Diagnosing the Context of Inter-Organizational Systems by Mapping Key-Players

Albert Boonstra, University of Groningen, Landleven 7, Groningen, The Netherlands, 9700 AV; E-mail: albert.boonstra@rug.nl

ABSTRACT

Inter-organizational systems (IOS) are generally used in a context of various interested parties. If these parties are not identified and if their power and interests related to the IOS are not explored and taken into consideration, implementation is likely to become a disappointing and troublesome affair. This paper presents a diagnostic method for the identification of stakeholders involved in IOS and the assessment of their power and interests with respect to these systems. The diagnostic approach is illustrated by means of an in-depth case study. The case study indicates that addressing power and interest relationships may help make the critical success factors in the implementation and improvement of inter-organizational systems more explicit. On the basis of the case study, conclusions are drawn regarding the application and usefulness of the diagnostic approach.

Keywords: inter-organizational system, stakeholder, interests, power, diagnosis

INTRODUCTION

Especially since the rise of the Internet, there has been a clear tendency toward the use of inter-organizational systems (IOS). Many organizations as well as industry boards and government departments are involved in the development and implementation of such systems. The possibilities of IOS are clear: closer links between value chains of organizations can lead to lower transaction costs and a quicker delivery of goods and services. Also intangible benefits of IOS are considered to be important, including an improvement in services and closer partnerships. Although the benefits seem to be attractive, many of the parties involved in the development and use of IOS have already experienced that the potential benefits are not always achieved easily. Although some systems have become success stories, others are not doing so well at all and can even be called failures. So, some IOS are taking off very quickly whereas others are only accepted hesitantly. Clearly, some systems have achieved high penetration among target users, whereas others appeal to a few intended users only. This illustrates that the implementation of IOS systems is a complicated endeavor, both from a technical point of view and from many other perspectives, including strategic, organizational, political, and cultural viewpoints. Moreover, a large number of stakeholders from different organizations are involved in developing and using IOS. For this reason, the question who participates in the analysis, development and implementation of IOS becomes even more difficult, since decisions are no longer only made internally (Pouloudi, 1997; Cavaye, 1995; Webster, 1995).

This paper therefore presents a diagnostic framework, which aims to assess the potential critical success factors from the power and interest perspectives of the various stakeholders. This framework can be used to predict the potential success and critical factors playing a role in the implementation and improvement of IOS. By applying the framework, IOS developers and implementers will be able to assess potential risks and identify barriers to the use of IOS. On the basis of that assessment, focused actions can be taken to alter power/interest positions in ways that stimulate a successful implementation.

THEORETICAL BACKGROUNDS

Perspectives on Stakeholders

It has been generally acknowledged in the literature that the development of information systems requires the participation of interested parties and that the willingness and the effectiveness of this participation influences whether the resulting system is successful. Normally these participants include developers, intended users and managers. However, in the case of an IOS this range of people and parties is much broader. It crosses organizational borders, which means that the stakeholders are more loosely coupled. Identifying these stakeholders and exploring their perspectives in terms of their interests in the system and their power to 'make or break' the system are essential steps in establishing a diagnostic framework aimed at assessing the critical factors of an IOS (Pan et al., 2003). As part of the diagnostic framework, a practical technique is required to identify these groups and individuals.

Stakeholders can be identified in many different ways (Mitchell et al., 1997). There are different kinds of stakeholders, such as persons as well as groups inside and outside an organization. In this research study we have adopted Freeman's classical definition of stakeholders to IOS: "A stakeholder is any group or individual who can affect or is affected by the IOS" (Freeman, 1984, adapted to IOS by the authors).

Relevant questions that help identify relevant groups and individuals in this context are for example (Pouloudi, 1997; Cavaye, 1995):

- Who are the sponsors and the initiators of the system?
- Who have to adopt the system and make it work?
- Who are the intended users?

Answers to these questions may reveal stakeholders not yet identified by the top-down approach or make it possible to refine certain categories of stakeholders into relevant subgroups.

Stakeholders' Interests

When the stakeholders are identified, their interests have to be connected with the IOS. This means that part of the analysis consists of the assessment of the stakeholders' perception of the IOS. How do they interpret the IOS (Walsham, 1993) and to what extent do they believe that the IOS will fit their values and help them attain their objectives? In other words: what are their perceived interests in the IOS?

The degree to which parties are interested in an IOS can vary from low to high (Coltman, 2001). In case of a low interest level, the stakeholder may be inclined to believe that the IOS will lead to increasing operational costs as well as a decrease in efficiency due to incompatible internal and external technologies, and that it will offer insufficient support in the control of the primary process. On the other hand, a high degree of interest relates to the perception that an IOS contributes to the overall goals of the company.

Within the context of this study, it is not relevant whether perceptions are realistic. The perceived (dis)interest normally includes several elements and it is often based on strategic, organizational, financial and behavioral aspects (Chen, 2003; Coltman et al., 2001; Parker et al., 1988; Porter, 2001). These aspects are not of

equal relevance to all stakeholders: intended users have other kinds of interests than business managers. This means that the dimensions and the diagnostic questions should be prioritized in relation to the stakeholder in question. Questions that may help identify the degree of interest of a stakeholder in an IOS are:

Strategic Interests of Stakeholders
- Does the IOS affect the power, autonomy and independence within the value chain?
- Does the IOS lead to competitive advantage?
- Is the IOS instrumental in reaching new customers or does it lead to losing customers?

Operational/Organizational Interests of Stakeholders
- Is it easy or difficult to implement the IOS?
- Is it easy or difficult to link the IOS with internal business systems?
- Are the operational risks of the IOS high or low?

Financial Interests of Stakeholders
- Are the initial investments in the IOS high or low?
- Are the operational costs of the IOS high or low?
- Are the financial risks of the IOS high or low?

Behavioral Interests of Stakeholders
- Is the IOS compatible with the current culture, values and working procedures?
- Is the IOS easy to learn and use?
- Is the IOS useful for the intended users?

