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ABSTRACT

This proposed study is to investigate the design and development process of electronic performance support systems (EPSSs). The primary purpose of this study is to help the EPSS designers by proposing a more effective and productive EPSS design and developmental model. By analyzing EPSS products and observing EPSS design projects, the research will propose a design model for future EPSS designers. Discussion includes what makes EPSS different; the need for an EPSS design/development approach; current approaches to EPSS design/development and their problems; help from other fields; information systems design and EPSS; and Chaos theory (dynamic systems or adaptive development). The paper concludes that EPSS development is at the edge of technology, and it requires a mixture of Chaos-based top-down and bottom-up processes. (Contains 55 references.) (Author/AEF)

A Design and Development Model for Building Electronic Performance Support Systems

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Abstract

The proposed study is to investigate the design and development process of EPSSs. The primary purpose of this study is to help the EPSS designers by proposing a more effective and productive EPSS design and development model. By analyzing EPSS products and observing EPSS design projects, the researcher will propose a design model for future EPSS designers.

Introduction

The recent developments of technologies have been changing the way we live. Many organizations, such as business, educational or governmental settings have been challenged to integrate information technologies into their work settings. Parallel to this change, in the past decade, there has been a significant shift from traditional training and instructional systems to performance-based, individualized and just-in-time support.

As stated by Hung (1998), today's organizations convey the ineffectiveness of traditional performance support interventions, represented by both traditional training and traditional performance support technologies. Traditional interventions have helped a little, but not significantly, to move the organization successfully into the performance zone. Moreover, according to Rosenberg (1995), for a performance-based approach the concepts of students, courses, curricula and instruction have little meaning. Rosenberg, Coscurelli, and Hutchinson (1999) note that:

> The overwhelming amount of complex information required to perform work at a competent level has placed considerable strain on traditional education and training systems. This situation has led to the development of job aids, computer databases, and electronic training systems as well as of structured text design. (p.30)

Therefore, especially because of the wide availability of new information technologies, knowledge-based organizations, such as educational institutions and corporations, have started to implement and use Electronic Performance Support Systems (EPSS) to increase both performance and productivity.

Laffey (1995) indicates the goal of an EPSS as providing whatever is necessary to ensure performance and learning at the moment of need. It is agreed upon by several researchers (Gery, 1989; Gery, 1995; Raybould, 1995; Lawton, 1999; Gustafson, 2000) that, in order to improve performance and reduce the time spent on task, the ultimate goal of an EPSS is to provide performers with the right information, in the right quantity and detail, at the right time. In those respects, EPSS is different from traditional training systems.

With the help of such systems, performers receive support during performance, rather than before they perform their jobs. Laffey (1995) adds that an EPSS is not only a vehicle for delivering static information, but also a reconceptualization of the work environment that is grounded in the fluid nature of support in the work environment. This is a major shift from the traditional approach to training.

As pointed out by Raybould (2000), the major question facing organizations today is not whether to do performance-centered design, but how to get it done. Since the ultimate goal of EPSSs is to reduce the cost of training while increasing productivity and performance, they have been developed and used by many organizations during the last decade.

As stated above, EPSSs are different from traditional training and instructional systems, because their primary purpose is to support performers while doing their actual job. According to Rosenberg (1995), EPSS is a fundamental paradigm shift in thinking, and it requires a broader perspective about what is possible in improving human performance. Rosenberg criticizes many educators because they are locked in a linear cultural model that focuses on learning as an end and instruction as a means, both of which contrast with the means and ends of EPSS. This difference also makes the EPSS design and development process different. Since the overall purpose of an EPSS is different from the traditional purpose of instruction, several researchers (Milheim, 1997; Northrup, 1999) state that the use of traditional instructional system development models is inadequate for EPSS development. Northrup (1999) summarizes this difference as "instructional design is the process of designing and developing instruction to achieve specific learning outcomes, where EPSS is more focused on producing task performance" (p.

1). Rosenberg (1995) adds that involvement in building and implementing EPSSs requires a fundamental rethinking of the relationship between learning and performance. Parallel to this, the design and development of more effective EPSSs is becoming a critical issue that needs to be focused on by researchers. Therefore, since EPSS has significant differences from instruction, then the approach to its design/development process should also be different.

