Performance Improvement Quarterly, 15(3) pp. 81-93

Object-Oriented Performance Improvement

Ian Douglas
Florida State University

Scott P. Schaffer
Purdue University

ABSTRACT

In this paper, a framework to support an object-oriented approach to performance analysis is described. The framework includes the use of collaboration, automation, visual modeling, and reusable repositories of analysis knowledge. The need for a new framework is related to the increasing concern with the cost effectiveness of student and employee development. Efforts to improve the return-on-investment in such development have been hindered by a craft orientation to the design and construction of learning and performance support materials. One solution to this problem has been to enhance the reuse of such materials. Rather than build every new system from scratch in a craft-oriented manner, it is envisioned that systems will be constructed largely of standardized, reusable objects shared through Web-based repositories. Currently, the main focus is on the technological framework necessary for an object-based approach to learning system development. There appears to be little consideration of the changes in analysis and design thinking required for the move towards object-based systems. Such systems should still be required to be directly linked to performance problems and opportunities at both the organizational and individual system levels.

The professional field of instructional design has been greatly impacted by the increase in "on-demand" information required to support the performance of a worker or team. To address this emerging reality and the resulting need to provide cost-effective training, many organizations are committed to converting a significant amount of current instructional material to electronic media and, increasingly, to the World-Wide Web. These realities have forced many in the field of instructional design to think about a shift from development of large, stand-alone training products to smaller, component-based training modules (Wiley, 2000).

Current evidence is inconclusive, however, in determining if this increase in distributed education and training activity increases learning and performance (Keegan, 1996). By extension, it may also be assumed that the return-on-investment (ROI) in such training and education is relatively low. It is difficult if not impossible to determine the cost-benefit of potential solutions and ROI of delivered solutions without using a system-oriented approach. Such an approach requires significant stakeholder involvement in identifying mission critical results and related metrics or measures for those results (Robinson & Robinson, 1989; Phillips, 1994).

The ever-increasing appetite for just-in-time Web-based training and performance support products also requires a shift of thinking from purely instructional design to performance, learning, and information system design (Gery, 1991). More recently, a performance-centered approach to design of electronic performance support systems (EPSS) has emerged (Gery, 1991; Dickelman, 2000; Raybould, 2000). This approach relies quite heavily on analysis of the performer and the total performance environment in an attempt to design solutions intimately tied to the work context. Potential barriers to performance are removed as part of this design approach, and learning is considered a consequence of as well as a precursor to performance. Thus, performance support design is somewhat of a blend of instructional systems design, performance engineering, and software design. Two recently emerging trends accompany this shift in design focus.

The first trend is the movement towards a human performance orientation from a training orientation to solve performance problems. Pioneers in the field of performance technology such as Tom Gilbert (1998), Robert Mager (1997), and Joe Harless (1988) have long advocated the view that organizational system elements such as expectations and feedback, tools and equipment, rewards and incentives, and motivation must be analyzed in addition to skills and knowledge to identify performance barriers. The essence of this approach is to identify valuable behaviors that produce measurable results and to support performance using a combination of training and non-training solutions (Gilbert, 1998). A study conducted with over 1000 organizations by Huselid (1995) found that human resources practices such as employee selection and recruitment, performance management, incentive systems, employee involvement, and training combined to significantly impact turnover, productivity, and short- and long-term financial success. This study is significant in that training was but one of many human performance interventions impacting organizational results. By extension, efforts to develop technologies to create and use reusable objects to develop employee performance should look beyond traditional training and personnel development paradigms.

The ever-increasing appetite for just-in-time Web-based training and performance support products also requires a shift of thinking from purely instructional design to performance, learning, and information system design.

