Performance Improvement Quarterly, 18(4) pp. 71-86

A Comparative Study of Electronic Performance Support Systems

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ABSTRACT

Electronic performance support systems (EPSS) deliver relevant support information to users while they are performing tasks. The present study examined the effect of different types of EPSS on user performance, attitudes, system use and time on task. Employees at a manufacturing company were asked to complete a procedural software task and received support from either an intrinsic, extrinsic, external performance support system or no system at all. Results revealed significant differences on performance, attitudes and use between several treatment groups. The study suggests that providing any kind of EPSS to support task performance is better than having none at all. In addition, designers can improve user performance, attitudes and use by creating systems that integrate with the primary work interface.

Gloria Gery (1991) introduced the concept of *electronic performance support systems* (EPSS) as a method to enable human performance through just-in-time learning and task support. She asserted that through EPSS one could generate "day-one performance…for novice performers" (Gery, 1995, p. 47). Since its introduction, Gery has reported that the principles of EPSS have been applied to a wide range of work interfaces from applications that automate tax preparation to financial planning Web sites to tools that help consumers plan and purchase travel (Gery, 2003).

To guide practitioners, authors and experts have shared their insights on a wide range of EPSS topics over the past decade. For instance, a number of experts have focused on the unique methods and processes required to develop EPSS. Raybould (2000) introduced a performance support mapping methodology. This approach combines elements from disparate fields including business process reengineering, human performance technology and instructional design into a new field dubbed performance support engineering. Huber, Lippincott, McMahon, and Witt (1999) provided a framework for the skills, competencies and job roles that make up an effective EPSS development team.

Other authors have focused on the value of performance support. Chase (1998) asserted that EPSS could reduce the time and cost associated with training new employees. Altalib (2002) provided a detailed process on how to measure the return on investment (ROI) for

EPSS. Based largely on the work of Davidson (1998), Phillips (1997), and Hawkins, Gustafson, and Nielson (1998), Altalib's comprehensive ROI approach examined potential benefits derived from EPSS including hard measures such as increased sales or manufacturing production to soft measures such as employee attitudes.

Some have offered strategic views on how EPSS relates to and complements other information interventions such as knowledge management and training. Rosenberg (1995) argued that trainers and others involved in instructional design should shift to the more holistic views of human performance technology (HPT) which embraces EPSS and training among other types of interventions. With the advent of HPT, Sherry and Wilson (1999) predicted the convergence of the traditional roles of instructional designer, performance support designer and information technologist.

Interestingly, very few of the current ideas and principles related to EPSS are based on any substantive research. In fact, although EPSS has been discussed for almost two decades, very few studies have been conducted to measure its effectiveness. One of the few research studies that examined EPSS compared the effectiveness of computer-based and print-based performance aids in the Army (Morrison & Witmer, 1983). While this study found no significant differences between the two delivery media, it did not address more fundamental issues such as the overall effectiveness of EPSS or the specific EPSS designs that may be better under differing performance conditions.

To this end, Gery introduced a conceptual framework for EPSS that illustrates key design differences between potential performance support systems. She asserted that there are three fundamental types of EPSS: external, extrinsic and intrinsic support (Gery, 1995).

External systems store content used to support task performance in an external database. This content is not integrated within a user's work interface. As a result, users are forced to manually locate relevant information in the external EPSS. Common examples of external performance support systems include search engines, frequently asked question pages, and help indexes. In addition, external performance support "may or may not be computer mediated" (Gery, 1995, p. 53). Job aids or documentation are common external performance support interventions.

Extrinsic "[p]erformance support…is integrated with the system, but is not in the primary workspace" (Gery, 1995, p. 51). In other words, extrinsic systems integrate with the user's work interface in such a way that the EPSS can identify the user's location in a system or even the exact task that they may be working on. With this contextual information, the extrinsic system can intelligently locate content that may be relevant to support the task at hand. Like external performance support systems, though, the content used to support a task is external to the work interface.