Power

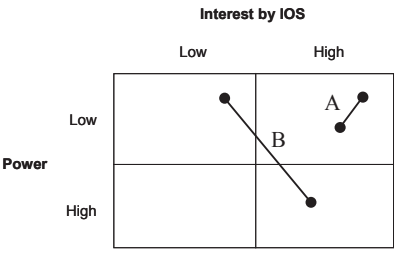
Another element of the framework is an analysis of the power relations among the parties involved. A powerful party with a clear interest in an IOS can apply its power to force less powerful parties to also start using the IOS, independent of their perceived interest in it (Standifera et al., 2003). At the same time, if certain parties only have little interest in an IOS it might be rather difficult for parties with a great deal of interest but a lack of power to implement an IOS successfully. In this paper, we will define power as the capacity to exert one's will over others in order to realize certain intended benefits. Since power is the capacity to exert one's will, it is possible to indicate the source of this capacity, or in the context of IOS: parties may possess different sources of power to urge others to use (or not to use) an IOS.

Processual
- Can the stakeholder force other stakeholders to comply with the implementation and use of the IOS?
- Can the stakeholder independently block the implementation and use of the IOS?
- Is the stakeholder (economically) dependent upon a party who can force another party to comply with or block the implementation and use of the IOS?

Institutional
- Does the stakeholder have the resources to develop and implement the IOS?
- Does the stakeholder have the size and/or resources to block the implementation or use of the IOS?
- Does the stakeholder has sufficient formal or legal authority to force others to use the IOS?

By linking the dimensions of power and interest, stakeholders involved in setting up and implementing an IOS can be categorized in a matrix. In this way, different IOS relationships can be distinguished. IOS relationship A for instance (figure 1), shows all characteristics of a balanced IOS. In this situation both parties believe that they can benefit from applying an IOS and they both possess an equal amount of power when it comes to its development and implementation. Relationship B on the other hand, can be categorized as an unbalanced IOS. In this case, one party benefits significantly more from the IOS than the other one does.

Figure 1. Example of a balanced and unbalanced IOS relationship



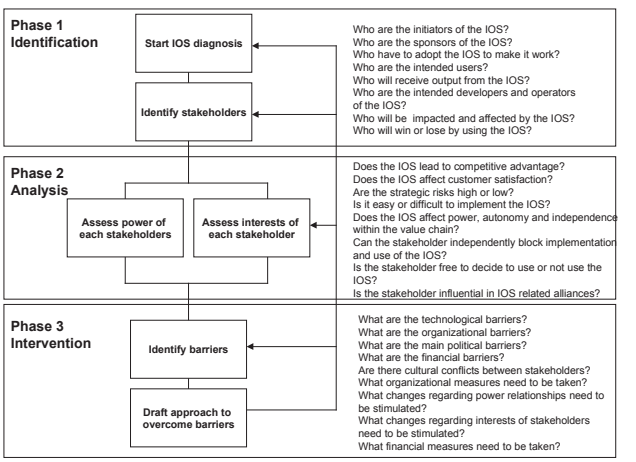
THE FRAMEWORK

The perspectives explained above can be combined in a diagnosing framework for the assessment of barriers to the development and implementation of an IOS. Figure 2 summarizes the main stages of diagnosis as well as the key issues to be addressed when applying the framework. The diagnosis starts with a formal agreement on the (proposed) IOS, its aim, the characteristics of the IOS and the planning of the development and implementation process. Then, the stakeholders involved are further identified (phase 1) in accordance with the guidelines as described above. In phase 2 the power and interests of each stakeholder are assessed by applying the dimensions and issues addressed in the previous section. Finally, the fourth phase concentrates on addressing the main barriers to the implementation of the IOS or, in case the IOS has already been developed, the operating-barriers. This phase obviously includes an action plan encompassing the issues of power relations as well as the interests in and alternatives to changing the IOS relationships.

RESEARCH METHODOLOGY

The empirical part of our study is founded on an in-depth study of an IOS project that took place during the period 1997-2004. The case study deals with the introduction as well as the operating phase of a dedicated and complex IOS in the retail sector. The initial research objective of the project was to study the potential benefits of and the barriers to the implementation of an IOS linking a cooperative wholesaler to its affiliate members. During the early stage of adoption however, it appeared that political processes played an important role and it was therefore generally expected that the success or failure of the IOS would be closely linked to the interests and power of the IOS parties involved in these processes. It was for this reason that the research objective of the project gradually shifted from a feasibility study to a monitoring study, aiming at exploring how power and interest relationships interact with each other and how the operation and modifications of the IOS are influenced by these two dimensions. However, this was clearly a 'how' question about a contemporary set of events over which the researcher has

Figure 2. Overview of the diagnosing framework



no control. It also had some open and explorative characteristics. Consequently, a case-study approach appeared to be the most appropriate choice (Yin, 1991) and we therefore conducted a longitudinal case study in order to compare the different strategies used by companies to implement and adopt an IOS.

WHOLESALER - MULTI-STORE CASE[1]

Episode 1: Backgrounds of the Project and Agenda Formation

At the end of the 1990s, after a long period of discussions and informal meetings, Wholesale Corp. decided to initiate a feasibility study on the design and implementation of an IOS. Wholesale Corp. is a purchasing organization representing independent retail formulas in the Netherlands. By means of joint purchasing, Wholesale Corp. is able to achieve substantial financial benefits for its members, e.g. supermarkets and retailers. Wholesale Corp. covers about 20% of the entire food market in the Netherlands and represents 23 affiliated members, including Multi-store Corp. Multi-store Corp. is a medium-sized chain of supermarkets consisting of three distribution centers and 26 stores. The company has a turnover of €200 million and employs about 2000 employees. Figure 3 summarizes the main good flows as well as the information flows among the stakeholders involved in the supply chain.

In 1999, Wholesale Corp. conducted a study on designing and implementing an IOS. Five driving forces triggered this study:

- the exchange of data between Wholesale Corp. and its affiliated members is characterized by high volumes;
- the food market is under high pressure to reduce costs;
- many supermarkets and retailers experience decreasing profit margins;
- supermarkets are confronted with a high competitive market forcing Wholesale Corp. to be more efficient;
- the aspect of 'time' is crucial in the ordering-process of food and retail products.

