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VALIDATION OF BUSINESS PROCESS MODELS USING SWIMLANE DIAGRAMS

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ABSTRACT

Swimlane diagrams are regarded to be an important tool when validating business rules and procedures with stakeholders because they are believed to convey information about business process models effectively and efficiently. However, the literature lacks empirical support for such an assumption; the literature is void of studies evaluating the efficacy of swimlane diagrams. We conducted two studies that required students to examine swimlane and non-swimlane diagrams of the same business process. Based on 142 and 131 responses, respectively, for the two studies, we found that the non-swimlane diagrams are more effective overall in conveying information to stakeholders, but that swimlane diagrams are more efficient in conveying information to stakeholders, especially when they include important visual clues and handshake activities.

Keywords: Swimlane Diagrams, Modeling Tool, Enterprise-wide Systems, Cross-functional, Business Processes, Process Map, Stakeholder

INTRODUCTION

Great effort has been dedicated to the development of methodologies for software development. There are over a thousand methodologies, each specifying processes to complete, and deliverables to produce so that software project teams may create the best possible information systems (IS). There are methodologies appropriate for every possible scenario in which software could be developed, and processes for improving the use of those methodologies, such as CMMI and ISO [3], [8], [12], [21]. However, system failure rates continue to be above 50%, and perhaps as high as 65% [6], [11], [20]. Further, practitioners complain about the time they must spend creating the prescribed documentation. This raises the question of whether the deliverables are helpful and necessary to guarantee the effectiveness and efficiency of the development process.

For example, consider the class of deliverables of diagramming tools. Most methodologies prescribe one or more diagramming tools to facilitate communication with clients, because such communication is both critical and difficult. Such tools serve as the primary mechanism by which systems analysts discover business rules, procedures and processes governing organizational operations. Meticulous communication is the key to accurate definition of requirements, which, in turn, is the critical component to good systems design and implementation [11]). Ambiguity in language and differences in assumptions can result in misunderstood information from the customer and/or conflicting information from different stakeholders[1]. Because of the importance of communication of requirements, most methodologies prescribe learning, verifying, *and validating* business rules and procedures prior to the design and development of IS to ensure systems analysts have interpreted correctly. The diagramming techniques generally help with the *validation* process, where systems analysts test the internal consistency of the business rules, and whether the resulting system is what the user actually needs [19], [5]. This is different from the process of *verification*, which examines whether the product is built correctly. Instead, validation refers to those activities that ensure "the right product is built by determining whether it... fulfills specific user-defined intended purposes" [13]. The *validation* process requires evaluation each time requirements are translated from one domain to another, such as represented by the diagram in Figure 1 [13].

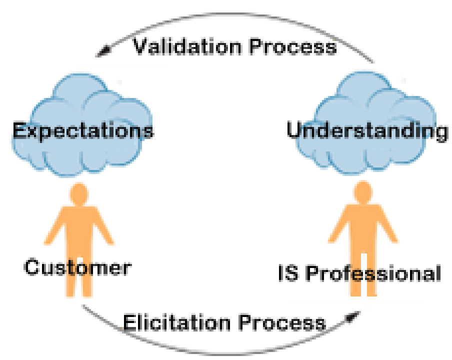

Figure 1: The Validation Process that ensures the analyst's understanding of the requirements meets the expectation of the Customer. This diagram is adapted from [13].

This validation process is facilitated by many tools, such as data flow diagrams, activity diagrams, and event-driven process chains [9], [16], [22], [23]. A more recent tool, found among methodologies addressing enterprise-wide processes, is the cross-functional process map, also known as a swimlane diagram [15]. Swimlane diagrams differ from other diagrams in that they denote user roles for the modeled workflow, assign tasks to specific user groups, describe the order of tasks, and include conditions to decide which task comes next if multiple tasks are available. There is a general perception that a customer's organizational operations and business processes can be profiled effectively using these diagrams, and thus can facilitate the validation process [18]. However, the perception has been proposed without systematic research that offers evidence that swimlane diagrams may be used to profile operations effectively, *and* that they do it efficiently. This paper describes research that empirically examined the extent to which swimlane diagrams may be effective and efficient for validation of business process models with customers.

SWIMLANE DIAGRAMS

Originally proposed by [17], the swimlane diagram has become the primary modeling tool for planning business process reengineering and enterprise-wide software development [10], [7]. Viewing the business process as a collection of sequenced internal activities that may be performed by an organization to achieve an output of value, the swimlane diagram enables the visual depiction of the activities resulting in *business process models* such that business processes can be defined and analyzed [1], [15]. The swimlane diagram notations have been included in major business process modeling languages such as the Business Process Modeling and Notation (BPMN) [4] and the Unified Modeling Language (UML) [16].