Intrinsic systems provide users with task support that is incorporated directly within their work interface. Due to this direct integration with the interface, Gery asserted that intrinsic EPSS provides "[p]erformance support that is inherent to the system itself. It's so well integrated that, to workers, it's part of the system" (Gery, 1995, p. 51). Under this rather broad definition, examples of intrinsic performance support systems can range from tools that automate tasks and processes, user-centered design of work interfaces to reduce complexity and improve usability, or embedded knowledge that is displayed directly in the work interface.

With this distinction between external, extrinsic and intrinsic EPSS, Gery (1995) provided designers with a guideline to implement 80% of their support systems as intrinsic, 10% extrinsic, and the remaining 10% external. She argued that this guideline optimized designer and performer time, decreased performance development overhead, and still accomplished the desired impact: user performance.

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However, the impact of the three types of EPSS has not been empirically tested. Thus, performance technologists lack validated principles to guide them in the selection, design and development of EPSS. To address this gap, this article summarizes a study that focused on four key research questions:

1. Of the three types of EPSS (external, extrinsic, or intrinsic), which one is better at enabling user performance?
2. Which type of EPSS do users prefer?
3. Which type of EPSS do they use more often?
4. Which one minimizes the time it takes for a user to complete a given task?

Method

Participants

Seventy-two employees from a semiconductor manufacturing company participated in the study. The employees were recommended by their direct managers or identified by other participants. All participants involved in the study had completed at least four years of college: forty-six obtained a bachelor's and twenty-six obtained a master's degree in various fields. Potential participants were screened for prior knowledge of the corporation's learning management system used in the study; any individuals with previous experience using the system, which served as the basis for the task, were not selected to participate in the study.

The participants represented a diverse range of job roles: twenty-eight software engineers, fourteen training professionals, twelve managers, five business analysts, five human resource professionals, three accountants, two financial analysts, one design engineer and one customer support specialist. The participants were distributed across four western states: forty-seven were located in Arizona, nine in Oregon, eight in Northern California, and seven in Utah.

Materials

Software application. One portion of the company's learning management system was adapted for use in the study. As part of the process to create an online training course, employees are required to submit data that describes their training course. Such metadata typically includes the course's name, description, objectives and other relevant data. The course registration software that is normally used to submit this metadata was extracted from the learning management system and tied to an isolated database designed specifically for the study.

As illustrated in Figure 1, the course registration software screens included a series of open text fields that required the user to input relevant data as well as menus that required the user to select from a number of pre-defined choices. In total, the course registration module required twelve user inputs or selections. Data entered into the course registration software were stored in a database for analysis.

Performance support systems. The course registration software was modified to include three different types of performance support systems. The three treatments were

