Teaching Tip
Using Activity Diagrams to Model Systems Analysis Techniques: Teaching What We Preach

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ABSTRACT

Activity diagrams are used in Systems Analysis and Design classes as a visual tool to model the business processes of 'as- is' and 'to-be' systems. This paper presents the idea of using these same activity diagrams in the classroom to model the actual processes (practices and techniques) of Systems Analysis and Design. This tip accomplishes three things: (1) helps students better understand the purpose of drawing activity diagrams, (2) illustrates how useful activity diagrams are in understanding and communicating techniques and business processes at both high and low levels, and (3) teaches the various systems analysis and design practices and techniques in a creative manner that visual learners will appreciate.

Keywords: Teaching Tip, Systems analysis and design, Business modeling, Unified modeling language (UML)

1. INTRODUCTION

The IS 2010 Model Curriculum includes as a guiding assumption that undergraduate Information System (IS) students must possess skills in modeling business processes before they graduate (Topi, et al., 2010). Information Systems faculty agree and tend to teach this topic in the Systems Analysis and Design (SAD) course. Whether the faculty member teaches a structured approach using data flow diagrams or an object-oriented approach using Unified Modeling Language (UML), process modeling is an important part of the skills taught in an SAD course (Guidry, et al, 2011). In a course using the object-oriented approach to Systems Analysis Design, UML Activity Diagrams are used extensively.

When teaching UML, our textbook indicates that activity diagrams can be used to model any business process (Dennis, et al., 2012). Along with others, we believe that a picture is worth a thousand words (Whitten & Bentley, 2007). We stress that process models are an excellent communication tool especially because they are easy for the non-expert to understand (van der Aalst & van Hee, 2004). Of course, systems analysis and design itself consists of many high-level processes. Yet often times these actual practices and techniques used in the development of an information system are communicated only through words alone.

For example, in project initiation our textbook discusses how a project sponsor requests an information system, how that request is sent to the steering committee and how that request can be approved and sent on to the project team. In Dennis et al. (2012), this description takes six pages. In this teaching tip, we recommend that this written description be supplemented with an assignment where students draw an activity diagram of the project initiation activity. With this assignment, the student learns how to draw an activity diagram along with discovering how useful an activity diagram is in conveying the flow of a business processes and higher-level SAD practices and techniques. In a follow up lecture, the diagram then serves as a conceptual model to thoroughly understand the project initiation process. We continue this type of modeling throughout the semester as we

cover subsequent SAD activities that correspond to various phases of the Systems Development Life Cycle (SDLC).

Some textbooks have used examples of process flows or UML diagrams to illustrate Systems Development activities. For example, Whitten and Bentley (2007), used a data flow diagram to illustrate all the phases of the SDLC. Jacobson et al. (1995) used a process flow diagram to illustrate business process improvement and a portion of a use case diagram to illustrate software development as a use case. Bruegge and Dutoit (2010) used a class diagram to illustrate a project and an activity diagram to illustrate systems testing. What we propose is an extension of this idea to make it a formalized teaching model for a systems analysis and design class.

The remainder of this paper provides a description of our theoretical basis and setting (Section 2), activity diagrams and process modeling (Section 3), how we use activity diagrams to teach the practices and techniques of SAD (Section 4), faculty and student reactions (Section 5), and teaching suggestions (Section 6).

2. THEORETICAL BASIS AND SETTING

This paper describes a method of teaching the various systems analysis and design techniques using activity diagrams. The diagrams used can be drawn by students individually, in groups, and by the instructor. As will be shown in this paper, by the end of the course, an activity diagram becomes a natural method of illustrating processes and is something that students feel very comfortable using as a means of analyzing various process scenarios. This technique is grounded in two pedagogical concepts: visual versus verbal learning and learner-centered teaching.

2.1 Visual Learners

Students have different styles or preferences for learning. These learning styles vary across several dimensions including the dimension of verbal-visual learning (Felder, 1993). A visual learner prefers information presented through pictures; a verbal learner prefers information presented in words, either written or orally. Preferences on this dimension may vary from strong to weak, with some students able to learn effectively through either presentation. More than 40% of college students are strong visual learners, learning best though pictures, charts, graphs, or flowcharts (Clarke, et al., 2006). If something is mentioned to these students in a lecture, the content may simply not be heard or not retained (Felder, 1993). Felder suggests that the lack of focus on the visual learner may be one of the factors turning students away from the sciences. He further states that the best way to deliver material so that it can effectively be learned by all students is to deliver it both verbally and visually. Our teaching tip is grounded in this philosophy: the various activities within systems development can best be learned by all students if they are presented in both a verbal and visual form.