Significance of the Study

Several researchers state the need for a clear methodology for building EPSSs (Fisher & Horn, 1997; Gustafson, 2000; Milheim, 1997). Cote (2000) states that the focus on the "work process" makes the design and development of an EPSS quite different than the traditional models of instructional design. If the primary purpose of an EPSS is to support performance, learning is of secondary importance; and if an EPSS is different than instruction, how should it be designed?

Despite a growing number of success stories, the EPSS remains a relatively new concept and little is known about the different aspects of EPSS design. This study will create a better understanding of the EPSS design process. By observing and analyzing EPSS design projects in different phases of the production path, the researcher will propose a design model for future EPSS developers.

For this study, rather than having in-depth analysis of individual steps, the focus will be on the generic design process, with the major components that reflect the patterns of design activities carried out by EPSS designers in the field. Identifying the underlying detailed steps is beyond the scope of this study. They can be addressed in future studies.

Literature Review

It is generally agreed upon that Gloria Gery is the first person who introduced the term EPSS at the end of the 1980s (Gery, 1989). Gery (1989) and Brown (1996) define an EPSS as a self-contained, online system which is designed to integrate a knowledge base, expert advice, learning experiences, and guidance with the goal of providing individuals with the ability to perform at a higher level in the workplace and requires minimal support and intervention by others. Another EPSS pioneer Raybould (1995) defines EPSS as

> ...the electronic infrastructure that captures, stores, and distributes individual and corporate knowledge assets throughout an organization, to enable individuals to achieve required levels of performance in the fastest possible time and with a minimum of support from other people. (p. 11)

Later, Gustafson broadens those dimensions by including multiple knowledge sources, expert systems or artificial intelligence, contextual multimedia instruction and more sophisticated tools (Gustafson, 2000).

As seen from the literature, EPSS is still a young and evolving field (Moore, 1998). Therefore, even though the term EPSS has been widely used recently, there is no generally agreed-upon definition (Cole, Fischer & Saltzman, 1997; Villachica & Stone, 1999; Hannafin, Hill & McCarthy, 2000). According to Brown (1996), the best use of an EPSS happens under the following circumstances: if there is a profusion of information required to perform work at a competent level and technology explosions exist, experts are not available, expectations for performers are high, and performers have a self-directed learning style.

Similar to the case of different definitions of EPSS, there are also different views about the components and characteristics of EPSS. For example, Schwen et al. (1993) argue that an EPSS has four characteristics: information management, collaboration management, productivity through embedded guidance and work metaphor, and finally a problem solving environment that integrates basic tools, information management, collaboration and productivity tools in a seamless environment.

Hannafin et al. (2000) list the four core components of EPSS as resources, contexts, tools, and scaffolds. The ways in which the varied elements within the components are combined will vary depending upon the goals, context, and participants.

Reigeluth (1999) defines an EPSS as a computer program that provides support for the performance of a task. According to him, an EPSS usually has four major components: a database, an expert system, an instructional system and tools. These components are explained below:

- A database. A store of information that can be accessed by keywords or topical menus during the performance of a task. In addition, the database could provide access to other tools or software to help the worker do his or her job, such as spreadsheet and word processing software. "The EPSS would integrate tutorials or instructional systems and expert systems into the database, both in order to make them context-sensitive, and to allow them to share data" (Sleight, 1993, p.7). The type of data in this database may be textual, numeric, visual (photographs and video), or audio (conversations, speeches, and music). The information would be linked with related information via non-linear hypertext links, providing fast access to information, and allowing for different levels of knowledge in users. The effectiveness of an EPSS strongly depends on how well the database matches with the user's task and environment.