The second trend is the move to increase the cost-effectiveness of learning and performance support systems through sharing and reuse of previously developed materials and resources. Traditional methodologies tend to be oriented towards developing integrated stand-alone systems rather than systems constructed from pre-existing reusable components. Efforts have been undertaken by practitioners, vendors, and scholars within the field of information systems to standardize and meta-tag learning [the activity of adding meta-data] and information objects so that they may be stored, retrieved, and potentially re-used. These efforts are spearheaded by organizations such as the U.S. Department of Defense's Advanced Distributed Learning (ADL) initiative, which has developed standard specifications such as the Sharable Content Object Reference Model (SCORM). New component-based instructional design paradigms (Clark, 1999; Merrill, 1998) have also been developed and centered on the concept of the development of standard, reusable information objects, or RIO. Creation of these objects allows specification of learning requirements at the level of detail required for storage and retrieval from an information repository. A repository is essentially a Web-accessible database populated with objects.

Clark and Estes (1999) have argued that a solution-oriented approach to development promotes a "craft" rather than scientific approach to product development. A craft approach is not based on theory and is generally used to address a particular situation in a particular context. This type of development is not standard and is thus untestable; i.e., it is difficult to determine what works and what doesn't. An object-based approach may help those in the human performance technology (HPT) field begin to satisfy some of the requirements for scientific product development. Such an approach promotes standard outputs and could incorporate the necessary infrastructure for testing and continuously improving the quality of performance improvement products.

Figure 1 illustrates a lifecycle model of the planning and building of performance support systems. Currently, much energy is being expended to create the technological framework necessary for the building phase of this model, particularly the repository and the construction and assembly. There has been a recent focus on object-based instructional design (Wiley 2000). However, there appears to be little consideration of the planning phase and the changes in analysis required for the move towards object-based systems. Such systems still require analysis of human performance problems and identification of related performance support tools that will address those problems across organization and individual system levels. Thus, objects should be identified during the analysis process that provide an environmental and organizational context for the reuse of objects during subsequent design, construction, and evaluation processes. This approach should be supported by automated tools and repositories based around modeling notations for analysis of object-based systems. The automation will facilitate the visualization and reuse of analysis thinking.