2.2 Learner-Centered Teaching

Learner-centered teaching is a philosophy which focuses on what the students learn rather than what content is delivered to the student (Weimer, 2002). Weimer suggests five changes to teaching practice to achieve this including moving the responsibility for learning from the instructor to the student (Weimer, 2002). In other words, she suggests that enhanced learning is achieved if students take more of an active role in building their own knowledge. If we assign reading about a systems development activity and lecture to students about that reading, we keep the focus on the instructor providing the content to students. Instead, if we ask students to read about a systems development activity and then make sense of it on their own by creating an activity diagram, we put the responsibility for learning on the student. The student is then able to discover how systems development works in a more self-fulfilling manner. This discovery then leads to the student "owning" the knowledge and being more motivated to use it.

2.3 The Setting

Our university is a public, medium-sized university in the mid-Atlantic region of the United States. Additionally, our Computer Information Systems department is within the School of Business. The Systems Analysis and Design Course is taught primarily to seniors who are either Computer Information Systems majors or minors. We currently teach an object-oriented systems analysis and design class that uses the Dennis, et al, (2012) textbook. In the class, we cover four UML diagramming techniques for the purpose of analysis. These techniques include: activity diagrams, class diagrams, sequence diagrams, and use case diagrams. In addition, we employ Use Case Descriptions to fully describe the functionality that we model in our Use Case Diagrams. In this course, many of the assignments, given both in and out of the classroom, are done by students working primarily in groups.

One main objective of this course is that students should be able to analyze a business problem and to identify and define the various technical and organizational requirements appropriate to its solution. The UML diagrams taught are tools for achieving this objective. However, we have noticed that some students have a tendency to place too much focus on the syntax of the UML diagram (the tool) rather than the value of the diagram in performing systems analysis and design (the activity). This teaching tip aims to present these tools as a natural means for the student to use in analysis. "Tools simply empower the individual, freeing him or her to concentrate on the truly creative aspects of analysis and design" (Booch, et al., 2007).

3. MODELING BUSINESS PROCESSES USING ACTIVITY DIAGRAMS

A business process is a set of activities that take inputs and create some type of output with the intention of adding value for an organization (Davenport, 1993; Hammer & Champy, 1993). A business process has a beginning, an end, and a series of ordered tasks that run in between taking the inputs to build the outputs (Davenport, 1993). In developing information systems, we must understand current business processes, expose their inefficiencies, and improve them by designing new processes. Much of this work uses process models as a means of communicating the content of an existing or future process. "Process modeling has been a

mainstay of software development for decades and will continue to be as long as we need to build business systems" (Ambler, 2004, page 262).

All business process modeling strategies must provide a way of modeling sequence, choice, parallelization, and iteration (van der Aalst & van Hee, 2004). Some popular business process modeling tools taught in SAD courses are activity diagrams, data flow diagrams and flow charts (Ambler, 2004). An object-oriented SAD course with UML will use activity diagrams to model select business processes in addition to use case diagrams and use case descriptions or narratives to describe business processes from the point of view of the user. While an activity diagram shows the sequential flow of activities or tasks in a business process, a use case diagram and its subsequent descriptions focus more on the interaction of a human with the information system.

An activity diagram illustrates processes with symbols to indicate start and end, activities or actions, decisions, splits and joins. In addition, an activity diagram can be drawn with swim lanes which indicate which person, department, or organization performs an activity. An example of an activity diagram which illustrates all of these symbols is shown in Figure 1. Activity diagrams can be used to model both high-level business processes or to document the detailed complex logic within a use case or system (Ambler, 2004). We focus on the former. For more details on how to use or draw an activity diagram, the reader is referred to an object-oriented SAD textbook or on line at Scott Ambler's agile modeling website (Agile Modeling, 2012).