- *An expert system.* An expert system is a computer-based system, which emulates the decision-making ability of a human expert (Jonassen & Reeves, 1996). It can be accessed as an expert is accessed—by asking questions or receiving unsolicited suggestions—during performance of a task. It may suggest the most appropriate procedure or step to do next. Today, the terms expert system, knowledge-based system, and knowledge-based expert system are used synonymously.
- *An instructional system.* A set of methods (such as providing hints, suggestions, and guidance to move the student along) of instruction to help performers just in time for performance. It may be a list of steps to take, a motion video showing a procedure, or a simulation of a task that allows the user to practice.
- *Tools.* Programs that a performer uses to perform specific tasks, such as grade book programs, electronic notebooks, spreadsheets, statistical analysis packages, and even e-mail programs and Web browsers.

Reigeluth states that the Human-Computer-Interface (HCI) aspect of EPSS covers all these components and can be thought of as an umbrella under which all of the other components are located.

What Makes EPSS Different?

As stated in the previous pages, it is generally agreed among EPSS experts that an EPSS is different from an instructional system (IS) in many respects. One of the most important differences is its main focus, which is performing rather than learning. In their article, Witt and Wager (1994) compare EPSSs with instructional systems to highlight the differences between them. They argue that an instructional system is "a product that contributes to the achievement of some type of learning outcome," and instruction has methods "for bringing about desired changes in student knowledge and skills for a specific course content and a specific student population" (p. 20). In contrast, "while learning may occur during the use of electronic performance support, its primary purpose is to facilitate performance of a task; learning is of secondary importance" (p. 20).

The second important difference between IS and EPSS is using EPSS while doing the actual job, not beforehand. On this aspect, Cole et al. (1997) state that EPSS is actually a paradigm shift for training organizations because in EPSS "knowledge delivery takes place soon enough that is applied to the appropriate situation, and late enough that the user does not have to go through training or information overload" (p. 50).

The third difference reported is that people do not need to follow a predetermined sequence while using the EPSS. A novice and an expert may use it differently. In addition to this, in an instructional system it is assumed that the terminal requirements of an instructional product are predetermined (Witt & Wager, 1994). According to Ryder and Wilson (1996), if the content is well-defined and stable, and it is based on algorithms and rules, an instructional system becomes the best solution. However, an EPSS provides contextually relevant information for a dynamic environment (Laffey, 1995).

As seen until this point, even though there are some similarities between Instructional Systems and EPSSs, the differences are important. For certain kinds of well-defined content within stable training environments, instructional systems may work satisfactorily. However, as stated by Wilson, Jonassen, and Cole (1993), the limitations of this approach become apparent when working in ill-defined content domains, which requires self-pacing and creativity or when working with highly diverse populations.

Need for an EPSS Design/Development Approach

As seen in the previous section, EPSSs are significantly different from instructional systems. Therefore, as stated by Witt and Wager (1994), the fundamental differences of purpose between the two products indicate that different methodologies need to be used to create them. Laffey (1995) emphasized that EPSSs will no longer be simply extensions of what we know about instructional design and the design of databases. The same point is made by Gustafson (2000) that the design of EPSSs requires alternative (or mixed) methods. Finally, the lack of well-established design models is obvious from the literature. For example, Gery (1995) states,

> Few [EPSSs] are guided by a set of integrated and fully articulated design principles. Many innovations are the result of individual or team creativity and iterative design employing rapid prototyping coupled with ongoing usability and performance testing (p. 48)

Current Approaches to EPSS Design/Development and Their Problems

There is a broad consensus that there is a lack of well-defined EPSS design and development models (Gustafson, 1993; Gustafson, 2000; Milheim, 1997; Laffey, 1995; Rosenberg, Coscarelli & Hutchison, 1999), and information that describes how people have actually designed and developed EPSSs is also insufficient (Gery, 1989b). As stated by Dickelman (1996) even though the definition of EPSS is clear for many people, they cannot tell you "how to go about doing it".

According to Gustafson (2000), there are three main reasons for this lack of information. First, since many EPSSs are developed by commercial organizations and are their property, they do not share this information with others. Winer et al. (1999) also support this argument. They state that because of competitive advantage and strict confidentiality regulations, it is difficult to obtain data about specific EPSS developments. Second, the history of EPSS is no more than 10-12 years. Therefore, procedures have not been well developed and tested. Gery (1995a) supports the view that since EPSS is relatively new, it is difficult to define a detailed development methodology for EPSS. Finally, Gustafson reports the third reason, as ".. some EPSS designers may be reluctant to talk about what they have done, since they are unable to clearly articulate specific and replicable procedures." (p. 42).