The feasibility study mainly focused on the technical aspects of the IOS and included issues, such as IOS-software, the protocols to be used, the necessary technological changes to be made and the costs associated with implementing an overall IOS standard to be applied by Wholesale Corp. and its members. Clearly, during the early stage of adopting the IOS many stakeholders were involved in the project. A project group of senior managers representing different business areas (sales, logistics, finance, IT) from Multi-store Corp., Wholesale Corp., and some other affiliated members worked closely together with external consultants. The group actively gathered information about the financial and technological benefits of the IOS and an assessment was made of the strategic risks to each of the stakeholders. With the aid of the diagnosing tool, also the issue of power was addressed by the group project. Especially representatives of Multi-store Corp. feared they would become dependent on Wholesaler Corp. So during several project meetings, this issue was explicitly addressed. Obviously, the discussions contained some political elements. The meetings, which were focused on the elements of power and dependence, were therefore chaired by an external consultant specialized in group processes. At the end of 1999, it was concluded that both Wholesaler Corp. and Multi-store Corp. would benefit from an IOS and an agreement was made upon the functionality requirements of the system. The project group also defined an action plan enabling the stakeholders to overcome potential barriers.

Episode 2: Development and implementation of the IOS

In 2001, Wholesale Corp. started with the development and implementation of an electronic procurement system that linked the ordering systems of the supermarkets and retailers to a central database. A substantial reduction in transaction costs, a further optimization of internal processes and increasing service delivery levels were expected to be the main benefits of the IOS. However, the implementation of the IOS within both Multi-store Corp. and Wholesale Corp. was confronted with numerous problems. Although some of these problems seemed to be of a technical nature, Wholesale Corp. also faced a number of organizational difficulties in its communication with Multi-store Corp. Project meetings were often canceled, information was not provided in time and pilot projects were often delayed severely. By the end of 2001, only a few functionalities of the IOS had been implemented, which were only partly used by Multi-store Corp. In 2002, both Multi-store Corp. and Wholesale Corp. concluded that the costs of implementing the IOS had largely outreached the benefits. It was therefore decided to reassess the functionalities of the IOS and to re-design the administrative procedures between Multi-store Corp. and Wholesale Corp. At the same time though, the implementation and usage of the IOS by Wholesale Corp. and some large supermarket chains appeared to be a great success. By means of a sophisticated IOS the leading three supermarkets were all successfully linked to Wholesale Corp.

Episode 3: Identifying Power and Interests

Starting from our model depicted in figure 1, the analysis showed that initially both parties possessed important sources of power. At the start of the project, the interdependence between Wholesale Corp. and Multi-store Corp. was strongly related to the company goals of Wholesale Corp. When buying products from suppliers, Wholesale Corp. was expected to represent the interests of its affiliated members, including those of Multi-store Corp. As a consequence, Wholesale Corp. strongly favored the development and implementation of an IOS, which was reinforced and stimulated by an informal strategic alliance between Wholesale Corp. and some large supermarket chains. The ability to develop and maintain a complex and sophisticated IOS as well as the control over an influential IOS alliance consisting of Wholesale Corp. and some large chains of supermarkets can be considered as the main sources of power of Wholesale Corp.

Regarding the (potential) interests in the IOS, at the start of the project both Wholesale Corp. and Multi-store Corp. were convinced of the benefits of implementing an IOS. It was expected that the IOS would be helpful in optimizing the internal processes of both companies and that it would significantly contribute to a reduction in the transaction costs. It was therefore concluded that the initial IOS situation for both parties could be categorized as one with high power and interest levels (see figure 4). In 2003, Multi-store Corp. was convinced that the benefits of the IOS did not outweigh the costs. Consequently, the IOS situation of Multi-store Corp. as it was initially assessed changed from a high power, high interest situation to a high power, low interest situation (see figure 4).

Figure 3. Overview of the relationships between the stakeholders involved in the supply chain

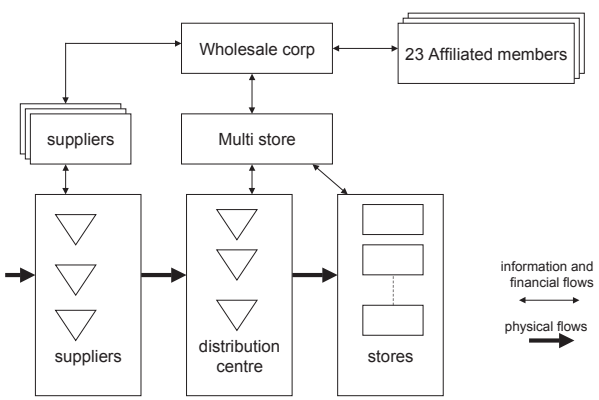
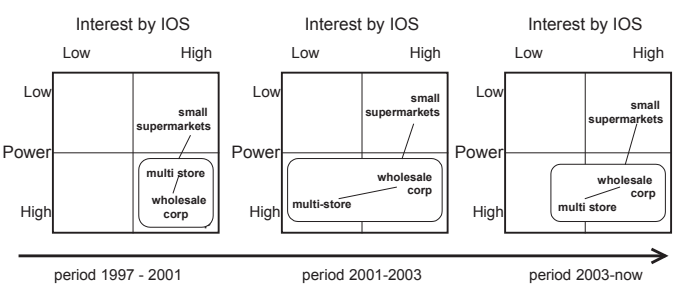


Figure 4. The dynamic character of the IOS-relationship



DISCUSSION

IOS are often presented as beneficial for all user organizations. The general assumption is that such systems may help to strengthen business relationships between participants. Stronger partnerships are normally associated with benefits such as clearer patterns of supply and demand, just-in-time, lower transaction costs, and closer vertical integration (Cavaye, 1995). However, closer partnerships can also have disadvantages. Partner organizations might feel overshadowed by powerful business partners and they may have to give up part of their independence. They may become dependent on their more powerful IOS partners, a dependency that may have existed before the IOS partnership, but that will become stronger and more explicit and tangible when the organization becomes electronically linked with the more powerful partner.

Stakeholders

The framework as presented in this article can be a helpful tool in identifying the most relevant stakeholders involved in an IOS proposal. The guiding questions as well as the other approaches mentioned in the backgrounds section are effective methods to identify this group. With respect to IOS projects, stakeholders can be divided in initiators, developers, implementers, and users and/or sponsors of the system. Identifying stakeholders is an important activity in relation to a broader goal, which is the management of stakeholders. Promoters of a certain IOS initiative have a clear interest in building an effective coalition of parties that may not have the same interests, but that may find each other through pursuing congruent goals that can be (partially) achieved by the successful implementation of an IOS.