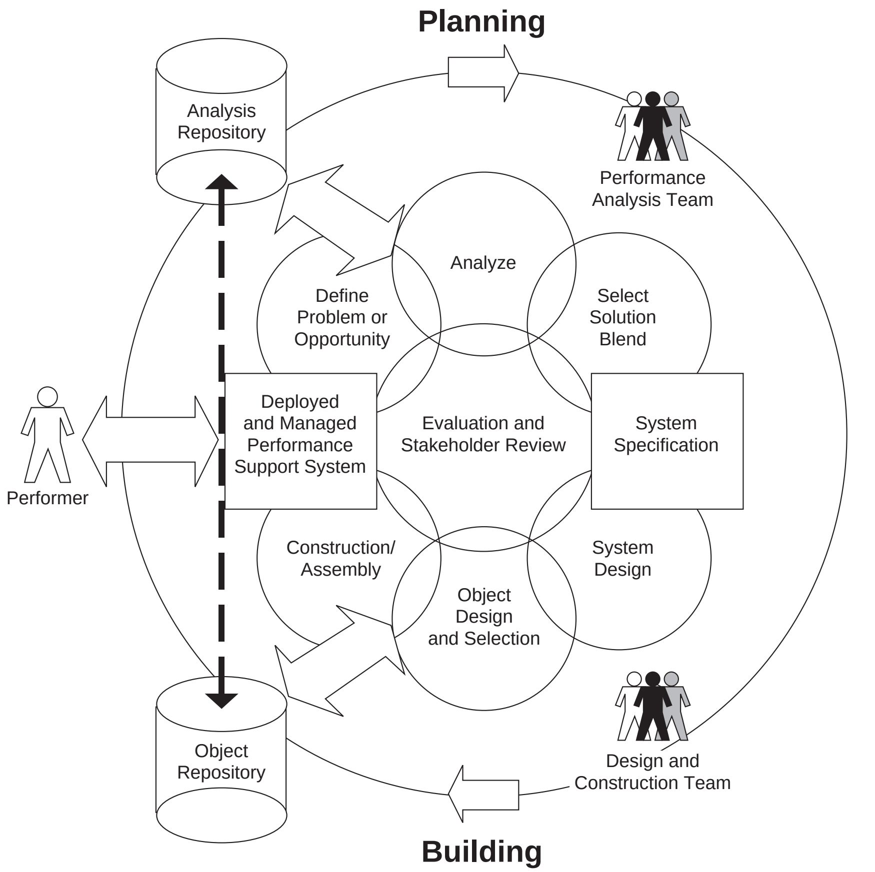

Figure 1. Lifecycle Model for Object-Based Performance Support Development

A Framework for Object-Based Performance Analysis

A major challenge for program planners and designers in this environment is identification and selection of reusable objects from repositories that will actually lead to measurably improved performance. It has been the experience of the computing field that object-based construction technologies alone are not enough to attain reuse; object thinking must begin in analysis and follow through into design and construction (Due, 2002). The object-based approach needs to complement a performance orientation rather than just reinforce the use of the latest solution technology.

We propose a framework for configurable methodologies (Cameron, 2002) based on a number of key features and the development of standards for modeling and documenting performance analysis work. A configurable methodology is based on agreed-upon and sharable work products but is flexible regarding the methods used in the construction of those products. The modeling and documentation should be digitized and sharable through a repository. It should provide a basis for searching for pre-existing solution objects and packages of objects. It may also incorporate metrics for the evaluation of those objects' success in enhancing performance.

The major features that we consider essential to this framework are that it includes visual modeling, integration with a repository, collaboration, blended solutions, rationale management, automated support, and a link to managed deployment.

Visual Modeling

Prior to the development of a new system, it helps to create a graphical model of what you are going to build. In architectural design, for example, an architect will create a drawing of a building design. This drawing may be altered many times at relatively low cost before a final plan is used for construction. Once the building is constructed, alterations become difficult and costly. A similar approach is used in many design domains and is facilitated by a commonly used modeling notation.

In learning and performance systems, visual modeling is not yet an established part of most methodologies, and there is no standard modeling notation. In software systems development, the Unified Modeling Language (UML) has recently become popular for modeling both domains and object-oriented software solutions (Booch, 1999). The language has been used primarily in object-orientated software development, but it has also been adapted for business modeling (Marshall, 2000). The Unified Modeling Language is designed to facilitate communication, in a visual manner, throughout a project's duration and to ensure that participants have a clear understanding of the system and its components. The language includes a number of different diagram types for modeling a system. Each diagram type illustrates a different view of a system. There are two types of UML diagrams that can be used with slight modification to help analysts to visualize performance: 1) use cases (see Figure 2) can be adapted to model the individual performer level, and 2) activity diagrams (see Figure 3) can be used to model the process/tactical level.

Visual models should be used at each of the performance levels to help with the analysis process. Completed models and model components become artifacts that can be stored in the analysis repository; these will be available to be reused and repurposed in the future. Analysts will select the appropriate diagram type for a particular performance level (organizational, process, individual).

Performance case modeling is a combination of the typical non-visual methods that performance analysts use and the visual modeling method of the UML use case (see Figure 4). Performance cases provide a visual method for structuring performance knowledge within an organization and for determining gaps at the operational/individual performer level. The ellipses represent performance cases, which represent a specific performance goal. The stick figures represent performance roles; they are abstract role responsibilities that can