In the literature, EPSS designers have used classical instructional design approaches (e.g. ADDIE) (Benko & Webster, 1997; Graham & Sheu, 2000), a modification of ED^4 (an instructional design and development methodology from Digital Equipment Corporation) (Brown, 1996), rapid prototyping (Tripp & Bichelmeyer, 1990; Law, Okey & Carter, 1995), prototyping and layers of necessity (Wedman & Tessmer, 1991; Northrup et al., 1998), or combination of them (Gustafson, 2000). Witt and Wager (1994) report that large companies modify the ISD models "to meet the unique challenges and complexities of EPSS solutions." (p. 20)

However, as stated by several researchers (Wilson, 1999; Rosenberg, Coscarelli & Hutchison, 1999), ID models have several limitations in performance support systems development. The most significant problem with them is that they generally analyze the job tasks to identify whether someone can perform the task or not. Performance support is concerned with providing information and assistance when the employee needs it and how they need it (Witt & Wager, 1994). Rosenberg et al. (1999) report the necessity of a paradigm change to performance technology systems development models.

Habelow (2000) also raises the issue of the difference between the EPSS design process and ISD, and she discusses the need for involvement of other disciplines. She states

> ... most organizations have their own customized version of an ISD process that is used as an approach to the design of EPSS applications. With such a striking difference in perspective, learning versus performance, a new model of EPSS design and development that combines the instructional value of education focused models and incorporates a more technological perspective of computer and information systems models may be warranted. (p.76)

Raybould (1995) suggests that the methodology for developing this electronic infrastructure must have a wider scope than other existing methodologies. He emphasizes the need for involving different elements in EPSS design methodology, namely human performance technology, instructional systems development, computer based training, information engineering, business process reengineering, knowledge engineering and technical writing and interface design (Raybould, 1995; Raybould, 2000).

Help from Other Fields

As stated above, an EPSS is composed of several modules or components. The implementation process needs to be based on multiple theories and approaches. Therefore, the process of building those components in an integrated manner has to be a multidisciplinary approach. Raybould (2000) calls this approach Performance Support Engineering (PSE).

For a successful EPSS design/development process, Hannafin, Hill and McCarthy (2000) emphasize the importance of welcoming other approaches that emerged outside of our traditional community, in other related disciplines. Similar to other researchers, they also agree on the multidisciplinary nature of EPSS design, stating that:

> EPSS design practices represent a convergence among several related fields and specialties, including human performance technology, computer-supported collaborative work, technical communications, electronic publishing, instructional design, and workplace training. (p. 3)

Similarly, Gustafson (2000) affirms this view and argues that EPSS design/development is an immature technology, so exploring other disciplines and applying their related methodologies will definitely make a significant contribution to the work in EPSS design/development.

It is obvious that EPSS design and development is a complex and multidisciplinary process. Among the several methodological approaches that I have found in the literature, there are two approaches that look very promising for building a model for the EPSS design and development process. Multiview is one of them, which comes from Information Science, one of the Soft System Methodologies (SSM). The second one is Chaos Theory, which is related to SSM and ISD. Since the EPSS design and development process is so complex, Chaos Theory might provide us with a new perspective to better understand this process. It is this researcher's initial intuition that an EPSS has similar characteristics to a chaos system.

Information Systems Design and EPSS

According to Villachica and Stone (1999), Information Systems (IS) development models offer detailed strategies that can be applied to EPSS creation. Cole et al. (1997) also agree on this view and argue that EPSSs should adhere to general software engineering methods. Furthermore, Gustafson (2000a) strongly encourages the researchers in IST to look more at approaches in Information Science discipline. Foshay et al. (1999) capture the essence of building human performance theory from IS by stating that IS principles "define a common ground between HPT [Human Performance Technology] and information science" (p. 899). According to them three branches of IS support HPT: Information Technology, Information Systems and Information Management.