Interests

The diagnostic framework acknowledges that IOS partners may have a variety of reasons to support or to resist an IOS initiative. These reasons can be divided in strategic, operational, financial, technological and behavioral motives. However, this categorization is only meant as a tool to identify all sorts of reasons that may influence the stakeholders' interpretations. These interpretations determine the attitude toward the IOS. In practice, the reasons are intertwined. In the case history, Wholesale faced numerous technological barriers when trying to introduce the IOS. However, these technological barriers appeared to be the result of miscommunication and the fact that parties were not prepared to exchange crucial information or change their organizational processes in favor of the IOS to be introduced. The technological problems were actually often used as an alibi and as a means to exert power and influence the other IOS party. It is the challenge of the analyst to talk to interest parties, to interpret their opinions and to gain insight into their real interests.

Dynamic Process

The presence of stakeholders as well as their interests and power are subject to change over time. This means that due to changing environments, the progressive nature of the system, and the shifting interpretations and perceptions of the parties involved, IOS development is not static but inherently dynamic. Sometimes these changes are the result of a well defined and explicit decision-making process. In the case history, Multi-store deliberately moved its position from a high interest, high power situation toward a low interest and high power situation. However, the dynamic character of IOS design and implementation is more often the result of implicit processes. Changing market circumstances, technological evolutions, or actions from other parties may influence the interpretations and actions of the different stakeholders.

CONCLUSIONS

In this paper we have offered a diagnostic method for identifying stakeholders and assessing their power and interests. The method's framework can be used before and during an IOS project, but also afterwards, to evaluate the project and to explain its degree of success as well as particular problems. This may improve an organization's learning capabilities during the process of starting new projects. Sufficient insight may also help executives of interested organizations to use their influence to move the project into the desired direction. McDonagh (2003) notes that IOS projects are frequently managed with a technical rather than an organizational focus, which reflects the relative isolation of the executive and user communities. "Executive communities view it as an economic imperative while IT specialists view it as a technical imperative. The coalescent nature of these two imperatives is such that human and organizational considerations are regularly marginalized and ignored". The framework as described in this paper may help business managers, executives and IT specialists become aware of the broad range of issues related to the development of inter organizational systems.

REFERENCES

Cavaye ALM (1995) The Sponsor-Adopter Gap- Differences between promoters and potential users of Information Systems that link organizations. International Journal of Information Management 15, 2, 85-96.

Chen S (2003) The real value of 'e-business models', Business Horizons 46, 6, 27-33.

Coltman T, Devenney TM, Latukefu A, Midgley DF (2001) E-business: Revolution, Evolution or Hype? California Management Review 44, 1, 57-85.

Cummings JL, Doh, JP (2000) Identifying who matters: Mapping key players in multiple environments, California Management Review, 42, 2, 83-105.

Freeman RE (1984) Strategic Management, a stakeholder approach, Pitman, Boston.

McDonagh J (2003) Not for the Faint Hearted: Social and Organizational Challenges in IT-enabled Change. Organization Development Journal 19, 1, 11-19.

Mintzberg H (1983) Power in and Around Organizations, Englewood Cliffs, Prentice Hall.

Mitchell RK , Agle B (1997)Toward a theory of stakeholder identification and salience. Academy of Management Review 22, 4, 853-887.

Pan G, Flynn D (2003) Information Systems Project Abandonment: A Case of Political Influence by the Stakeholders. Technology Analysis & Strategic Management.

Parker MM, Benson RJ, Trainor HE (1988) Information Economics. Linking business performance to information technology, Englewood Cliffs, Prentice Hall.

Porter ME (2001) Strategy and the Internet. Harvard Business Review 79, 3, 79-91.

Pouloudi A, Whitley EA (1997) Stakeholder identification in Inter Organisational Systems: Gaining Insights for Drug Use Management Systems. European Journal of Information Systems 6, 1, 1-14.

Standifera RL, Wall JA (2003) Managing Conflict in B2B e-commerce. Business Horizons 46, 2, 65-70.

Walsham G (1993) Interpreting Information Systems in Organizations, Wiley, Chichester.

Webster J (1995) Networks of collaboration or conflict? EDI and power in the supply chain. Journal of Strategic Information Systems, 4, 1, 31-42.

Yin, RK (1991) Case Study Research, Design and Methods, Sage, London.

ENDNOTE

[1] In order to maintain anonymity the names of the firms are not revealed in this paper.

Teaching Java™: Managing Instructional Tactics to Optimize Student Learning

Henry H. Emurian, Information Systems Department, UMBC, 1000 Hilltop Circle, Baltimore, MD 21250, USA; E-mail: emurian@umbc.edu

INTRODUCTION

Direct mastery of the core knowledge in a discipline is increasingly recognized as a fundamental requirement to applying and extending that knowledge to solve novel problems. That recognition implies an instructional design to overcome the empirically verified shortcomings of teaching tactics that provide minimal guidance during a student's learning experiences (Kirschner, Sweller, & Clark, 2006). In that regard, our previous work consistently confirmed the value of programmed instruction in teaching introductory Information Systems students a Java applet as a first technical training exercise in preparation for advanced learning (Emurian, 2004, 2005, 2006a,b). Similar value of programmed instruction is evident in its applications within other disciplines, such as chemistry (Kurbanoglu, Taskesenligil & Sozbilir, 2006). The objectives of our work are to apply programmed instruction and to assess its effectiveness as a tactic to promote a common level of mastery by all students for a designated learning objective in Java programming. An optimal level of mastery is taken to reflect a *true gain* in learning (Anderson, Corbett, Koedinger, & Pelletier, 1995).