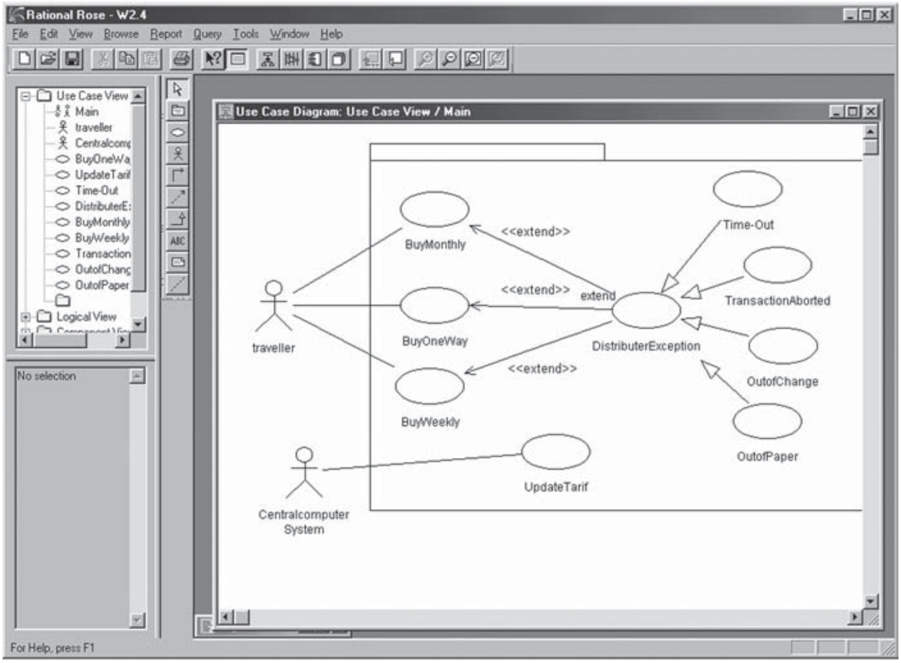

Figure 2. Example of Use Case Diagram Being Created With a Tool That Provides Automated Support for Software Analysis and Design

be achieved by anyone with the proper knowledge, skills, and support.

Performance case models can provide a framework for examining either the actual (is) or the required (should) performance. Information is obtained from performers and their supervisors based on real work scenarios, and the performance cases are abstracted from the common characteristics of the scenarios. The documentation for each performance case will provide the foundation for identifying the resources necessary to

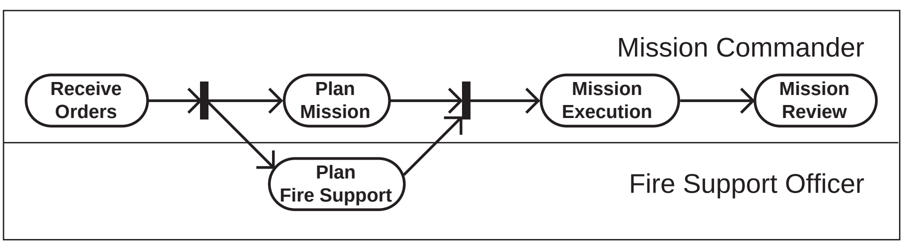

Figure 3. Example of an Activity Diagram

achieve performance support for the case. The performance case documentation will help analysts determine the barriers to achieving optimal performance. These barriers help classify the performance problems by causes and potential solutions, which help analysts develop recommendations to close performance gaps.

The performance-related information within the performance case documentation includes:

- A description of the performance result and linkage to strategic/organizational result
- The interaction of other performance roles
- The requisite knowledge and skills required by the performance roles relevant to this performance case
- Performance measures that identify standard and exemplary levels of performance

In addition, other information that may be linked to each performance case includes:

- Existing task analyses
- Cognitive models
- Detailed study of exemplary performers

Supporting documentation would focus on the various barriers to optimal performance. Analysts would use a standard template for this documentation. Completion of this information would help analysts classify performance problems and specify targeted object-based solutions.

Integration with a Repository of Reusable Objects

There are efforts underway to create Web-based repositories of reusable objects, which are used in the construction of learning and support systems. The thinking of analysts and designers must be consistent with this object repository approach for reuse to be successful. In addition, if it makes sense to use a repository as a central location for sharing solutions, it also makes sense to use a central location for sharing understanding of human performance. Object thinking begins at the analysis phase rather than at the construction phase. We propose that analysis models should be framed in terms of analysis objects, which are derived from the documentation of the performance cases illustrated in Figure 4. Analysis objects are descriptions of requirements that can be matched against existing objects in content repositories or form the specification for the construction of new objects.