Complex projects and unsuccessful attempts to realize them is a common problem for many disciplines/fields. Recently, a systemic approach to this kind of problem-solving has been provided in a methodology developed by Peter Checkland, Professor of Systems at Lancaster University, UK. This is known as the Soft Systems Methodology (SSM) (Checkland & Scholes, 1990). It was developed to overcome the limitations of the conventional systems analysis approaches. Such approaches are prescriptive and emphasize the "hard" aspects of the problem domain, which is the certain and the precise. However, Soft Systems Methodology is designed to allow the human element of such systems to be incorporated into system design work, and both technical and non-technical issues are explicitly addressed. It is most appropriate for systems that are complex and ill-structured (Finegan, 1994; Bennetts & Wood-Harper, 2000).

A well-known design framework from IS, which seems a promising approach for building an EPSS design/development model, is Multiview (Avison, 1996). Multiview contrasts with traditional IS design methodologies, where "the steps are prescribed in great detail and are expected to be followed rigorously in all situations" (Avison & Wood-Harper, 1990, p.13). Multiview is perhaps the most famous attempt at combining hard systems and soft systems philosophies.

As stated by Raybould (2000), a very important aspect of performance support engineering is its focus on human elements as well as computer elements. Therefore, I believe several aspects of Multiview, specifically SSM and STD, will best fit for the development of an EPSS design model.

From my practical experiences, both in IS and ISD, I see that traditional development methods are only used in theory. As stated by Raccoon (1995a), the practical development of such systems has always followed complex life cycles. Rather than phases being followed rigidly, they come and go as the project evolves. This is the same pattern that nature follows. The weather, political systems, economy, society and all other complex systems do not follow a predetermined path. Rather, they show a chaotic path. Therefore, I believe that, while exploring the EPSS design and development process, it is worthwhile looking at Chaos Theory. In the following section, this approach will be explored briefly.

Chaos Theory (Dynamic Systems or Adaptive Development)

Several researchers agree that the traditional systems approach to problem solving has a reductionist nature and it tends to solve a problem by fragmentation, one stage at a time (Finegan, 1994; You, 1993; Jonassen, 1990). This approach may work for some small scale and well-defined situations. However, the systems associated with human activity are complex and not well-defined. According to Jonassen (1990) "simple systems behave in simple ways, and complex systems behave in complex and less predictive ways. The behavior of a system cannot be examined accurately by analyzing its components" (p. 34). As an alternative to a linear, reductionist and deterministic approach, Chaos or the dynamical systems approach is proposed. In a complex system "the components are related and interlock with one another such that a change in one component invariably affects another part of the system, or eventually even the entire system" (Murnare, cited in Chieuw, 1991, p.25). Gordon and Greenspan explain Chaos as the study of disorder, and it appears in non-linear systems (as cited in King, 1991). Since Chaos deals with non-linear and disorderly systems, many disciplines, including technological, social and economic, are appropriate for applying its principles. As stated by Highsmith (2000) "from physics to biology to chemistry to evolution, complex adaptive systems theory began to help explain occurrences in the real world that the linear approximations of the old science could not" (p. 10). According to King (1991), for many different disciplines, Chaos gives new data, suggests innovative approaches to old ideas, and reaffirms certain approaches.

As pointed out by Hannafin, Hill and McCarthy (2000), "EPSS systems have evolved into larger and more complex environments" (p. 32). They do not have fixed features and components. In addition to this, especially in complex domains, "an effective performance requires expertise beyond the skill level" (Sinitsa, 2000, p.18) and performers follow unpredictable patterns that are discontinuous and complex (Paulson & Paulson, cited in You, 1993, p. 24). As a result, such factors make the design process itself less systematic and more situated (Sherry & Wilson, 1996). EPSS development does not operate in isolation, and not done in a linear manner (Ho & Hara, 2001). However, this life cycle is interdependent and connected.

To summarize, the EPSS design/development process has a complex nature. To the extent that it is similar to IS development, EPSS development is at the edge of technology, and it requires a mixture of chaos-based top-down and bottom-up processes (Raccoon, 1995b).

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