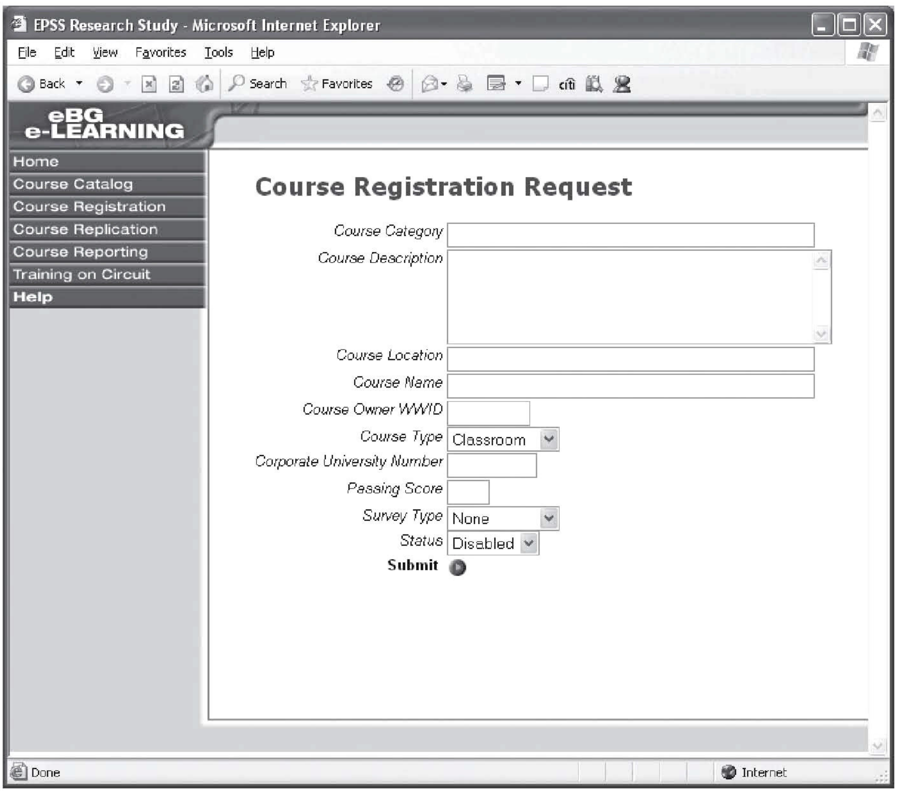

Figure 1. Software Application.

based on EPSS categories established by Gery (1995): including external, extrinsic and intrinsic support.

External performance support system. The external system implemented in this study was a search engine. When users in this treatment clicked a help button located in the menu of the course registration software, their request was recorded in a database and a popup window opened that prompted them to enter a keyword as shown in Figure 2. Once they submitted their keyword, the external support system searched through the EPSS content repository and presented the user with a choice of help topics based on their query. Participants then had to select the appropriate topic to read.

Extrinsic performance support system. The extrinsic system was a context-sensitive help system. Help buttons in the form of a question mark were inserted throughout the software application. When users clicked on the buttons, their request was recorded in a database and a new window opened displaying support information associated with the task as illustrated in Figure 3.

Intrinsic performance support system. The intrinsic performance support was an information-based system that provided the users with task-relevant text instructions directly in the course registration software screens as shown in Figure 4. In order to capture the number of times participants used the intrinsic performance

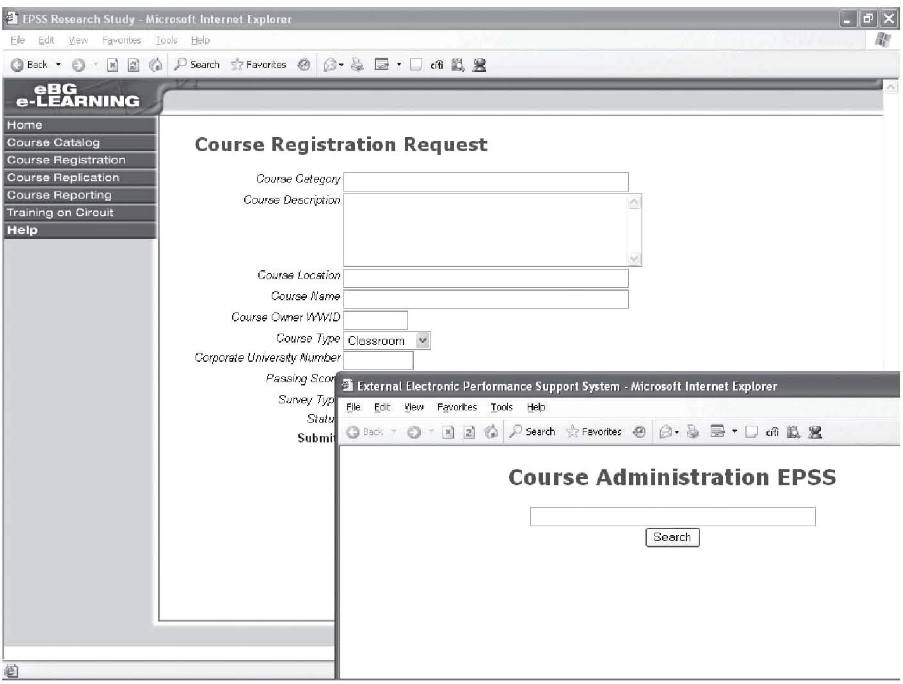

Figure 2. External Performance Support System.