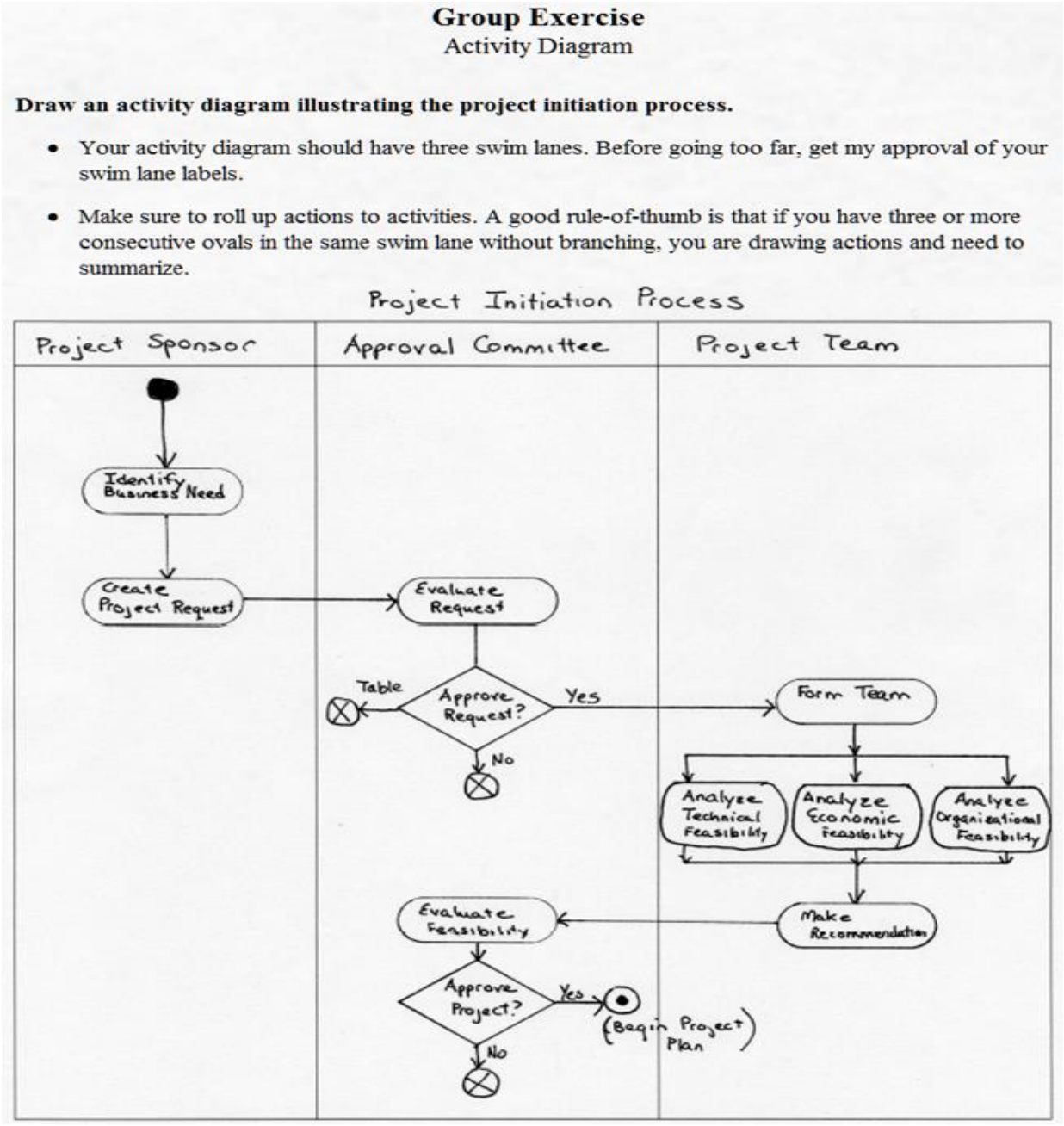

Figure 1: Project Initiation Activity Diagram: Assignment and Sample Answer

4. USING ACTIVITY DIAGRAMS TO TEACH SAD TECHNIQUES

The UML consists of fourteen different diagrams. Our textbook (Dennis et al., 2012) introduces many of these diagrams as part of the Analysis Phase chapters of the SDLC; with activity diagrams and use cases introduced in the same chapters. Our experience has been that this presentation led to students confusing the different diagrams and their purposes. In order to counteract this issue, we began teaching the activity diagrams very early in the semester. We first introduced them early in the SAD class, and later, introduced them as part of a junior-level Enterprise Architecture class taken before the SAD class. Thus in our SAD class, students have prior experience drawing activity diagrams by the time that we start the planning phase of the life cycle.