The defining characteristic of the swimlane diagram is that each actor (sometimes defined at the departmental level) involved in a business process is shown in a separate swimlane and all activities belonging to the actors are positioned within the respective swimlanes [4]. The swimlanes may be oriented vertically or horizontally as necessary (cf. BPMN and UML documentation). The actors placed within each swimlane may depend on the specific business process and the level at which it needs to be defined. For instance, an order fulfillment process may be described at the level of the departments within the organization and hence the actors on the diagram may refer to the departments such as Sales, Warehouse, and Production. On the other hand, a production process may need to be described at the level of the stations on the production floor and hence the actors on the diagram may refer to the stations such as Cutting, Machining, and Painting. The sequencing of activities is conveyed using the arrows, which typically connect the activities, such that

[1] *Customer* refers to the organization that requires information technology (IT) products or services. *Stakeholder* refers to any position or role within the customer's organizational hierarchy that may be served by the new IT product or service and that may provide pertinent information during the requirements gathering process.

the entire business process may be traced from a starting activity to an ending activity [4]. The diagram may optionally depict time delays between activities.

Swimlane diagrams also serve as the validation tools by which the accuracy and completeness of the business processes may be determined. Since business processes are generally cross-functional [14], swimlane diagrams typically contain actors from several departments and systems analysts may need to verify the same diagrams with multiple stakeholders. Since IS projects are typically executed subject to many constraints such as scope, time, and budget [2], the question regarding the effectiveness and efficiency of the swimlane diagrams in completely and quickly conveying information to the stakeholders assumes considerable importance. Although swimlane diagrams are believed to convey information effectively and efficiently to the stakeholders [18], empirical support for that premise is not available in the literature. This study empirically examines the effectiveness and efficiency of swimlane diagrams in the validation process.

RESEARCH METHODS

To examine the effectiveness and efficiency of swimlane diagrams in facilitating the validation of business process models, we developed a business process description and diagram based on the operations of a manufacturing organization in the Midwestern region of the United States. The resultant business process model was the basis for two separate studies we conducted during the course of this research. For the first study (Study #1), we set up two diagrams for the same business process model—a swimlane diagram (Figure 2) and a non-swimlane diagram. The only difference between the two diagrams was that the non-swimlane diagram did not identify the swimlanes for actors or the actor names labeled on swimlanes; hence, the activity boxes in the non-swimlane diagram also include actor names (e.g., the swimlane diagram may show an activity “Receives order from customer” on the swimlane for the “Sales” actor whereas the non-swimlane diagram may show the same activity as “Sales receives order from customer”). The physical arrangement of all other elements (i.e., activity boxes, decision points, and arrows) on the diagram was similar between the two diagrams. For the second study (Study #2), we employed two diagrams as well—a swimlane diagram (which was the same as the first study) and a non-swimlane diagram. The non-swimlane diagram (Figure 3) exhibited two differences compared to the swimlane diagram in this study—the swimlanes for actors were not included, and the physical arrangement of the other elements on the diagram was changed as well.