Figure 5 illustrates the use of an analysis repository within a framework for object-based performance analysis. The repository supports reuse within analysis through the sharing of both analysis artifacts (e.g., performance case diagrams, process diagrams, templates) and analysis objects. Analysis repositories have the potential to support a highly contextualized search of the content repository, potentially increasing the efficiency and quality of design/development products. Analysis objects represent the link between performance analysis and the design of performance and learning support. In this way, analysis objects represent the specification for some of the constituent parts of the performance support system. Given that analysis objects will encode performance measures, they can be used to evaluate the chosen or constructed

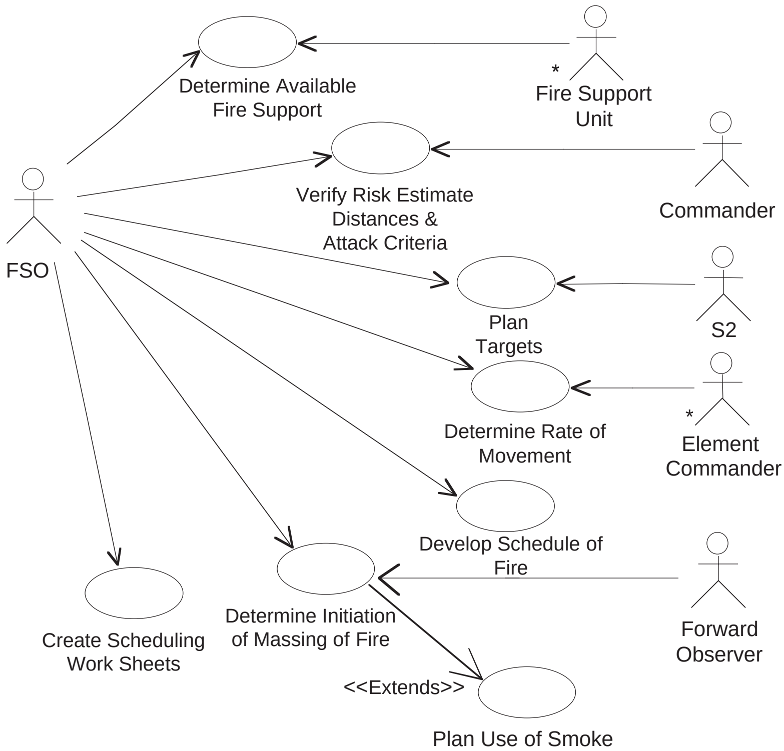

Figure 4. Example of a Performance Case Model for Part of an Army Process

systems that are designed to meet these specifications. In this role, analysis objects help measure the return on investment of the solutions that are developed.

A standard system for modeling, together with a repository for analysis models and documentation, would mean that over time, a comprehensive and evolving performance model for the whole organization would emerge. The model would provide a link into available reusable content objects and a filter for the performance metrics by which they are evaluated. It would also enable the analysis of problems of similar roles and performance goals to be reused within the organization and shared with similar organizations.

Collaborative Development

Traditional analysis and design can be seen as an expert-centered activity, i.e., an "expert" in design will work with a subject matter expert in a single geographical location to design a solution. The Internet has the potential to greatly widen the scope for collaboration of others in the analysis and design process when combined with the modeling approach noted above. If models of problem domains and intended solutions are published openly using a standard, easily understood graphical notation, these can be inspected by geographically distributed stakeholders. Thus, a group of analysis and design experts, subject matter experts, and end-users/performers can discuss and pass comment on models and identify flaws prior to final construction.