Among several recommendations for effective learning principles to promote retention and transfer of knowledge, however, are repeated practice with different instructional modalities (Halpern & Hakel, 2003) and socially supported interactions (Fox & Hackerman, 2003). The modalities that have been adopted in our classroom applications include (1) programmed instruction, (2) lectures with hands-on learning, and (3) collaborative peer tutoring. Although these tactics are demonstrably effective in promoting programming skill, software self-efficacy, and generalizable knowledge, our most recent assessment of learning effectiveness showed room for improvement in the goal of achieving maximal learning in all students on tests of far transfer following the collaborative peer tutoring (Emurian, 2006b). To potentiate the effectiveness of the collaborative peer tutoring, then, the present evaluation was undertaken with a modification to the instructions and materials that were presented to students to prepare for peer tutoring and to use during the collaboration session. The procedure also allowed the collaborating students to view and discuss together the questions that constituted the tests of far transfer. Finally, the Java program to be learned by students as the first technical exercise was updated to Java swing, and it contained more items to be mastered in comparison to the previous work in this area of classroom applications and research.

METHOD

Subjects

Subjects were 13 graduate students, four females and nine males, taking IS 613 (*GUI Systems Using Java*) during a four-week summer session (Summer 2006). The class met three times each week, and each class lasted three hours. The course was designed for Information Systems students, and the prerequisite was one prior programming course.

The background characteristics of the students were as follows: age (median = 28 years, range = 23 to 33), number of prior programming courses taken (median = 3, range = 1 to 15), rated prior Java experience (median = 2, range = 1 to 5 on a 10-point scale presented below), and rated prior programming experience (median = 5, range = 2 to 8 on a 10-point scale presented below).

The research protocol was exempt from informed consent by the Institutional Review Board, and the course syllabus clearly indicated that questions both embedded in the Java tutor and administered during several assessment occasions in class were eligible to appear on a quiz. The course description and syllabus provided information about the Java tutor and the collaborative peer tutoring, and they presented the rationale for the repetition of initial learning using the several different instructional modalities under consideration.

Material

Java Program

The instructional tactics in this study were based upon teaching students a JApplet program that would display a JLabel object within a browser window. The program was arbitrarily organized into 11 lines of code (*e.g.*, ***JLabel myLabel;***) and 37 separate items of code (*e.g.*, ***getContentPane()***). The 11 lines of code are as follows:

```
(1) import javax.swing.JApplet;
(2) import javax.swing.JLabel;
(3) import java.awt.Color;
(4) public class MyProgram extends JApplet {
(5) JLabel myLabel;
(6) public void init() {
(7) myLabel = new JLabel("This is my first program.");
(8) getContentPane().setBackground(Color.yellow);
(9) getContentPane().add(myLabel);
(10)}
(11)}
```

Access to the web-based Java tutor, as presented below, will also show the complete program as part of the tutor's instructions to the student.

Questionnaires[1]

Java software self-efficacy was assessed by requesting a rating of confidence, for each of the 23 unique items of code (*e.g.*, ***import***) in the program, in being able to use the Java code to write a program that displays a text string, as a JLabel object, in a browser window. The scale anchors were ***1 = No confidence.*** to ***10 = Total confidence.*** Twelve multiple-choice questions were administered that required applying a general concept of Java object-oriented programming to solve. These questions did not appear within the Java tutor, and they were intended to assess far transfer or meaningful learning (Mayer, 2002). Each question had five choices, and for each question, a rating of confidence was made that the selected choice was the correct choice. The scale anchors were ***1 = Not at all confident.*** to ***10 = Totally confident.*** Ratings of classification and functionality learning for eight Java identifiers were also obtained, but they are beyond the scope of this paper.

The pre-tutor questionnaire also solicited demographic information, to include age, sex, and college major. The total number of prior programming courses taken was also requested. Two programming experience rating scales were presented, one for general programming experience and one for Java programming experience. For both scales, the anchors were ***1 = No experience. I am a novice.*** to ***10 = Extensive experience. I am an expert.***

The post-tutor questionnaire omitted the demographic information, and it assessed evaluations of the tutor for (1) overall effectiveness, (2) effectiveness in learning Java, and (3) usability. The anchors were ***1 = Lowest value.*** to ***10 = Highest value***.

Procedure

Java Tutor

At the first class meeting, students completed the pre-tutor questionnaire. Students next completed the web-based Java tutor[2]. The tutor taught a JApplet that

displays a text string, as a JLabel object, in a browser window on the web. The Java code and a brief description of the eight stages of the tutor are presented as part of the open source material[3]. When a student finished the tutor, he or she next completed a post-tutor questionnaire, which duplicated the software self-efficacy ratings and multiple-choice rules questions and confidence ratings. The student next accessed a set of questions and guidelines, which were posted on Blackboard, that were to be used to structure the collaborative peer tutoring session during a subsequent class. This material also presented a link to access the textual explanations of the items and lines of code that were presented in the Java tutor. The instructions with this material indicated that the questions presented were eligible to appear on a quiz.

Lecture

At the second class meeting, the author gave a lecture on the program taught in the Java tutor. The students wrote the code in a Unix™ text editor during the lecture, which repeated the information presented in the tutor. The students were also taught the HTML file, used to access the Java bytecode file, as a URL on the web. Support was provided so that all students successfully ran the JApplet program at the conclusion of this lecture-based exercise.

This lecture required approximately one hour to complete, and the remaining class time was spent on the next unit of material, which related to the life cycle of an Applet. Students were encouraged to help each other during the subsequent classes in the semester, which combined lectures and hands-on demonstrations, with the understanding that files were not to be copied without prior permission of the instructor.

Interteaching

At the third class meeting, a collaborative peer tutoring session occurred based upon the dyadic "interteaching" model (Boyce & Hineline, 2002). Students formed six groups of two and one group of three students for the session, which lasted one hour. The assignment was for the students to discuss the set of questions and guidelines made available at the conclusion of the Java tutor work undertaken at the first class meeting. Also presented was the questionnaire, and students were encouraged to discuss the items together prior to answering individually. This was the major innovation in the study, providing the opportunity for students to discuss the rules questions together. The interteaching questionnaire instructions stated that the 12 rules questions were eligible to appear on a quiz, but the remaining items were there only to assess instructional effectiveness of the interteaching session. The interteaching questionnaire also requested ratings of the effectiveness of the session for (1) learning the material and (2) readiness to be tested on the material, where ***1 = Not effective*** to ***10 = Totally effective***.

During the interteaching session, students posted questions on a Blackboard discussion board, and the instructor provided feedback. For the 12 rules questions, the correct selection was never given. Instead, the instructor responded in a way that made certain that students understood the general principle underlying the correct choice, and this process was occasionally iterative.