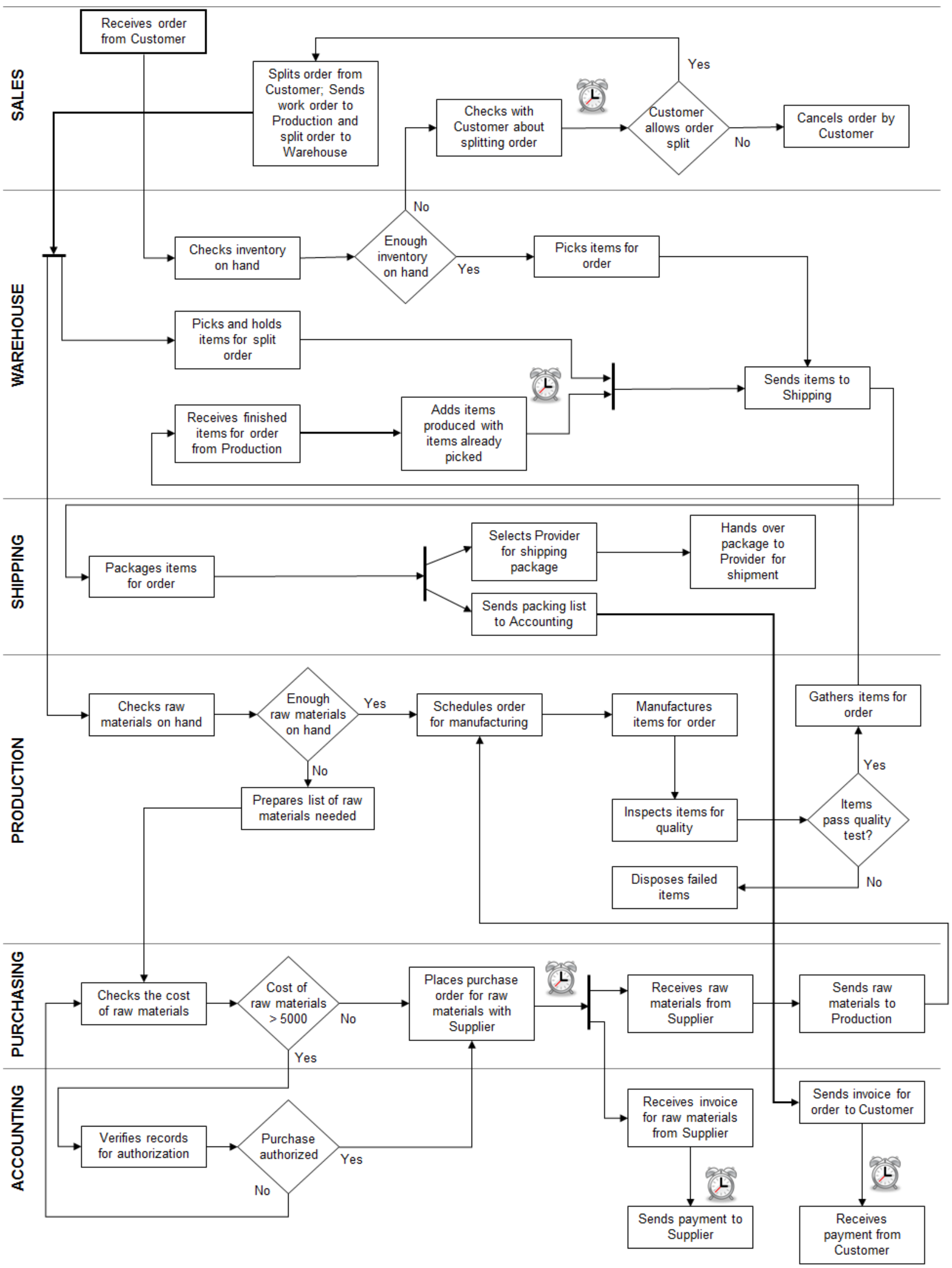

Figure 2: Swimlane Diagram

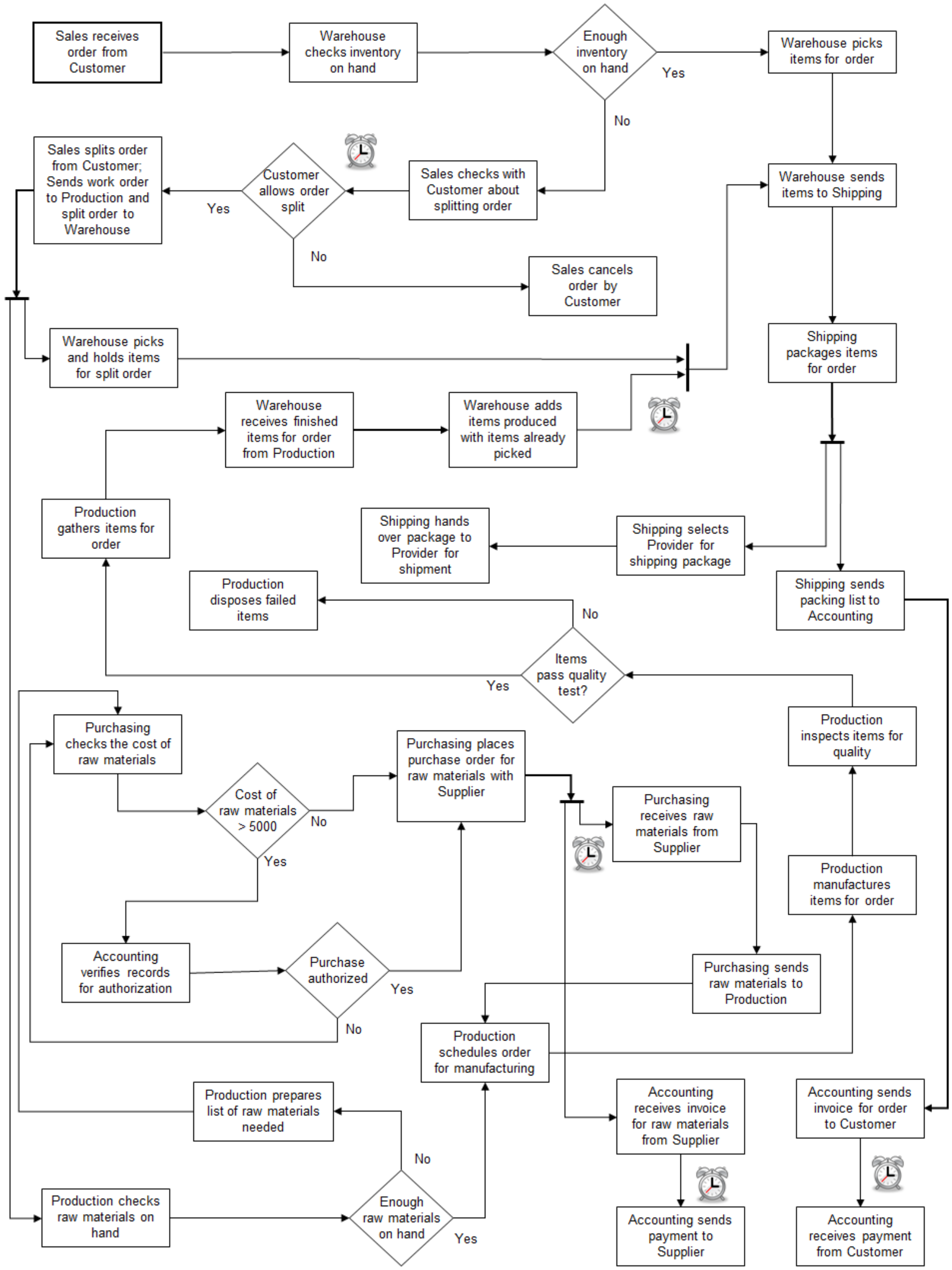

Figure 3: Non-Swimlane Diagram

Both studies were administered to business students enrolled in multiple sections of an introductory information systems course at a large university in Midwestern United States. The students, being business majors, were believed to have working knowledge of terms related to business operations such as names of departments (e.g., Accounting), activities (e.g., receive order from customer), and decisions (e.g., is there enough inventory on hand?) either due to the business fundamentals courses they have taken or their work experience. Since the introductory course in which we administered the study was typically the first course on information systems for all business majors, it was believed that they may not have been exposed to principles of information system analysis and design. Due to these reasons, the business students in our study are likely to resemble the 'customer' or 'client' stakeholders seen in information systems projects, and an appropriate sample for our study.

Within each section of the course, students were randomly placed in two groups: the first to swimlane diagrams and the other to non-swimlane diagrams. Students were informed that participation in the research was voluntary, and were requested to return the surveys within a week if they were interested in participation. The survey package distributed to students contained three sections: questions on demographics (e.g., age and gender), the appropriate diagram (i.e., swimlane or non-swimlane), and questions about what the respondents gathered from the business process diagram and the time taken to complete the questions on the survey. The last section included questions such as: "Identify the stakeholders (people or departments) involved with the system or who are affected by the system," "Identify all activities performed by the production department," "About how long did it take for you to determine the list of stakeholders?" and "About how long did it take for you to identify the activities performed by the production department?"