Blended Performance Solutions

Currently, performance problems are mainly solved with education and training solutions. By identifying a number of potential solutions to performance problems, it is possible, and appropriate, to create a blend of short- and long-term solutions to a performance problem. For example, performance models created during analysis have many potential uses. They may be excerpted to create job descriptions and new employee orientation checklists. Developed solutions can also be re-purposed to develop

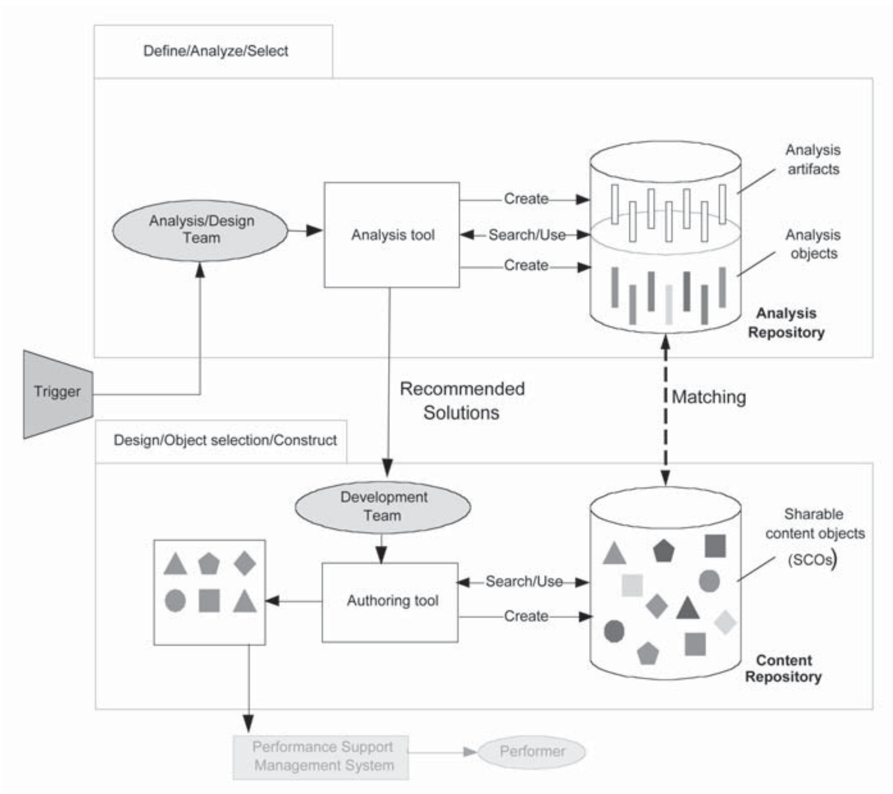

Figure 5. Relationship Between Automated Support and Repositories of Reusable Objects and Artifacts

collateral materials that will assist the performer when transferring or applying solutions in the workplace. Specifically, core skills might be taught in a training course, and a variety of reference materials created or excerpted from them. These job aids or knowledge bases provide performers with on-the-job access to knowledge and procedures for seldom occurring situations. Solution blending is thus focused on continuous improvement of performance with a focus on reuse and repurposing of readily available information.

Managed Deployment with Performance-Based Evaluation

The performance support developer's responsibility does not end with product delivery. A system of quality assurance should be in place, such that use of a system is managed and monitored with the resulting outcomes fed back into subsequent development and new versions of systems. Evaluation of the products that performers access in terms of their content quality and the value they add to the individual performer and organization requires management oversight and participation. The test of an effective system is not in functional performance or user satisfaction but in the closing of the performance gaps identified in the analysis across multiple levels of the performance system. There should be an iterative relationship between performance monitoring and performance support system analysis and design.

Rationale Management

Most performance problems have a range of potential solutions; despite this, developers often consider only one type of solution. It is not always the case that those making the decisions are unaware of the alternatives. It is more probable that political, historical, and cultural factors dictate that there are certain solutions for certain problems. Thus, it is important for decision-makers to have a defensible approach that promotes out-of-the box thinking with careful consideration given to potentially cheaper and better alternative solutions that are also politically palatable.