4.1 Documenting the Project Initiation Activity

Project initiation is the activity that starts a systems development project. It includes the steps where an end user requests a system, the request is evaluated for feasibility, and the organization decides whether or not to develop the system. To introduce the activity, the instructor begins by assigning the reading of the beginning of the project initiation chapter as homework to be done before the students come to class. In class, the instructor, using an interactive lecture strategy, reminds students that activity diagrams can be used to document both low-level business processes and the higher-level techniques of SAD such as project initiation.

The instructor hands out the activity diagram exercise as shown in Figure 1 to be done in class by groups of students. The typed portion of Figure 1 is the assignment as passed out and the handwritten portion would be typical work done by a group of students. After the groups have drawn the activity diagram, the instructor debriefs the entire class on the result.

Once the activity diagrams have been drawn to illustrate the systems initiation activity, the instructor begins discussion of the actual steps within project initiation. The discussion is then conducted in the context of the activity diagram. For example, the swim lanes can be used to prime a discussion of who is on the approval committee or the project team. The decision nodes can then be used to lead to a discussion of why a request is approved or not. In general, we have found that discussion of systems initiation tends to be more substantive when combined with an activity diagram exercise since students have already understood the steps within systems initiation by drawing it out.

The instructor then discusses the value of using an activity diagram as a communication device to help understand various SAD practices and techniques. Students have hopefully appreciated via lecture and group work how well this approach works which then leads to a better understanding of the purpose, meaning and power of activity diagrams. Later in the semester, as we discuss the activity of eliciting requirements, this discussion can then be revisited with an emphasis on gathering requirements and eliciting user reactions. The instructor may then suggest that activity diagrams can be used in interviews, in JAD sessions to ask questions of the end user, and to document the results of an interview or JAD session.