Those who propose swimlane diagrams suggest they provide improvements in the *effectiveness*, or accuracy, and the *efficiency*, or speed, of identifying the role of business units or stakeholders. Given those two claims about the business process diagram, we constructed four measures that may describe the effectiveness of those diagrams. For the question involving "stakeholders" or actors, we developed two measures: internal actors (i.e., stakeholders within the organization who enable the business process) and external actors (i.e., stakeholders outside the organization who affect the business process). The business process depicted on the two diagrams involved six internal actors and three external actors. We constructed the two effectiveness measures as "*internal actors success rate"* (i.e., number of internal actors identified by the respondent divided by 6) and "*external actors success rate"* (i.e., number of external actors identified by the respondent divided by 3). Thus, the values for both these variables can range from 0 through 1, in which higher values indicate greater effectiveness. For the question involving "activities," we developed two measures as well: internal activities (i.e., activities initiated by the production department) and external activities (i.e., activities initiated by other departments but that affect the production department). The business process diagram contains seven activities initiated by the production department and four activities initiated by other departments but also involve the production department. We constructed the two effectiveness measures as *internal activities success rate* (i.e., number of internal activities identified by the respondent divided by 7) and *external activities success rate* (i.e., number of external activities identified by the respondent divided by 4). Thus, the values for both these variables can range from 0 through 1, in which higher values indicate greater effectiveness. We employed two measures of efficiency based on the time taken by respondents to identify the actors and the activities respectively. Both these measures were expressed as number of minutes as reported by the respondents.