On the same day as the interteaching session, the instructor posted an announcement on Blackboard giving a rules question that was answered incorrectly by two of the students. The announcement was as follows: "Some students answered 'c' below for this question [also presented in the announcement]. The 'c' choice is not correct because JScrollPane is a class, not an object. An object name begins with a lowercase letter. If you have a question about this, please send me email." All student inquiries were answered privately in a way to promote understanding of the principle involved. The correct answer was not given.

Graded Quiz

At the fourth class meeting, a quiz was administered that included questions embedded within the Java tutor and the 12 rules questions as indicated above. The graded quiz did not include any rating assessments.

RESULTS

Figure 1 presents boxplots of correct answers on the rules test over the five assessment occasions. For each of the 12 questions answered during the Pre-Tutor assessment, one student did not select any answer, but instead indicated being unprepared to answer. The figure shows graphically that the median total correct answers increased over the first four occasions and reached the ceiling of 12 on the Interteaching occasion. A Friedman test (Conover, 1971, p. 264) was significant (Chi-Square = 42.259, df = 4, p = 0.000). The figure also shows that the greatest change occurred between the Pre-Tutor and Post-Tutor occasions, and both medians were 12 for the Interteaching and Quiz occasions. A Welch robust test (Maxwell & Delaney, 2004, p. 134), based on the differences, Di, in correct answers between successive pairs of occasions over the five occasions, was significant (W = 10.889, p = 0.000). Planned pairwise comparisons were significant[4] for D1 compared to D2 (W=10.145, p = 0.005), not significant for D2 compared to D3 (W = 1.513, p = 0.231), and significant for D3 compared to D4 (W = 12.295, p = 0.003).

Figure 1. Correct answers on rules test

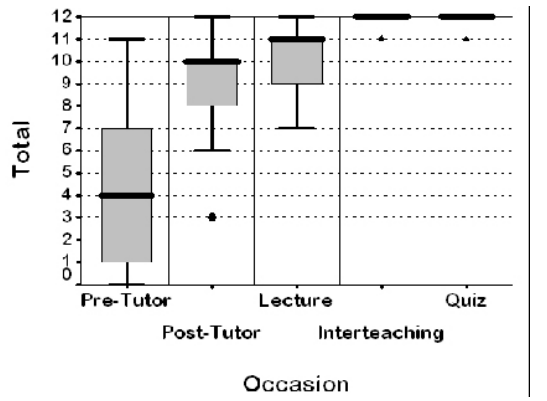


Figure 2 presents boxplots, over four successive occasions, of the ratings made by the students regarding confidence that the selected answer on the rules test was correct for answers that were Right and for answers that were Wrong. Ratings were not obtained during the graded quiz. The number below each boxplot reflects the number of students who answered Right and/or Wrong over the four assessment occasions, and that is the reason that the frequency for a boxplot is sometimes less than 13 (*e.g.*, number of students giving incorrect answers for the interteaching occasion). The Welch robust test, used because of unequal sample sizes, was significant for Right answers (W = 16.632, p = 0.000) and for Wrong answers (W = 40.864, p = 0.000). The latter test was based on the first three occasions because the variance for the Interteaching occasion was zero. For Right answers, planned pairwise comparisons were significant for Pre-Tutor and Post-Tutor (W = 27.398, p = 0.000), not significant for Post-Tutor and Lecture (W = 0.108, p = 0.745), and not significant for Lecture and Interteaching (W = 4.959, p = 0.044) occasions. For Wrong answers, planned pairwise comparisons were significant for Pre-Tutor and Post-Tutor (W = 55.646, p = 0.000) and not significant for Post-Tutor and Lecture (W = 1.220, p = 0.282) occasions. An overall comparison of confidence ratings between Right and Wrong answers was significant (W =

Figure 2. Confidence in accuracy of rules test answers

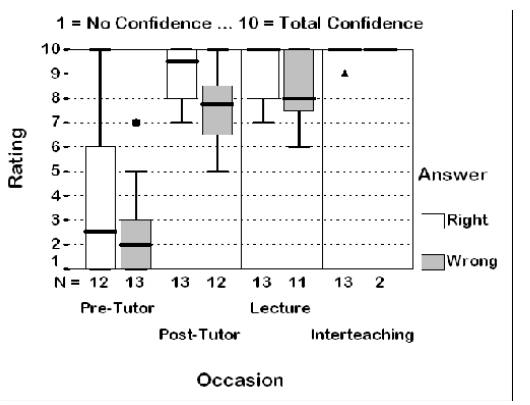


Figure 3. Interteaching evaluation

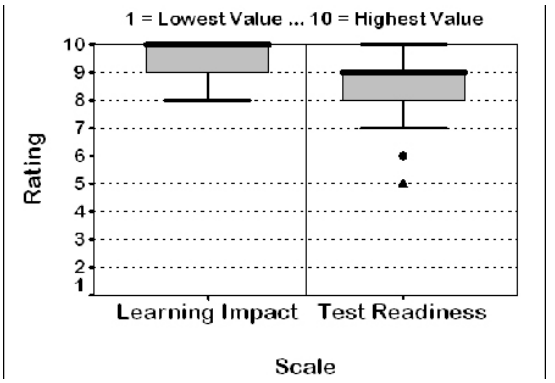
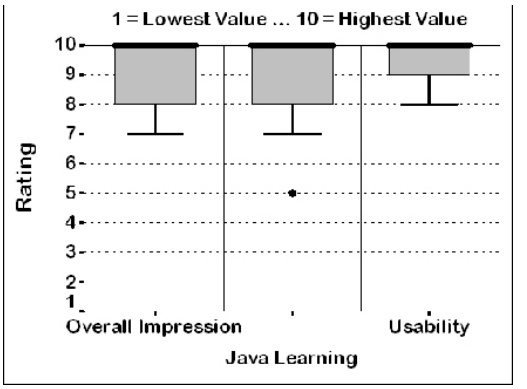


Figure 5. Evaluation of the tutor



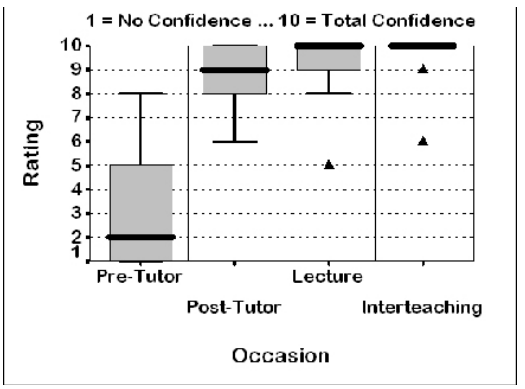
9.481, p = 0.003). Confidence generally increased over the assessment occasions, reaching the ceiling for correct answers after the lecture. However, confidence was seen to increase for both correct and incorrect answers, although an overall comparison favored the correct answer choices.