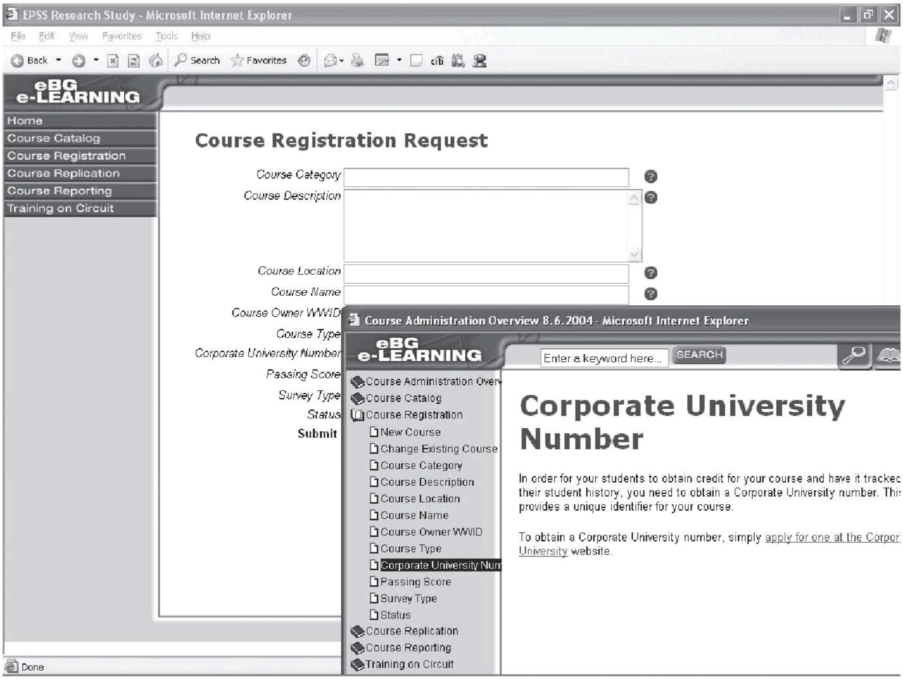

Figure 3. Extrinsic Performance Support System.

support system, help buttons were inserted throughout the software. When users clicked the buttons, their request was recorded in a database and the information associated with the support instance was displayed adjacent to the button. While this approach deviated somewhat from typical instances of intrinsic performance support where information may be displayed automatically, the researchers felt that it was an important modification that facilitated the comparison of EPSS use across the three treatments.

In addition to the three performance support types, the system was also modified to display no performance support at all to facilitate a control group. The no performance support system is illustrated in the software application screen shown earlier in Figure 1.

The content across the three performance support systems was identical and differed only in the manner in which it was accessed and presented. When the user accessed the course registration software, the system randomly assigned the user to one of the four performance support treatments described above. As the software was loaded onto the participant's computer, the system automatically changed the interface to show or hide the appropriate buttons and on-screen information based on the participant's treatment group assignment.

Task scenario. The task scenario portrayed a realistic issue that a new

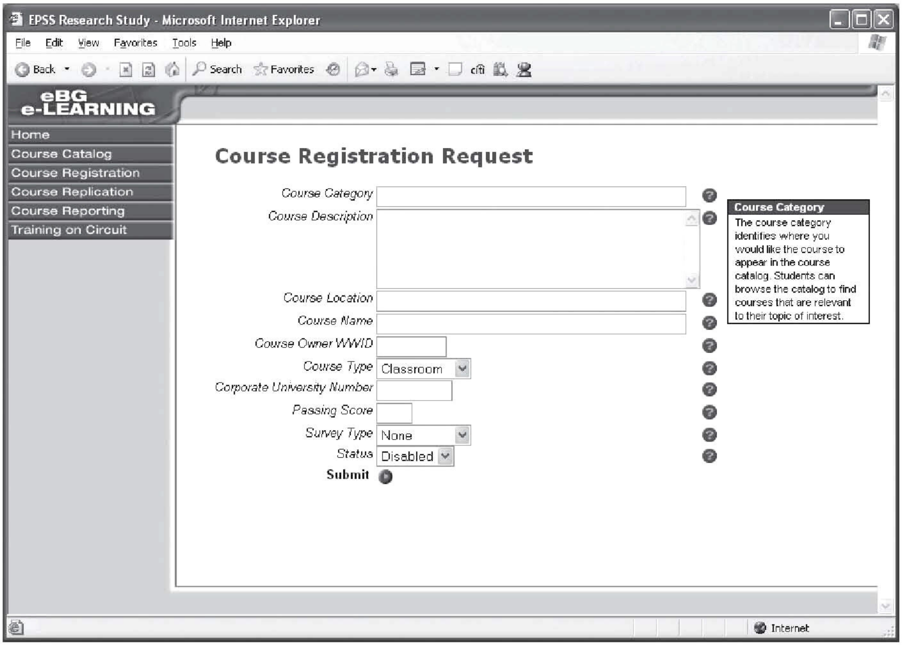

Figure 4. Intrinsic Performance Support System.