RESULTS

We received completed instruments from 142 respondents in Study #1, and 131 respondents in Study #2. Table 1 shows the profiles of the respondents for both studies.

Study #1

An analysis of the effectiveness measures for the two diagrams through t-tests showed that the swimlane and non-swimlane diagrams were not significantly different from each other in several respects (Table 2). The one exception was with regard to the success rate in identifying external actors. Somewhat surprisingly, the non-swimlane diagrams proved to be more effective in letting respondents identify external actors in the business process. Table 2 also shows that the mean value for external activities success rate is really low for both diagrams whereas the means of the other three effectiveness measures are considerably higher. It is possible that identifying external activities is a problem regardless of the type of diagram used for validation.

Table 1: Profile of Respondents

Variable		Study #1			Study #2		
		Swimlane Diagram	Non-Swimlane Diagram	Total	Swimlane Diagram	Non-Swimlane Diagram	Total
Gender	Male	50 (53.8%)	43 (46.2%)	93 (65.5%)	35 (46.7%)	40 (53.3%)	75 (57.3%)
	Female	26 (55.3%)	21 (44.7%)	47 (33.1%)	24 (44.4%)	30 (55.6%)	54 (41.2%)
	Missing	1	1	2 (1.4%)	1	1	2 (1.5%)
Age	At most 21 years	27 (54.0%)	23 (46.0%)	50 (35.2%)	24 (40.7%)	35 (59.3%)	59 (45.0%)
	Between 21 and 25 years	27 (52.0%)	25 (48.1%)	52 (36.6%)	16 (50.0%)	16 (50.0%)	32 (24.4%)
	At least 25 years	22 (61.1%)	14 (38.9%)	36 (25.4%)	18 (48.7%)	19 (51.4%)	37 (28.3%)
	Missing	1	3	4 (2.8%)	2	1	3 (2.3%)
Major	Information Systems	6 (37.5%)	10 (62.5%)	16 (11.3%)	8 (36.4%)	14 (63.6%)	22 (16.8%)
	Non-Information Systems	70 (56.5%)	54 (43.5%)	124 (87.3%)	51 (47.7%)	56 (52.3%)	107 (81.7%)
	Missing	1	1	2 (1.4%)	1	1	2 (1.5%)
Total		77 (54.2%)	65 (45.8%)	142	60 (45.8%)	71 (54.2%)	131

Table 2: Comparison of Effectiveness and Efficiency (Study #1)

Variable	Mean (SD) for swimlane diagram	Mean (SD) for Non-swimlane diagram	T-Test
Internal actors success rate	0.84 (0.31)	0.81 (0.24)	0.58
External actors success rate	0.32 (0.30)	0.52 (0.34)	-3.70***
Internal activities success rate	0.87 (0.21)	0.88 (0.22)	-0.24
External activities success rate	0.07 (0.19)	0.06 (0.15)	0.19
Minutes spent identifying actors	4.16 (5.53)	4.44 (3.57)	-0.36
Minutes spent identifying activities	3.02 (2.97)	3.91 (2.63)	-1.85

N = 77 for Swimlane diagrams, N = 65 for Non-swimlane diagrams
*** p<0.01, ** p<0.05, * p<0.10, SD = standard deviation

We also examined the correlations (Panel A in the Appendix) between the effectiveness and efficiency measures and demographic variables. The results showed that there was no association between gender, age, and major of study and any of the effectiveness measures. The correlations also revealed that there may be an association between major of study and one efficiency measure (i.e., minutes spent identifying actors); all other associations between gender, age, and major of study with the efficiency measures were non-significant.

Study #2

The t-tests of differences between the effectiveness measures showed that the two diagrams were significantly different in some respects (Table 3). Unsurprisingly, following the results of and somewhat consistent with the first study, the non-swimlane diagrams proved to be more effective in conveying information about external actors and external activities. Further, the two diagrams were significantly different in the time taken by respondents to identify the activities as shown in the diagrams.