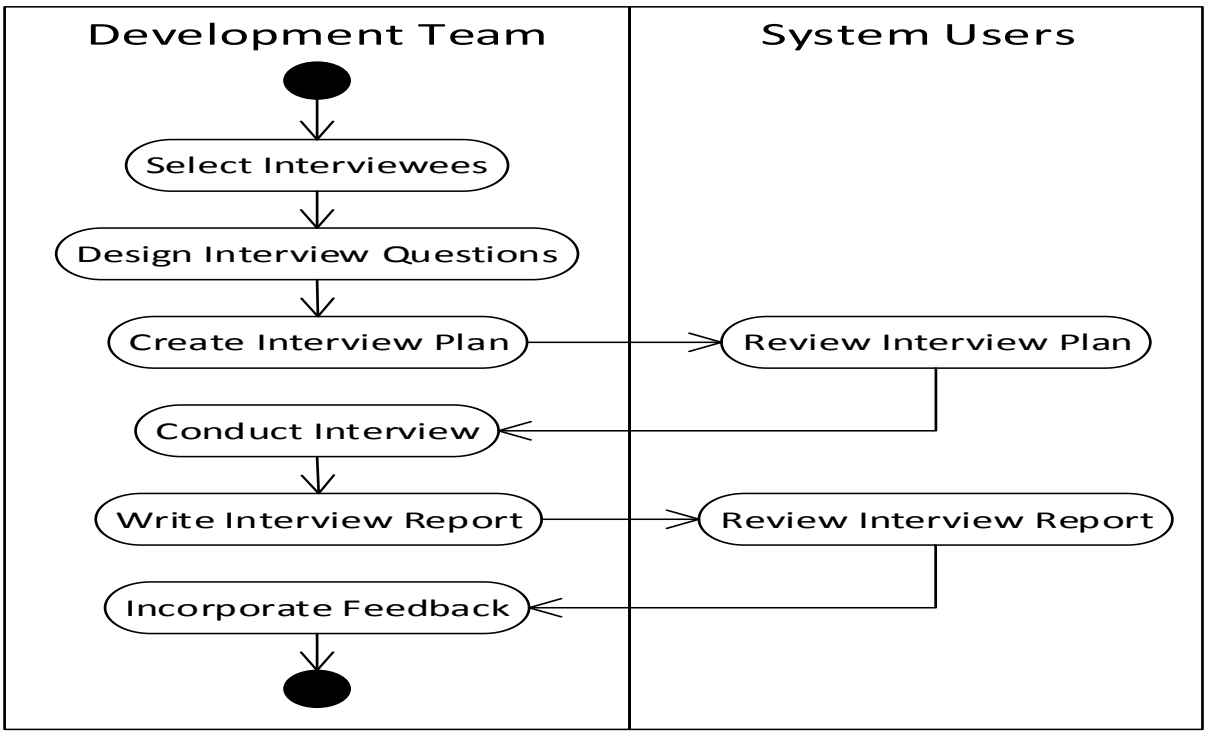

Figure 2: Requirement Determination Activity Diagram

4.2 Documenting other activities

As the semester progresses, the instructor continues to use activity diagrams to guide students through other SAD activities. Throughout the semester, the instructor will draw an activity diagram during the lecture to provide a visual guide that breaks down the topic more thoroughly. These diagrams can then be referenced in the same class or later classes to provide guidance on where a detailed activity fits into the bigger picture. Less often, the instructor will ask students to understand an activity by again drawing their own diagrams either individually or in groups.

In our class, along with documenting 'as-is' and 'to-be' business processes, we have used activity diagrams to document the entire SDLC methodology, the steps within a single phase, and for more detailed activities or techniques. Some areas where we have used activity diagrams successfully are:

- To illustrate the analysis phase showing how eliciting requirements, use cases, activity diagrams, class diagrams, sequence diagrams, and verifying diagrams can all be viewed as processes.
- To guide the process of detailed construction of use case diagrams and descriptions.
- To illustrate the interview process showing pre-interview activities, during interview activities, and post-interview activities. Figure 2 shows an example of a diagram that the instructor might draw. The instructor can lead a discussion of why both the analysts and the users need to prepare for the interview and why the user should review the interview report.
- To make sense of the testing showing who does each type of test (unit, system, and acceptance) and the order of testing. Figure 3 shows an example of this diagram and makes obvious that once you change a unit, the entire testing process is repeated.

We contend that this approach could be used for any activity within the life cycle. As the instructor uses activity diagrams, students become more acquainted with both the practices and techniques involved in SAD and with the power of activity diagrams.

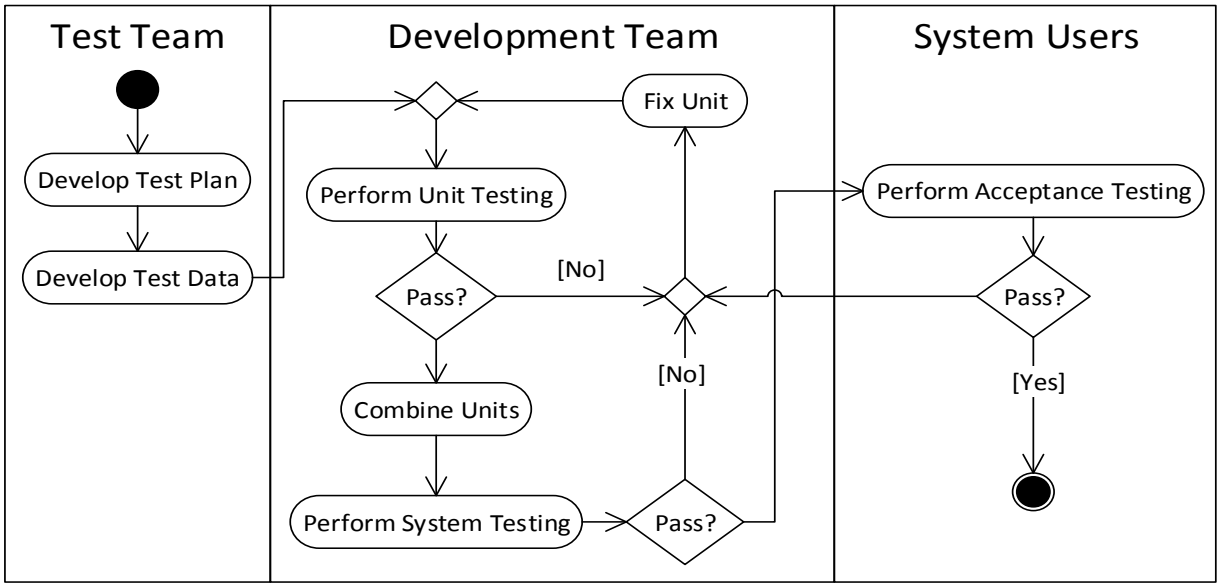

Figure 3: Conduct Systems Testing

5. FACULTY AND STUDENT REACTION

In general, the activity diagrams produced by students in our SAD class have improved dramatically since students have begun seeing them as a constructive tool rather than an assignment. Additionally, there is less confusion on understanding the purpose of activity diagrams versus use case diagrams. However, causality cannot be inferred since this noticeable improvement coincided with moving coverage of activity diagrams out of the analysis phase and introducing them earlier in the class.