employee might face. The scenario included information that a training manager might provide to an employee when registering a new course in the corporate learning management system. The following is an excerpt of the task scenario text:

> Imagine that you have been recently hired as a training administrator. The message below contains information that your new manager emailed you for an online training course that needs to be published.
>
> Thanks for taking care of this task for me. Here's how I'd like to have the course set up:
>
> ❑ The name of the course is Program Life Cycle.
>
> ❑ It is an online learning course that provides an overview of the eBG Program Life Cycle, or PLC.
>
> ❑ I would like for this course to appear in the course catalog under a category called Project Management
>
> ❑ I've already saved the course to the web server, and it is located in a folder called PLC.
>
> ❑ We're phasing out the classroom-based course. This will be an online, web-based course.
>
> ❑ The course's test contains 10 questions, and I'd like students to pass with 90% before they get credit.
>
> ❑ I'd like to have students take a survey right after they finish the course. We don't need to do the follow-up survey that is sent out six weeks later.

❑ Go ahead and set up the course so that students can see it in the catalog immediately.

❑ I'd also like to have this course set up so that the system replicates it to the other geographies. It looks like we will have students in China, Malaysia, Ireland, Israel and the United States.

Criterion Measures

Four criterion measures were used in the study: user performance on the task, user attitude surveys, use of EPSS, and time on task.

Performance. User performance on the task was measured by evaluating the number of correct items the participants submitted to the software application. As mentioned earlier, the course registration module required twelve user inputs or selections. Data entered by the user into the course registration software was stored in a database and subsequently evaluated by the lead researcher. Participants received one point for each correct input with a maximum of twelve points possible.

User attitude surveys. A four-item survey was developed to measure participant attitudes towards the respective performance support system provided in the task. Respondents used a 5-point Likert scale (5=*strongly agree*, 1=*strongly disagree*) to rate their attitudes regarding the effectiveness of the performance support system.

Use of EPSS. Various en route data were recorded to measure the number of access to the performance support system. When participants in the external performance support treatment clicked the *Help* button located on the software application's navigation menu, the participant's name and time of access were recorded. In addition, the performance support content that was subsequently accessed by the participant was noted. Each page of content that was opened by the participant was considered one access to the EPSS. Similarly, when participants in both the extrinsic and intrinsic performance support treatment clicked the question mark (*?*) icon embedded within the software application, the participant's name, time of access and location in the application were recorded. Each click on the question mark icon was considered one access to the EPSS. Since the control group was not provided with a performance support system, no accesses were recorded for participants in this group.

Time-on-task. The total amount of time participants spent completing the task in the study was measured by calculating the difference between the time at which participants logged into and out of the software application.

Procedures

Since the participants in the study were geographically dispersed, the researchers arranged approximately twenty data collection sessions at various sites over the course of two weeks. Small groups of 3-5 participants were directed to prearranged conference rooms to ensure that they were not distracted by phone calls, e-mail or co-workers while completing the study. The lead researcher gave participants the task scenario and instructed them to read it until they were comfortable with the task. Once all participants finished reading the task scenario, the lead researcher instructed them to complete the task using only the information provided by the task scenario and any help that may be provided by the software application. In addition, the researcher instructed participants to log out of the software application as soon as they felt they had completed the task.

The participants were then given the location of the software application on the corporate network and logged in using an automated authentication system pre-installed on all corporate-issued computers. When users accessed the software application, the system randomly assigned them into one of four treatment groups (intrinsic, extrinsic, external or no EPSS) and displayed the appropriate performance support system. Participants were not aware that they had been assigned to a different treatment group or that their system was configured with a different EPSS. The opening screen of the software application provided a brief set of instructions demonstrating how to access the support system. Participants individually worked through the task using the software program and performance support system. Once the participants completed the task and logged out of the system, they were automatically directed to and completed the user attitude survey. One participant in the control group declined to complete the survey.