Also unsurprisingly, the swimlane diagrams were more efficient than the non-swimlane diagrams. On average, respondents spent almost double the time they spent on swimlane diagrams for identifying activities related to the production department. Table 3 also shows that the mean for external activities success rate continues to really low (although it shows an increase for the non-swimlane diagrams relative to the first study) for both diagrams whereas the means of the other three effectiveness measures are considerably higher (although somewhat lower than similar measures in the first study). This result may reinforce the problems in identifying external activities.

The correlations (Panel B in the Appendix) showed that male respondents and older respondents exhibited greater success identifying internal actors. All other associations between gender, age, and major of study were not associated with the effectiveness or efficiency measures.

Table 3: Comparison of Effectiveness and Efficiency (Study #2)

Variable	Mean (SD) for swimlane diagram	Mean (SD) for Non-swimlane diagram	T-Test
Internal actors success rate	0.73 (0.35)	0.74 (0.29)	-0.24
External actors success rate	0.39 (0.35)	0.52 (0.26)	-2.34**
Internal activities success rate	0.78 (0.29)	0.75 (0.29)	0.63
External activities success rate	0.05 (0.12)	0.16 (0.24)	-3.48***
Minutes spent identifying actors	3.90 (3.79)	4.78 (5.24)	-1.07
Minutes spent identifying activities	2.92 (2.50)	5.57 (5.65)	-3.47***

N = 59 for Swimlane diagrams, N = 70 for Non-swimlane diagrams

*** p<0.01, ** p<0.05, * p<0.10, SD = standard deviation

DISCUSSION

We initiated this research in order to examine the effectiveness and efficiency of swimlane diagrams in the validation process. We conducted two studies in which students examined either the swimlane or non-swimlane diagrams and reported on the extent to which those diagrams were effective and efficient in helping them understand the same business process. Contrary to assumptions, we found that the swimlane diagrams may not provide significant advantages over the non-swimlane diagrams.

Our first study showed that respondents did not find the swimlane diagrams to be any better than the non-swimlane diagrams on three out of the four measures of effectiveness. For the success rate of identifying external actors, the non-swimlane diagrams were significantly more effective than the swimlane diagrams. In addition, respondents did not find the swimlane diagrams to be any more efficient than the non-swimlane diagrams. There were no significant differences between the swimlane and non-swimlane diagrams in the times taken by respondents to identify the actors and activities. These results are somewhat surprising since the first study was one which the differences between the two diagrams were minimal in that the non-swimlane diagram only excluded the swimlane separators but was otherwise consistent with the swimlane diagram in the relative physical positions of the other items such as activities, decisions, and arrows.

Our second study revealed that respondents did not find the swimlane diagrams to be any better than the non-swimlane diagrams on two of the four measures of effectiveness. However, the respondents found the non-swimlane diagrams to be significantly better than the swimlane diagrams for identifying the external actors and the external activities for an actor. This result is particularly intriguing since the second study used a non-swimlane diagram that excluded the swimlane separators and also rearranged the physical positions of the other items including activities, decisions, and arrows—and hence considerably different than the swimlane diagram. But respondents did find the swimlane diagrams to be more efficient for identifying activities of an actor, while there were no significant differences in efficiency between the two diagrams for identifying actors.

In summary, there is not much that seems to separate the swimlane and non-swimlane diagrams when it comes to identifying internal actors and internal activities. Whereas the swimlane diagram identifies the actors on its swimlanes and places the actor-relevant activities on unique swimlanes, the non-swimlane diagram is likely to show the names of actors as the first words in the activity boxes—any of which seems to be sufficient for identifying actors and the activities. On the other hand, the non-swimlane diagram seems to outperform the swimlane diagram in the context of identifying external actors and activities (although the overall proportion of external activities identified by respondents through either diagram is low). The swimlane diagram may not have dedicated lanes for external actors in general and may be on an equal footing with the non-swimlane diagram—that is, the names of external actors are embedded in activity boxes. In addition, the external activities for an actor may be depicted on other swimlanes (and not the actors' own swimlanes) and hence may escape the attention of stakeholders. The non-swimlane diagrams do not have the problem of dedicated swimlanes and the respondents may be required to peruse the entire diagram and hence are more likely to identify the relevant external activities. However, the swimlane diagram may be more efficient in enabling stakeholders understand the activities of the business process and their roles (although both diagrams seem on equal ground with regard to identifying actors).

Of course, these studies used students as subjects. While their role as business (and not IS majors) made them a good surrogate for customers in a business setting, they are not perfect in that role. It is possible that actual managers from non-IS departments would perform differently in completing these tasks. Further, managers in business may have pursued a variety of collegiate majors beyond business; those majors are not represented in this study. Finally, all students in this study were from the same university which could bias the results.