One instructor who uses this technique to guide many lectures has appreciated the use of the diagrams as a roadmap for discussing the techniques of systems analysis and design in class. It is common for students to get lost in the details of an SAD class. In the midst of trying to understand a technique or model, the students forget why they are doing it. "I find that the activity diagrams serve as a consistent guide to keep activities rooted in the big picture of SAD. They also seem to help students understand the individual SAD techniques more thoroughly."

In Spring 2012, students were asked for their reaction to the Project Initiation Activity diagram assignment shown in Figure 1. Students responded via an anonymous web survey. Some of their answers to two questions about the assignment were as follows:

Q1. What did you like about this assignment?

- "I am a visual learner and the visualization of seeing how a systems request is processed helped me to really understand how it works"
- "Gave me an overall view of how project initiation works"
- It helped me better understand the project initiation process"
-

Q2. Will it help you with other parts of the class?

- "I can use the activity diagram to understand techniques that may confuse me"
- "Yes. better understanding of process presented in the text"
- "No. Learning through PowerPoint and discussion is more beneficial in my opinion"

As shown, the vast majority of the comments were positive though at least one student reported not liking this approach as well as other techniques used in the classroom.

One of our favorite student reactions to the technique was when an instructor caught a glimpse of the notes of a student who was studying for her exam in this class. Her notebook had activity diagrams that she had sketched to help her make sense of the various phases and techniques within the course. Surely that student has come to appreciate the value of an activity diagram to document a process.

6. TEACHING SUGGESTIONS AND DISCUSSION

Our first recommendation in using this teaching tip is to use activity diagrams throughout the semester. Whenever you teach a systems analysis technique, draw an activity diagram. This illustrates to the student how important the technique is for understanding higher-level processes and how well it communicates what happens in the process. When you answer questions about a technique, you can sketch an activity diagram as part of the answer. In discussion, you may want to move an activity from one place in the diagram to another or redraw part of the diagram. Again this demonstrates how activity diagrams could be used when discussing higher-level processes with users and how discovery of the fine detail takes place.

Secondly, we recommend transparency in teaching methods with the students. Explain why an analyst uses activity diagrams to model SAD techniques. Explain the use in the context of the course for understanding and communicating SAD practices and techniques. Additionally, explain their usage in the learning style context. Felder (1993) suggests talking to students about different leaning styles and asking whether they learn best from reading or seeing pictures. This transparency helps the student who prefers to learn from reading understand why we use multiple techniques in teaching.

Thirdly, we recommend a learner-centered philosophy that allows students to learn on their own what activity diagrams do well and what they do not do well. The deeper understanding developed using the approach presented in this paper makes that self-discovery possible. For example, activity diagrams are valuable for sequential processes with parallel activities and decisions. However, other types of processes are not modeled easily. Later in the semester after students are comfortable with activity diagrams, ask them to try modeling a non-linear activity such as prototyping where analysis, design, and programming are all done at the same time. Neither the sequential nor parallel structures in an activity diagram illustrates that prototyping involves a little analysis, a little design, a little programming, and goes back and forth between them. Let students discover that they will see processes in the real world that do not fit within the scope of activity diagrams.

For example, the instructor can also allow students to discover that while a swim lane in an activity diagram clearly indicates who does an activity, an activity diagram does not handle well a process where people in two swim lanes work together on the same task. Ask students how they would model having analysts and end users work together on finding requirements. The instructor may get suggestions such as putting the activity on the border between the swim lanes or putting the activity in both swim lanes. Eventually, someone will probably suggest making the analyst and the end user part of the same swim lane which they might title Project Team. The students have then discovered on their own a lesson about how requirements determination can be done and a type of process where activity diagrams are less useful at conveying the process.