Rationale management (Burge & Brown, 2000; Moran & Carroll, 1996) is concerned with capturing the knowledge that leads to the construction of a system. In particular, it requires an auditing of the decision making when choosing problem solutions. Most performance analysts will be able to produce reasons for their analysis decisions. The distinction in giving a rationale is that there should be the following:

- A description of the issues that were addressed prior to the design decision
- A list of the alternative solutions considered
- The criteria used in the selection
- The argumentation used to support each alternative
- The decision

The benefit of rationale management is that it requires the performance analyst to use a rational process to make her or his decision-making explicit. It discourages decisions based on whim or prejudice; as such, decision making will not have a clear rationale.

Automated Support

There are a now a large number of software tools that assist in the implementation of automated instruction and a number that manage the delivery of instruction via the Web. There are relatively few tools relating to the systematic analysis and design that should precede construction and delivery of performance improvement materials and none that incorporate the emerging object model. There is scope for creating the equivalent of computer-aided software engineering (CASE) tools for object-based performance improvement.

Goodyear (1997), Kasowitz (1997), and Spector and Muraida (1997) review much of the previous work in automated design support tools. Spector and Muraida note that there is strong motivation to develop such tools given there is "a lack of instructional design expertise, pressures for increased productivity of designers, and the need to standardize products and ensure the effectiveness of products."

Conclusion

The aim of this paper is to describe a conceptual framework for the specification of a "planning" system tool that includes decision documentation, modeling, advice, and tutorials. This tool should assist analysts to create an object model for a problem solution that has considered alternative approaches (training, performance support) and can be matched against existing objects in a repository. The goal of the system is to increase the quality and speed of planning processes by supporting decision-makers in defining, analyzing, and selecting appropriate training and non-training solutions. It does this through facilitating visual modeling of analysis understanding and interaction with a centralized analysis repository (see Figure 3). In creating such a tool, there is a need for research in the integration of existing relevant technologies, e.g., groupware tools, modeling tools, rational management tools. Usability of such tools is a crucial consideration; they should be supportive of the analyst's work rather than being prescriptive.

In this approach, human performance problems or opportunities are defined by identifying new systems or reassessing existing systems. Requirements of human performance relative to these systems are specified and modeled as "analysis objects" across system levels (strategic, operational, tactical). Collaborative analysis methods support the information gathering process, which results in development of models of performance. These models are used to determine current effectiveness of these systems with respect to a particular problem or opportunity that has been identified. Gaps in performance–or in the case of new equipment or processes, new performances across system levels–are identified. Drivers or causes for these gaps or current system strengths that can be leveraged to support new performances are then further identified and specified as analysis objects.

These analysis objects contain information about specific performance and learning requirements and are subsequently matched against existing information and learning objects in a repository. Designers of information and instruction have the potential to identify and match learning and performance objects more quickly with analysis objects. The intended effect of this process is to assure that solutions are designed that add measurable value to the organization and are delivered in the most cost-effective manner.

Use of an object-based approach to modeling performance characteristics allows program planners to better gauge the potential effectiveness and cost of particular solutions based on the match of reusable objects within information repositories. This capability could facilitate the concurrent analysis and design of blended solutions which offers an advantage over more traditional linear analysis, design, and development processes since it may reflect the reality of the analysis and design process more closely.

References

Booch, G., (1999). UML in action. *Communications of the ACM*, 42(10), 26-28.

Burge, J., & Brown, D. (2000). Inferencing over design rationale. In J. Gero (Ed.), *Artificial Intelligence in Design '00* (pp. 611-629). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Cameron, J. (2002). Configurable development process. *Communications of the ACM,* 45(3), 72-77.

Clark, R. (1999). Four architectures of instruction. *Performance Improvement*, *39*(10), 31-38.

