the quantitative research methods included in the system could be increased. Furthermore, the scope of the domain could also be extended in order to make it more general. This could be achieved by supporting the process of research from 'start to finish' rather than only research methods. Although various textbooks describing or prescribing the overall research process are available - see, for example, Robson (1993) - online support in the form of an EPSS is still lacking

The functionality of the EPSS can be extended in order to support a wider range of tasks within a learning or research context. For example support for communication between users could be provided. This could be implemented by linking with existing tools for electronic communication. Furthermore, the set of tools provided by the EPSS and the number of links to other (online and off-line) resources could be expanded.

ACKNOWLEDGEMENT

A previous version of this paper has been published by the UK's Staff and Educational Development Association (SEDA) in their journal *Innovations in Education and Teaching International*.

REFERENCES

Banerji, A.K., (1995). Designing Electronic Performance Support Systems, PhD Thesis, University of Teesside, Middlesbrough, UK.

Barker, P.G., (1995). Electronic Performance Support Systems, Special Edition of Innovations in Education and Training International, 32(1), 1-73.

Barker, P.G. and Hudson, S., (1998). An Evolving Model For Multimedia Performance Support Systems, 60-73 in Trends in Communication: Part 4 Interface Technology - Enhancing the Quality of Life, edited by H. van Oostendorp and A.G. Arnold, Boom Publishers, The Netherlands. This paper is available online at: http://www-scm.tees.ac.uk/users/philip.barker/maastricht/mmeps.doc.

Beacham, N.A. (1998). Distributed Performance Support Systems, PhD Thesis, University of Teesside, Middlesbrough, UK.

Bezanson, W., (2002). Performance Support Solutions - Achieving Business Goals Through Enabling User Performance, Trafford Publishing, Victoria, Canada.

Branford, A.J., (2001). Statistics Computing Laboratory, Paper C6 in Proceedings of Computer-based Learning in Science, CBLIS 2001, Edited by G.M. Chapman, University of Ostrava Press, Czech Republic.

Davis, F.D. and Venkatesh, V. (1996). A critical assessment of potential measurement biases in the technology acceptance model: three experiments. International Journal of Human-Computer Studies, 45(1), 19-45.

Flinders, S., (2000). A Prototype Electronic Performance Support System Facility to Support Web-based Information Retrieval, MSc Thesis, School of Computing and Mathematics, University of Teesside, Middlesbrough, UK.

Gery, G.J., (1991). Electronic Performance Support Systems - How and Why to Remake the Workplace Through the Strategic Application of Technology, Ziff Communications Company, Cambridge, MA.

Hazemi, R. and Hailes, S., (2001). The Digital University - Building a Learning Community, Springer-Verlag, Heidelberg, Germany.

McGraw, K.L., (1994). Electronic Performance Support Systems: Integrating AI, Hypermedia and CBT to Enhance User Performance, Journal of Artificial Intelligence in Education, 5(1), 3-26.

Morris, E., (2001). The Design and Evaluation of Link: a Computer-based Learning System for Correlation, British Journal of Educational Technology, 32(1), 39-52.

Moukadem, I., Barker, P.G. and van Schaik, P., (2002). Virtual University Support for Lifelong Learning in Lebanon, 1399-1403 in EDMEDIA 2002 Conference Proceedings, Denver, Colorado, June, 2002, AACE, Norfolk, Virginia, USA.

Pearson, R., (2001). An EPSS for Quantitative Research Methods and Statistics, MSc Thesis, School of Computing and Mathematics, University of Teesside, Middlesbrough, UK.

Reeves, T.C. and Raven, A., (2002). Performance Support Systems, 93-112 in Handbook on Information Technologies for Education and Training, edited by H.H. Adelsberger, B. Collis, and J.M. Pawlowski, Springer-Verlag, Berlin.

Robson, C., (1993). Real World Research, Blackwell, Oxford, UK.

Stevens, G.F. and Stevens, E., (1995). Designing Electronic Performance Support Tools - Improving Workplace Performance with Hypertext, Hypermedia and Multimedia, Educational Technology Publications, Englewood Cliffs, NJ, USA.

van Merriënboer, J.J.G., (1997). Training Complex Cognitive Skills: a Four-Component Model for Technical Training, Educational Technology Publications, Englewood Cliffs, NJ, USA.

van Schaik, P., Bettany-Saltikov, J.A., and Warren, J.G. (2002). Clinical Acceptance of a Low-cost Portable System for Postural Assessment, Behaviour and Information Technology, 21, 47-57.

van Schaik, P., Pearson, R. and Barker, P.G., (2002). Designing Electronic Performance Support Systems to Facilitate Learning, Innovations in Education and Training International, 39(4), 289-306.

Wild, M., (2000). Designing and Evaluating an Educational Performance Support System, British Journal of Educational Technology, 31(1), 5-20.

Professor Philip Barker,
School of Computing and Mathematics,
University of Teesside,
Borough Road,
Middlesbrough,
TS1 3BA, UK.
Email : philip.barker@tees.ac.uk

Dr Paul van Schaik,
Psychology Section,
School of Social Sciences,
University of Teesside,
Borough Road,
Middlesbrough,
TS1 3BA, UK.
Email : p.van-schaik@tees.ac.uk

Robert Pearson,
Nissan Motor Manufacturing (UK) Limited,
Washington Road,
Sunderland,
Tyne & Wear,
SR5 3NS, UK.
Email : Robert@rspearson.freeserve.co.uk