Figure 3 presents boxplots of ratings on the interteaching evaluation, which was administered at the conclusion of the interteaching session. The figure shows graphically the students' reported value in the interteaching session even when it occurred after using the Java tutor and after running the program on the web. The median rating of learning impact reached the scale's ceiling of ten, with eight being the lowest rating observed. The rating of test readiness was only slightly less, with a median of nine. A Friedman's test was significant (Chi-Square = 5.444, p = 0.020). Similar to our previous work, the ratings of test readiness were lower than corresponding ratings of learning impact. These show that the students reported value in the collaborative peer tutoring even when the session followed several other instructional experiences.

Figure 4 presents boxplots of software self-efficacy ratings across the first four assessment occasions. These ratings were not obtained during the graded quiz. Each boxplot is based upon the median rating over the 23 unique items of code in the program for the 13 students. Cronbach's alpha reliability of the ratings within each assessment exceeded 0.90, and all were significant ($p < .05$). A Friedman test was significant (Chi-Square = 32.614, df = 3, p = 000). A Welch test, based on the differences in correct answers between successive pairs of occasions, was significant (W = 30.222, p = 0.000). Planned pairwise comparisons of the differences, Di, were significant for D1 compared to D2 (W = 60.215, p = 0.000) and not significant for D2 compared to D3 (W = 1.330, p = 0.260). Software self-efficacy increased over the assessment occasions, and it reached the ceiling following the lecture.

Figure 5 presents boxplots of ratings of evaluation of the tutor taken during the Post-Tutor assessment. Medians for all three scales reached the scale ceiling of ten, with only a single outlier observed for Java Learning. These data show that students reported value in their use of the tutor.

Figure 4. Software self-efficacy



DISCUSSION

The results of this study show the value of applying several different instructional modalities in furtherance of having Information Systems students achieve a common level of skill and understanding in a simple Java applet, presented as a first technical exercise in a semester-long course. The data support the utility of this approach as reflected in students' rules test performance and software self-efficacy, which progressively improved over the successive assessment occasions. Rehearsal is an intuitively obvious and well-researched factor in knowledge and skill acquisition (*e.g.*, Salas & Cannon-Bowers, 2001), and the present study shows how structured rehearsal may be managed using the several modalities under consideration. Principles underlying such managed skill acquisition with different instructional modalities are presented elsewhere (Fox & Hackerman, 2003; Halpern & Hakel, 2003).

Having students discuss rules questions together enhanced understanding in the present context. Similar to our previous observations, however, students showed "overconfidence" in incorrect rules answers, and that issue requires exploration in the design of future work. Importantly, students reported value in the Java tutor and in the collaborative peer tutoring, and taken together with the lecture, these approaches to managing rehearsal in the classroom environment converge on what are increasingly recognized as vital ingredients to facilitate science education, in general (DeHaan, 2005).

This study constitutes a systematic replication (Sidman, 1960) of a set of teaching tactics that were revised with the expectation that student learning would be improved as a consequence. The methodology reflects design-based research, which is a type of formative evaluation (Collins, Joseph, & Bielaczyc, 2004) that is emerging as an alternative methodology in support of developing and assessing improvements in instructional design within the context of the classroom (Bell, Hoadley, & Linn, 2004; Design-Based Research Collective, 2003). In that regard, the order of presenting the several instructional tactics was determined by anecdotal observations of student performance over the several classroom evaluations that were previously undertaken in this stream of work. It was decided that a hands-on lecture would benefit from students' prior rehearsal with the Java code and that collaborative peer tutoring would benefit from the cumulative learning obtained from the programmed instruction and the lecture. Since the components in the current ordering are well received by students and since a desired learning outcome was achieved, we have the view that it is worthwhile now to direct our attention to developing advanced instructional material, rather than to "prove" the optimal ordering under conditions of a traditional "effect-size" experiment. Support for that view is implicit within designed-based research and has been discussed by educational scholars (*e.g.*, Mayer, 2004; Sackett & Mullen, 1993).

There are many approaches to teaching computer programming, ranging from an emphasis on mathematics and algorithms (Hu, 2006) to supportive programming environments such as BlueJ (Kolling, Quig, & Rosenberg, 2003), DrJava (Hsia, Simpson, Smith, & Cartwright, 2005), Problem-Based Learning (Tsang & Chan, 2004), PigWorld (Lister, 2004), and the Environment for Learning to Program

(Truong, Bancroft, & Roe, 2005).The instructional tactics adopted here in the classroom at the start of a semester's work are based initially upon *programmed instruction*, which is a form of structured and optionally automated instruction, as discussed by Emurian and Durham (2003) and Emurian, Wang, and Durham (2003) with respect to teaching computer programming. They also include *interteaching*, which is a form of collaborative peer tutoring (Boyce & Hineline, 2002). As implemented in the present context, these tactics originated from behavior analysis, and the Cambridge Center for Behavioral Studies[5] provides fundamental definitions and a wealth of information regarding the philosophical underpinnings and applications of this approach to science, in general, and to education, in particular. Finally, these tactics are to be understood as providing only an initial series of learning experiences to students in preparation for subsequent learning with other instructional and program development tools and techniques, to include the use of an integrated development environment (IDE) such as Eclipse.

Behavior analysis is one promising approach in identifying the ontogenetic instructional learn units (Greer & McDonough, 1999) whose mastery provides the textual tools essential for advanced understanding, thinking, and problem solving in the domain of computer programming and beyond (Skinner, 1957). Teachers facing the difficult challenge of providing effective instruction to the diversity of students who enroll in introductory computer programming courses need to be mindful of all approaches to helping their students succeed. The present study represents one set of instructional tactics that are demonstrably effective for Information Systems students.