As part of the learner-center philosophy, if the instructor uses multiple business process modeling techniques in an SAD class, this method could be used to let students discover on their own the purpose of each model. For example, the instructor could ask students to draw a process using both data flow diagrams and activity diagrams. Ask them to decide what each model does well and not so well. The students should then notice that data flow diagrams do not handle parallel process or decision nodes while activity diagrams are not as good at showing the flow of data or data storage.

Finally, we make no recommendation on grading this activity. The first Project Initiation Activity Diagram assignment can be graded or not graded as the instructor prefers. We have tried it both ways. Even when graded, our emphasis has always been on the usefulness of the diagram rather than the grade. We constantly bring home the point that these tools will be used in the real world and will ultimately lead to a more productive career.

7. CONCLUSIONS

We have found that using activity diagrams to teach the techniques of SAD works well on many levels. First, if one believes that activity diagrams offer an effective means of understanding, documenting, and discussing a business process; why not use them when teaching the many higher-level processes of systems analysis and design? Second, modeling with activity diagrams throughout the course ultimately makes this tool become a natural part of the students' vocabulary. Students understand activity diagrams better, learn where they should and should not be used, and what they can or cannot do. The activity diagram then becomes a valuable part of the student's analysis tool kit. By having students create their own activity diagrams to make sense of SAD techniques, the students discover the

appropriate technique details on their own, forcing ownership and retention of the various SAD practices and techniques. Finally, this method helps the visual learner make sense of complex techniques. The combination of reading about techniques in the book, hearing about them in lecture, and creating and examining activity diagrams to model these techniques, provides an enhanced learning environment for students anywhere on the visual to verbal continuum.

7. REFERENCES

Agile Modeling (2012). http://www.agilemodeling.com/artifacts/activityDiagram.htm, accessed May 11, 2012.

Ambler, S.W. (2004). The Object Primer: Agile Model-Driven Development with UML 2.0. (3 ed.). Cambridge University Press, Cambridge, UK.

Booch, G., Maksimchuk, R.A., Engle, M.W., Young, B.J., Conallen, J. and Houston, K.A. (2007). Object-Oriented Analysis and Design with Applications (3 ed.). Addison-Wesley, Upper Saddle River, NJ.

Bruegge, G. and Dutoit, A.H. (2010). Object-Oriented Software Engineering Using UML, Patterns, and Java™. (3 ed.). Prentice Hall, Boston, MA.

Clarke III, I., Flaherty, T.B., and Yankey, M. (2006). Teaching the Visual Learner: The Use of Visual Summaries in Marketing Education. Journal of Marketing Education, 28(3), 218-226.

Davenport, T. H. (1993). Process Innovation: Reengineering Work through Information Technology. Harvard Business School Press, Boston, MA.

Dennis, A., Wixom, B.H., and Tegarden. D. (2012). Systems Analysis and Design with UML Version 2.0: An Object Oriented Approach, (4 ed.). John C. Wiley & Sons, Hoboken, NJ.

Felder, R. (1993). Reaching the Second Tier: Learning and Teaching Styles in College Science Education. Journal of College Science Teaching, 23(5), 286-290.

Guidry, B. N., Stevens, D.P., and Totaro, M.W. (2011). The Systems Analysis and Design Course: An Educators Assessment of the Importance and Coverage of Topics. Journal of Information Systems Education, 22(4), 331-345.

Hammer, M., and Champy, J. (1993). Reengineering the Corporation: A Manifesto for Business Revolution. Harper Collins, New York, NY.

Jacobson, I., Ericsson, M., and Jacobson, A. (1995). The Object Advantage: Business Process Reengineering with Object Technology. Addison-Wesley, Woking-ham, England.

Topi, H., Valacich, J. S., Wright, R. T., Kaiser, K. M., Nunamaker, Jr., J.F., Sipior, J. C., and de Vreede, G. J. (2010). IS 2010 Curriculum Guidelines for Undergraduate Programs in Information Systems. Association for Computing Machinery and Association for Information Systems.

van der Aalst, W. and van Hee, K (2004). Workflow Management: Models, Methods, and Systems. MIT Press, Cambridge, Massachusetts.

Weimer, M. (2002). Learner-Centered Teaching: Five key changes to practice. Jossey-Bass, San Francisco, CA.

Whitten, J.L. and Bentley L.D. (2009). Systems Analysis and Design Methods. (7 ed.). McGraw-Hill Irwin, Boston, MA.

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