Clark, R., & Estes, F. (1999, March-April). The development of authentic educational technologies. *Educational Technology*, *39*(2), 5-16.

Dickelman, G. (2000). *EDIT 797: Performance-based design.* [Online]: http://pcd-innovations.com/EDIT797/id98_m.htm

Due, R. (2002). *Mentoring object technology projects*. Upper Saddle River, NJ: Prentice Hall PTR.

Gery, G. (1991). *Electronic performance support systems: How and why to remake the workplace through the strategic application of technology*. Tolland, MA: Gery Performance Press.

Gilbert, T. (1998). Human competence: Engineering worthy performance. Amherst, MA: HRD Press.

Goodyear, P. (1997). Instructional design environments: Methods and tools. In S. Dijkstra, N. Seel, F. Schott, & D. Tennyson (Eds.), *Instructional design: International perspectives* (Vol . 2). Mahwah, NJ: Lawrence Erlbaum.

Harless, J. (1988). *Accomplishment-based curriculum development*. Newnan, GA: Harless Performance Guild.

Holcomb, C., Wedman, J., & Tessmer, M. (1996). ID activities and project success: Perceptions of practitioners. *Performance Improvement Quarterly*, 9(1), 49-61.

Huselid, M. (1995). The impact of human resource management practices on turnover, productivity, and corporate financial performance. *Academy of Management Review*, 38(3), 635-672.

Kasowitz, A., (1997). *Tools for automating instructional design.* ERIC Clearinghouse in Information Technology in Education. Syracuse, NY: http://www.ed.gov/databases/ERI_Digests/ed420304.html

Keegan, D. (1996). *Foundations of distance education* (3rd ed.). London: Routledge.

Mager, R., & Pipe, P. (1997). *Analyzing performance problems.* Atlanta, GA: Center for Effective Performance.

Marshall, C. (2000). *Enterprise modeling with UML: Designing successful software through business analysis*. Reading, MA: Addison-Wesley Longman.

Merrill, D. (1998). ID expert: A second-generation instructional development system. *Instructional Science, 26*(3-4), 243-62.

Moran, T., & Carroll, J. (1996). *Design rationale: Concepts, techniques, and use.* Mahwah, NJ: Lawrence Erlbaum Associates.

Phillips, J. (Ed.). (1994). *Measuring return on investment*. Alexandria, VA: American Society for Training and Development.

Raybould, B. (2000). Performance support engineering: Building performance-centered Web-based systems, information systems, and knowledge management systems in the 21st century. *Performance Improvement*, *39*(6), 32-39.

Robinson, D., & Robinson, J. (1989). *Training for impact*. San Francisco: Berrett-Koehler Publishers.

Spector, J., & Muraida, D. (1997). Automating design instruction. In S. Dijkstra, N. Seel, F. Schott, & D. Tennyson (Eds.), *Instructional design: International perspectives* (Vol. 2). Mahwah, NJ: Lawrence Erlbaum.

Wiley, D. (2000). Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy. In D. Wiley (Ed.), *The instructional use of learning objects: Online version*. Retrieved August 13, 2001, from: http://reusability.org/read/chapters/wiley.doc

IAN DOUGLAS is assistant professor of computer science at Florida State University. Dr. Douglas is also a faculty member of the university's Learning Systems Institute. His research interests are in object-oriented analysis and design, educational technology, and human factors in systems engineering. *Mailing address:* Suite 109, Morgan Building, Innovation Park, Florida State University, Tallahassee, FL 32310. *E-mail:* idouglas@lsi.fsu.edu

SCOTT P. SCHAFFER is an assistant professor of educational technology at Purdue University and a member of the research faculty of the Learning Systems Institute at Florida State University. Research interests include performance and learning system design, analysis, and evaluation. *Mailing address:* Department of Curriculum and Instruction, 1442 Liberal Arts & Education Building, West Lafayette, IN 47907-1442. *E-mail:* sschaffer@lsi.fsu.edu