To ensure participant motivation, the researchers worked with a subset of managers within the company to identify all employees in their organizations with no prior experience with the corporate learning management system. These managers encouraged their employees to participate in the study. In addition, refreshments were offered to participants upon completion of the task, and a letter of recognition was sent to the manager and participant after the study.

Design and Data Analysis

This study used a posttest-only control-group design. One-way analysis of variance (ANOVA) was conducted on participants' performance on the task, use of EPSS and time on task. One-way multivariate analysis of variance (MANOVA) was conducted on the data from the attitude survey, followed by univariate ANOVAs where appropriate.

Results

Results reported in this section are for performance on the task scenario, user attitudes, use of EPSS, and time on task.

Performance

The first research question investigated the effect of different types of support systems on user performance while completing a procedural software task. Table 1 shows the mean scores and standard deviations for performance on the task scenario. The table reveals that the mean scores were 10.83 (90%) for the extrinsic group, 10.06 (84%) for the intrinsic group, 9.61 (80%) for the external group, and 8.50 (71%) for participants who were not provided with a performance support system. A one-way analysis of variance conducted on the performance scores yielded a significant overall difference, $F\,(3, 68)=7.74$, $p<.01$. The strength of the relationship between the treatments and the performance scores was large, $\eta^2=.25$.

Post-hoc tests were conducted to determine significant differences in mean performance scores. Multiple comparisons conducted using the Tukey method revealed that both

Table 1
User Performance Across EPSS Types

Support Condition	*M*	*SD*
Extrinsic EPSS	10.83	1.20
Intrinsic EPSS	10.06	1.47
External EPSS	9.61	1.54
No EPSS	8.50	1.69

Note: Maximum total correct=12.

the intrinsic and extrinsic groups had significantly higher scores on the task over the group with no performance support system. The difference in the performance scores between the intrinsic, extrinsic and external groups was not significant. The difference between the external and no support group performance scores was also not significant.

User Attitudes

The second research question investigated the effect of performance support systems on the attitudes of the participants. A four-item, five-point Likert-type survey was administered after completion of the task scenario. The mean attitude scores by treatment are shown in Table 2. The overall mean score across the four items was 3.33 (5=strongly agree, 1=strongly disagree), indicating neutral attitudes towards the statements about the performance support systems. The table reveals that the average rating was 4.37 for the extrinsic group, 3.71 for the intrinsic group, 3.26 for the external group, and 1.88 for participants who were not provided with a performance support system.

A 4 x 4 MANOVA was conducted on the data to test for significant differences. The overall means were significantly different across the four treatment groups, Wilks' Λ=.52, F (12, 170)=3.91, p<.01. The strength of the relationship between the treatments and user attitude scores was moderate, η^2=.19.

Follow-up univariate analyses of variance revealed significant differences between treatment groups on all four of the items. Post-hoc tests were conducted to determine significant differences between treatment groups on the four survey items. Pairwise comparisons revealed 14 significant differences between groups. On all four questions, the three groups with a performance support system (external, extrinsic and intrinsic) had significantly more positive attitudes than the participants in the no EPSS group. In addition, participants in the extrinsic group had significantly more positive attitudes than external performance support users on two of the questions: "Information in the help system was easy to find" and "I felt confident that I could complete the task using the help system."

Use of EPSS

The third research question examined the effect of treatment on

Table 2
User Preference Across EPSS Types

	Extrinsic	*Intrinsic*	*External*	*No EPSS*
The help system provided the appropriate level of detail to aid in task completion.	4.44	3.78	3.33	2.00
Information in the help system was easy to find.	4.44	3.44	3.33	1.82
I felt confident that I could complete the task using the help system.	4.33	3.89	3.11	1.82
I would use the help system again.	4.28	3.72	3.28	1.88
	4.37	3.71	3.26	1.88

Note: Questionnaire items were measured on a five-point scale from 1 to 5 (Strong Disagree to Strongly Agree)

performance support system use. The number of times each user accessed the appropriate help system during the task scenario was tracked by the software application. The mean use scores are shown in Table 3. The table reveals that participants who were provided with an extrinsic EPSS accessed the system an average of 6.72 times, intrinsic 2.94 times, and external 2.11 times. A one-way analysis of variance conducted on the use scores yielded a significant overall difference, F (2, 51)=11.44, p<.01. The strength of the relationship between the treatments and the use of EPSS was large, η^2=.31.