CONCLUSION

This study examined the effectiveness and efficiency of swimlane diagrams in enabling stakeholders to correctly and quickly verify the business process by comparing the performance of swimlane diagrams against non-swimlane diagrams. The results show that the non-swimlane diagrams may outperform the swimlane diagrams in effectiveness although the swimlane diagrams may have an edge over the non-swimlane diagrams in efficiency. The paper provides a discussion on the implications of using swimlane diagrams.

For practice, the non-swimlane diagrams may be a more appealing choice for the validation process if effectiveness is the overriding concern (i.e., completeness and accuracy are the major goals of validation) and when the IS project can afford extra time (i.e., efficiency is not as important as effectiveness). However, if efficiency is more important for the IS project and the swimlane diagrams are to be used for the validation process, the following recommendations may be taken into consideration. First, the swimlane diagram may benefit from the inclusion of some visual clues for the external actors. These may be simple tweaks such as showing external actors in boldface or underlined font styles that have the potential to catch the attention of those stakeholders verifying the diagrams. Second, the swimlane diagram may be designed to include "handshake" activities such that the stakeholders can still correctly identify the activities even when they examine only their own dedicated swimlanes. For example, if an external activity is labeled as "Purchasing sends raw materials to Production" and is placed in the swimlane for the Purchasing department, it may be useful to include a handshake activity labeled as "Production receives raw materials from Purchasing" that is placed in the swimlane for the Production department. Finally, the stakeholders may need to be expressly trained on the use of swimlane diagrams such that they can understand the notations better and more effectively and efficiently evaluate the content of the swimlane diagrams.

For research, this suggests there is room for empirical evaluation of the various tools suggested in methodologies to determine their efficacy in reducing system failure rates. Certainly processes and deliverables that decrease effectiveness in providing good solutions should be eliminated. However, even processes and deliverables that do not contribute as much to the solution as intended should be improved to improve solution success.

REFERENCES

[1] Aldin, L. and de Cesare, S., "A Literature Review on Business Process Modelling: New Frontiers of Reusability," *Enterprise Information Systems*, Volume 5, Number 3, 2011, pp. 359-383.

[2] Atkinson, R., "Project Management: Cost, Time and Quality, Two Best Guesses and a Phenomenon, It's Time to Accept Other Success Criteria," Internal Journal of Project Management. Volume 17, Number 6, 1999, pp. 337-342.

[3] Avison, D.E. and Taylor, V., "Information Systems Development Methodologies: A Classification according to the Problem Situation," *Journal of Information Technology*, Volume 12, 1997, pp. 73-81.

[4] Bera, P., "Does Cognitive Overload matter in understanding BPMN Models?" *Journal of Computer Information Systems*. Volume 52, Number 4, 2012, pp. 59-69.

[5] Bourque, P. and Dupuis, R. (eds) SWE-BOK: Guide to the Software Engineering Body of Knowledge, IEEE CS Press, http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=827017, 2004.

[6] Dalcher, D., and Drevin, L., "Learning from Information Systems Failures by Using Narrative and Ante-narrative Methods," in Annual Research Conference of the South African Institute of Computer Scientists and Information Technologists on Enablement Through Technology, South African Institute for Computer Scientists and Information Technologists, 2003.

[7] Davenport, T.H., *Process Innovation: Reengineering Work through Information Technology*, Harvard Business School Press, Boston, MA, 1993.

[8] Fitzgerald, B., "An Empirical Investigation into the Adoption of Systems Development Methodologies," *Information & Management*, Volume 34, Number 6, 1998, pp. 317-328.

[9] Gane, C. and Sarson, T., *Structured Systems Analysis: Tools and Techniques*, Prentice-Hall, Englewood Cliffs, NJ, 1979.

[10] Hammer, M. and Champy, J., *Reengineering the Corporation: A Manifesto for Business Revolution*, Harper Collins, New York, NY, 1993.

[11] Johnson, J., *My Life is a Failure*, Standish Group International Incorporated, 2006.

[12] Jayaratna, N., *Understanding and Evaluating Methodologies, NISAD: A Systematic Framework*. McGraw-Hill, Maidenhead, UK, 1994.

[13] Michael, J.B., Drusinsky, D., Otani, T.W. and Shing, M.T., "Verification and Validation for Trustworthy Software Systems," *IEEE Software*, Volume 28, Number 6, 2011, pp. 86-92.