REFERENCES

Anderson, J.R., Corbett, A.T., Koedinger, K.R., & Pelletier, R. (1995). Cognitive tutors: lessons learned. *Journal of the Learning Sciences*, *4*(2), 167-207.

Bell, P., Hoadley, C.M., & Linn, M.C. (2004). Design-based research in education. In M.C. Linn, E.A. Davis, & P. Bell (Eds.). *Internet Environments for Science Education* (pp. 73-88), Laurence Erlbaum Associates.

Boyce, T.E., & Hineline, P.N. (2002). Interteaching: a strategy for enhancing the user-friendliness of behavioral arrangements in the college classroom. *The Behavior Analyst*, *25*, 215-226.

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: theoretical and methodological issues. *Journal of the Learning Sciences*, *13*(1), 15-42.

Conover, W.J. (1971). *Practical Nonparametric Statistics.* New York, NY: John Wiley & Sons, Inc.

DeHaan, R.L. (2005). The impending revolution in undergraduate science education. *Journal of Science Education and Technology*, *14*(2), 253-269.

Design-Based Research Collective. (2003). *Educational Researcher*, *32*(1), 5-8.

Emurian, H.H. (2004). A programmed instruction tutoring system for Java: consideration of learning performance and software self-efficacy. *Computers in Human Behavior*, *20*(3), 423-459.

Emurian, H.H. (2005). Web-based programmed instruction: evidence of rule-governed learning. *Computers in Human Behavior*, *21*(6), 893-915.

Emurian, H.H. (2006a). A web-based tutor for Java™: evidence of meaningful learning. *Journal of Distance Education Technologies*, *4*(2), 10-30.

Emurian, H.H. (2006b). Assessing the effectiveness of programmed instruction and collaborative peer tutoring in teaching Java™. *International Journal of Information and Communication Technology Education*, *2*(2), 1-16.

Emurian, H.H., & Durham, A.G. (2003). Computer-based tutoring systems: a behavioral approach. In J.A. Jacko and A. Sears (Eds.), *Handbook of Human-Computer Interaction* (pp. 677-697). Mahwah, NJ: Lawrence Erlbaum & Associates.

Emurian, H.H., Wang, J., & Durham, A.G. (2003). Analysis of learner performance on a tutoring system for Java. In T. McGill (Ed.), *Current Issues in IT Education* (pp. 46-76). Hershey, PA: IRM Press.

Fox, M.A., & Hackerman, N. (2003). *Evaluating and improving undergraduate teaching in science, technology, engineering, and mathematics*. Washington, DC: The National Academies of Science Press.

Greer, R.D., & McDonough, S.H. (1999). Is the learn unit a fundamental measure of pedagogy? *The Behavior Analyst*, *22*, 5-16.

Halpern, D.F., & Hakel, M.F. (2003). Applying the science of learning to the university and beyond: teaching for long-term retention and transfer. *Change*, *35*(4), 37-41.

Hsia, J.I., Simpson, E., Smith, D., & Cartwright, R. (2005). Taming Java for the classroom. *SIGCSE'05,* February 23-27, St. Louis, MI, 327-331.

Hu, C. (2006). It's mathematical after all: the nature of learning computer programming. *Education and Information Technologies*, *11*(1), 83-92.

Kirschner, P.A., Sweller, J., & Clark, R.E. (2006). Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*, *41*(2), 75-86.

Kolling, M., Quig, B., Patterson, A., & Rosenberg, J. (2003). The BlueJ system and its pedagogy. *Journal of Computer Science Education*, *14*(Dec), 1-12.

Kurbanoglu, N.I., Taskesenligil, Y., & Sozbilir, M. (2006). Programmed instruction revisited: a study on teaching stereochemistry. *Chemistry Education Research and Practice*, *7*(1), 13-21.

Lister, R. (2004). Teaching Java first: experiments with a pigs-early pedagogy. *Proceedings of the Sixth Conference on Australian Computing Education* (pp. 177-183), Volume 30, Dunedin: Australian Computer Society, Inc.

Mayer, R.E. (2002). *The promise of educational psychology. Volume II. Teaching for meaningful learning*. Upper Saddle River, NJ: Pearson Education, Inc.

Mayer, R.E. (2004). Should there be a three-strikes rule against pure discovery learning? *American Psychologist*, *59*(1), 14-19.

Maxwell, S.E., & Delaney, H.D. (2004). *Designing Experiments and Analyzing Data: A Model Comparison Perspective. Second Edition*. Mahwah, NJ: Lawrence Erlbaum Associates.

Sackett, R.R., & Mullen, E.J. (1993). Beyond formal experimental design: towards an expanded view of the training evaluation process. *Personnel Psychology*, *46*, 613-627.

Salas, E., & Cannon-Bowers, J.A. (2001). The science of training: a decade of progress. *Annual Review of Psychology*, *52*, 471-499.

Sidman, M. (1960). *Tactics of Scientific Research*. New York: Basic Books.

Skinner, B.F. (1957). *Verbal Behavior*. New York: Appleton-Century-Crofts, Inc.

Truong, N., Bancroft, P., & Roe, P. (2005). Learning to program through the web. *Proceedings of the 10th annual SIGSCE conference on innovation and technology in computer science education*, ITiCSE'05, June 27–29, Monte de Caparica, Portugal. ACM Press.

Tsang, A.C.W., & Chan, N. (2004). An online problem-based model for the learning of Java. *Journal of Electronic Commerce in Organizations*, *2*(2), 55-64.

ENDNOTES

1. The Java tutor source code and all assessment instruments, to include the rules test and quiz, are freely available on the web: http://nasa1.ifsm.umbc.edu/irma/2007/
2. The Java tutor is freely accessible on web, and this report is based on version 2 of the tutor. The course material is also freely available: http://nasa1.ifsm.umbc.edu/IFSM413_613/
3. http://nasa1.ifsm.umbc.edu/learnJava/tutorLinks/TutorLinks.html
4. To control for the experimentwise error rate, the significant *p* value for each planned comparison must be less than 0.05/number-of-planned-comparisons.
5. http://www.behavior.org/index.cfm