Post-hoc tests were conducted to determine significant differences in mean use scores. Multiple comparisons conducted using the Tukey method revealed that the extrinsic group used the performance support system significantly more often than both the intrinsic and external groups. The difference in use of EPSS between the intrinsic and external groups was not significant.

Time-on-Task

The final research question investigated the effect of treatment on total time to complete the task scenario. This was measured by calculating the difference between the time at which participants logged into and out of the software application. The data revealed that the external group spent an average of 7.99 minutes on the task, the extrinsic group spent 8.66 minutes, no EPSS participants spent 8.77 minutes, and the intrinsic group spent 11.25 minutes. A one-way analysis of variance conducted on the time on task yielded no significant overall difference between the mean scores.

Table 3
User Access to EPSS

Support Condition	*M*	*SD*
Extrinsic EPSS	6.72	4.01
Intrinsic EPSS	2.94	2.90
External EPSS	2.11	2.00
No EPSS	--	--

Discussion

This study examined the effect of various electronic performance support systems on user performance, attitudes, use of EPSS, and time on task. Four treatment groups completed a task scenario using an intrinsic EPSS, extrinsic, external, or no support system at all.

Performance

Performance scores for the extrinsic and intrinsic groups were significantly higher than scores for the group that was not provided with a performance support system. A closer examination of the data reveals that performance of the participants who received the extrinsic EPSS was 19% more accurate on the task than those who were not given an EPSS and the intrinsic group was 13% more accurate than the no EPSS group. Furthermore, performance for the external EPSS group was 9% more accurate than the no EPSS group, although the difference between these two groups was not statistically significant. Nevertheless, the positive improvement in performance scores for all three treatment groups over the control group indicates that providing an EPSS to support task performance is better than having none at all.

It is not surprising that the external group scored the lowest of the three EPSS treatments. Since external performance support systems are not integrated with the work interface, users are responsible for locating the support content that is relevant to the task. Findings for user attitudes in the current study suggest that users may perceive external support systems as less useful than extrinsic support. For example, the extrinsic group was more likely to strongly agree with the statement that the “Information in the help system was easy to find” and “I felt confident that I could complete the task using the help system.” Furthermore, qualitative data reported by Spool (2001) indicated that when provided an external EPSS to conduct a single search, users located relevant content only 55% of the time. Spool noted that the “more times users searched, the less likely they were to find what they wanted” (p. 1). Users who searched twice found relevant content only 38% of the time; those who searched three or more times never found the correct support information (Spool, 2001). Combined with the result of the current study, these observations suggest that designers can improve user performance by creating performance support systems that are integrated with the primary work interface.

Given Gery's assertion that 80% of a performance support solution should be comprised of intrinsic systems, it is somewhat surprising that users provided with the intrinsic EPSS did not perform significantly better than those given the other types of support systems. The intrinsic EPSS in this study used an "embedded knowledge" approach (Gery, 1995, p. 70). As users encountered issues or questions in the procedural task, they referred to embedded help buttons that provided support information directly in the primary workspace. A more robust approach to intrinsic EPSS would be to physically redesign and optimize the application workspace to logically align with the users' workflow through the task and perhaps even automate certain manual processes. This type of human factors engineering approach would likely have a positive effect on user performance. Software work interfaces are often built around systems or databases rather than human tasks or processes. By designing logical interfaces around user workflows, as one would in human factors engineering, work interfaces become more intuitive and user friendly.

Use of EPSS

Participants provided with an extrinsic EPSS used their support system significantly more than those provided with intrinsic or external systems. Participants accessed extrinsic EPSS on average two times more than those provided with an intrinsic system and three times more than those provided with an external system. This result suggests that designers can increase use of performance support systems by integrating them more directly into the primary work interface.