[14] Ould, M.A., *Business Processes: Modelling and Analysis for Re-engineering and Improvement*, John Wiley and Sons, West Sussex, England, 1995.

[15] Ramias, A.J. and Rummler, R., "The Evolution of the Effective Process Framework: A Model for Redesigning Business Processes," *Performance Improvement*, Volume 48, Number 10, 2009, pp. 25-32.

[16] Rumbaugh, J., Jacobson, I., and Booch, G., *The Unified Modeling Language Reference Manual*, Addison-Wesley Professional, Boston, MA, 1999.

[17] Rummler, G. and Brache, A.P., *Improving Performance: How to Manage the White Space on the Organization Chart*, Jossey-Bass, San Francisco, CA, 1999.

[18] Rummler, G. and Priest, K.M., "Know you Client's Business," *Performance Improvement*, Volume 48, Number 10, 2009, pp. 9-17.

[19] Sakthivel, S., "A Survey of Requirements Verification Techniques," *Journal of Information Technology*, Volume 6, 1991, pp. 68-79.

[20] Schwaber, K. and Southerland, J., "The Crisis in Software: The Wrong Process Produces the Wrong Results," in Schwaber, K. and J. Southerland (eds.) *Software in 30 Days*, John Wiley and Sons, New York, NY, 2012.

[21] Sutcliffe, A.G., "Object-Oriented Systems Development: Survey of Structured Methods," *Information and Software Technology*, Volume 33, Number 6, 1991, pp. 433-442.

[22] Van der Aalst, W.M.P., "Formalization and Verification of Event-Driven Process Chains," *Information and Software Technology*, Volume 41, 1999, pp. 639-650.

[23] Zhu, H., Jin. L., Diaper, D., and Bai, G., "Software Requirements Validation Via Task Analysis," *The Journal of Systems and Software*, Volume 61, 2002, pp. 145-169.

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APPENDIX: CORRELATIONS OF STUDY VARIABLES

Panel A: Study #1

Variable		Mean	SD	IAR	EAR	IAS	EAS	DIAG	GNDR	AGE	IS	MAR
Internal actors success rate	IAR	0.82	0.28									
External actors success rate	EAR	0.41	0.34	0.08								
Internal activities success rate	IAS	0.87	0.22	0.42***	0.24***							
External activities success rate	EAS	0.07	0.18	0.09	0.21**	0.02						
Type of diagram (Swimlane = 1)	DIAG			0.05	-0.30***	-0.02	0.02					
Gender (Male = 1)	GNDR			0.02	-0.06	0.004	-0.06	-0.02				
Age group	AGE			0.12	-0.09	-0.04	0.07	0.05	0.01			
Major of study (IS = 1)	IS			0.03	0.06	0.04	-0.02	-0.12	0.07	-0.05		
Minutes spent identifying actors	MAR	4.29	4.72	-0.38***	-0.13	-0.30***	-0.05	-0.03	0.03	-0.11	0.18**	
Minutes spent identifying activi-ties	MAS	3.43	2.84	-0.12	0.19**	-0.08	0.14	-0.16	-0.10	-0.06	-0.03	0.55***

*** p<0.01, ** p<0.05, * p<0.10
Pairwise correlations reported (Highest N = 142, Lowest N = 134)

Panel B: Study #2

Variable		Mean	SD	IAR	EAR	IAS	EAS	DIAG	GNDR	AGE	IS	MAR
Internal actors success rate	IAR	0.74	0.33									
External actors success rate	EAR	0.46	0.31	0.07								
Internal activities success rate	IAS	0.76	0.30	0.30***	0.19**							
External activities success rate	EAS	0.11	0.21	0.12	0.27***	0.08						
Type of diagram (Swimlane = 1)	DIAG			-0.02	-0.21**	0.06	-0.28***					
Gender (Male = 1)	GNDR			0.20**	0.04	0.11	-0.06	0.02				
Age group	AGE			0.26***	-0.15	0.06	0.01	0.07	0.26***			
Major of study (IS = 1)	IS			0.05	-0.01	-0.02	0.10	-0.09	0.22**	0.21**		
Minutes spent identifying actors	MAR	4.38	4.65	-0.16	0.09	-0.17	-0.02	-0.10	-0.11	-0.05	-0.06	
Minutes spent identifying activi-ties	MAS	4.40	4.71	-0.13	0.15	-0.18**	0.06	-0.28***	-0.08	-0.06	-0.04	0.79***

*** p<0.01, ** p<0.05, * p<0.10
Pairwise correlations reported (Highest N = 129, Lowest N = 121)