It is not surprising that use of the external performance support system was lowest among the three treatment groups that received an EPSS. External systems require users to search for and locate information, sometimes in futility. Spool (2001) noted that less than 25% of participants searched more than two times. Furthermore, "those that did persevere [by searching more] did not see positive results" (p. 1). Extrinsic and intrinsic systems integrate with the work interface allowing them to understand work contexts and deliver the appropriate support information. This integration reduces the amount of work required by the user to find support information and improves the chances of finding the correct information on the first attempt.

It is surprising that use of the intrinsic EPSS was significantly less than the extrinsic. Once again, this finding may be due to the fact that an embedded knowledge approach was used for the intrinsic EPSS. Most modern computer displays default to a resolution of 1024 by 768 pixels. Software developers are challenged to fit the necessary components of a work interface—forms, fields, menus, icons, and toolbars—in this limited area. When intrinsic systems employ an embedded knowledge approach, it must display support content directly into the primary workspace. This can be done through the use of a tooltip, embedded pane, or resizing the primary work interface to accommodate an adjacent window. By doing so, the intrinsic EPSS must compete with the other interface elements for precious screen real estate. The lack of space to display the intrinsic EPSS content may explain the significantly reduced use of intrinsic support as compared to extrinsic.

Extrinsic and external performance support systems both require the user to access content stored and delivered by an outside system. As a result, they do not compete for limited space in the primary work interface as intrinsic systems do.

Performance and Use of EPSS

When considering performance and use factors together, one may note that extrinsic performance support was used significantly more by participants in the study than intrinsic support. However, the greater use of extrinsic performance support did not result in a significant performance difference between the two groups.

User Attitudes

Participants in the three performance support groups had significantly more positive attitudes than the no EPSS group. This finding can be attributed to the fact that participants in the control group were not provided with any on-task support or guidance. Participants in this study indicated a strong preference for any kind of on-task support from an external, extrinsic or intrinsic system. This finding further validates the notion that providing any kind of EPSS to support task performance is preferable to having none at all. In addition, the extrinsic group had significantly more positive attitudes than the external users on two survey questions. This finding is consistent with results for the performance and use variables. It is likely due to the fact the extrinsic participants could immediately locate relevant support content on the first request rather than having to search for and locate support information using the external system.

Performance, Use of EPSS and User Attitudes

The fact that the extrinsic group rated their performance support system significantly higher than the external group corresponds to the significant increase in use of the extrinsic system in comparison to the intrinsic and external groups. This relationship highlights the fact that, for interventions like EPSS that rely on learner control and self-regulation, it is important to design the system in such a way that users prefer the support system, have easy access to information, and feel that they will find the answers they need. More simply, although certain systems like intrinsic EPSS may have psychological benefits over other designs, if the users feel that the system is annoying or unhelpful, they will not use it and therefore will not maximize the benefits it may offer to aid task performance.

Limitations

This study focused on a relatively simple procedural software task. As a result, the findings may not be valid when extended to more complex tasks or work contexts that are not based in software. While the subjects in the study had no prior knowledge of the task, they are all employees that work in a corporate setting that requires high computer system use. Users that may have less computer experience could perform differently when exposed to the performance support systems offered. In addition, the data entered by participants as they completed the task was evaluated only by the lead researcher in this study. Future studies that involve evaluation by a group of observers may yield different results.

Future Research

Although these findings shed light on the relative effectiveness of different types of performance support, many questions remain. The dependent measures used in this study are a handful of many important factors to human performance technologists. Studies that examined a broader range of measures such as information retention, error rate and time-on-task reduction would be invaluable. The task that participants were asked to complete in this study was fairly simplistic. A follow-up study that used a similar but more complex task would provide better context for the results of this study. While this study focused on procedural software tasks, human performance technologists are also applying EPSS towards the improvement of performance that involves physical tasks. Examples include aircraft repair, automobile repair, and manufacturing equipment operations. It would be useful to extend this study in other settings to determine if the results can be transferred to these other work contexts. Furthermore, a comparative study that examines the effectiveness of a broader range of intrinsic EPSS (embedded knowledge versus human factors engineering) compared to other EPSS designs would provide additional insight into the value of electronic performance support systems.

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