

# UML COVERAGE IN SYSTEMS ANALYSIS AND DESIGN TEXTBOOKS

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## ABSTRACT

*This paper extends previous research by the authors into the usage of the Unified Modeling Language (UML) in the Systems Analysis and Design (SAD) curriculum. This research builds on previous research findings indicating the necessity to include UML into the Systems Analysis and Design courses. The opportunity to transition to object-oriented analysis and design using UML, in the CIS curriculum, is based on the available UML coverage in textbooks. An empirical analysis of the available systems analysis and design textbooks revealed the incidence, level, completeness and relative quality of the available coverage for individual UML diagrams. This research might be valuable to textbook authors intending to update or revise their textbooks to include UML. It is also helpful to instructors looking to adapt UML into their Systems Analysis and Design courses.*

**Keywords:** UML, Systems Analysis and Design, Object-oriented, Textbook.

## INTRODUCTION

In April of 2003 the Object Management Group revealed its UML 2.0 (7, 3) standard. UML has clearly become the specification language of choice for systems analysis and design in the industry (1, 3). A previous research (6) demonstrated the necessity to use UML diagrams in designing web applications. Another research (5) exhibits the use of UML diagrams for description of software components. These and many other papers indicate that as the industry continues to adapt web applications and component based application development, it will actively recruit students who have received training in UML. For this reason, CIS and related programs should actively pursue to incorporate UML into their curricula. The ability to make this transition successfully highly depends on the available UML coverage in textbooks. This paper examines the commonly available System Analysis and Design textbooks with the intention to determine the incidence, level, completeness and relative quality of available coverage for individual UML diagrams.

## RESEARCH QUESTIONS AND METHOD

Our previous informal examination of SAD textbooks indicated that only a few UML diagrams are covered in those textbooks. Based on our previous findings, the following general research question is proposed:

Q1: Do SAD textbooks provide an adequate source for teaching UML?

In order to answer this general question, this study attempts to provide the detailed analysis of the topical coverage of SAD textbooks by answering the following research questions:

- Q2: Which UML diagrams are covered and how extensively are they covered?
- Q3: How well are the diagrams illustrated and incorporated into a continuing case study?
- Q4: Are the terms and concepts explained?

This study was conducted during the fall of 2003. The research instrument included examination copies of 13 textbooks. The study sample was selected using the facultyONLINE web site (2), web sites of textbook publishers and a previous survey of SAD textbooks (8). Table 1 summarizes the bibliographical data of the textbooks, sorted in alphabetical order by their first author. This table also contains the number of faculty using that textbook, where available, provided by facultyONLINE (2). This may indicate a relative popularity of the textbooks.

<b>Id</b>	<b>Author</b>	<b>Title</b>	<b>Publisher</b>	<b>Ed.</b>	<b>Pub Date</b>	<b>Usage*</b>
BRO	Brown	An Introduction to Object-Oriented Analysis: Objects and UML in Plain English	John Wiley & Sons	2	2001	
DW	Dennis & Wixom	Systems Analysis and Design: An Applied Approach	John Wiley & Sons	2	2002	106
DWT	Dennis, Wixom, Tegarden	Systems Analysis and Design: An Object Oriented Approach with UML	John Wiley & Sons		2002	
DEW	Dewitz	Systems Analysis and Design and the Transition to Objects	McGraw-Hill, Inc.	1	1996	27
GBVH	George, Batra, Valacich,. Hoffer	Object-Oriented System Analysis and Design	Prentice Hall		2004	
HGV	Hoffer,George, Valacich	Modern Systems Analysis and Design	Prentice Hall	3	2002	9
KK	Kendall, K. Kendall, J.	Systems Analysis and Design	Prentice Hall	5	2002	9
MAR	Marakas	Systems Analysis and Design: An Active Approach	Prentice Hall		2001	
SCH	Schach	Introduction to Object-Oriented Analysis and Design with UML CD	McGraw-Hill, Inc.		2004	
SJB	Satzinger, Jackson, Burd	Systems Analysis and Design in a Changing World	Course Technology/ Thomson Learning	2	2002	37
SCR	Shelly, Cashman, Rosenblatt	Systems Analysis and Design	Course Technology/ Thomson Learning	4	2003	63
VGH	Valacich, George, Hoffer	Essentials of Systems Analysis & Design	Prentice Hall	2	2004	45
WBD	Whitten, Bentley, Dittman	Systems Analysis and Design Methods w/Project Cases CD	McGraw-Hill, Inc.	6	2004	151

\* Number of faculty using this book

Table 1: Bibliographical data of the SAD textbooks.

Empirical studies of an evolving topic are always limited; we deliberately excluded professional books not widely known to be used in SAD courses by CIS programs. At least one such book deserves an honorable mention here. A popular text by Larman (4) is in its second edition and

has been used for years at numerous CIS programs, but as far as the authors are aware, it is more popular in CS and Software Engineering programs.

Textbooks were closely examined to determine their size in terms of the total number of pages, chapters and appendices. The textbooks were further examined according to their overall UML coverage. Next, we performed a detailed examination of the textbooks in terms of quantity level, completeness and usage of the individual UML diagram coverage. The completeness of coverage is measured by examining if all the necessary terms and concepts for a given UML diagram, listed in Table 2, are covered.

		Type of Diagram							
		Use Case	Activity	Class	Sequence	Collaboration	Statechart	Component	Deployment
Terms and Concepts	Use case	Activity	Class	Object	Object	State	Component	Node	
	Actor	Initial activity	Attributes	Lifeline	Link	Initial state	Package	Connections	
	Association	Final activity	Associations	Operation region	Message	Final state	Interface	Dependencies	
	Include	Transition	Roles	Creation	Message direction	Transition	Dependency		
	Extend	Concurrent fork	Multiplicities	Destruction	Sequencing	Event	Realization		
	Generalization	Concurrent join	Generalization	Control structure		Super state			
		Branching	Aggregation	Message		Concurrent sub states			
		Guard expression	Composition	Return		Sequential sub states			
		Swim lanes	Association class			Guard condition			
			Operations			Self transition			

Table 2: Necessary terms and concepts for UML diagrams.

## RESEARCH RESULTS

Our findings are reported in the following two tables. Table 3 summarizes the total number of pages, total number of chapters and appendices, if textbook is object-oriented or not, as well as number of pages, chapters and appendices devoted to UML. These findings are used to determine for which books to perform the detailed analysis.

The textbook by Dewitz does not cover UML and is not included in the detailed analysis. It is important to mention that this book uses a structured SAD approach and uses the term “object” instead of “entity” calling the extended entity-relationship-diagram an “object relationship model”. The textbooks by DW, HGV, KK, MAR, SCR and VGH cover all UML diagrams in one chapter as an alternative approach and therefore, do not represent an adequate source for teaching UML. These textbooks are not included in the detailed analysis.

Only six out of thirteen examined textbooks provide a somewhat comprehensive coverage of UML diagrams. Table 4 provides data about the detailed topical coverage for each UML diagram in terms of: a) number of dedicated chapters; b) number of dedicated pages; c) list of unexplained terms and concepts; d) number of illustrations; and e) is UML used in the ongoing case study.

	BRO	DW	DWT	DEW	GBVH	HGV	KK	MAR	SCH	SJB	SCR	VGH	WBD
Number of pages	668	544	515	555	500	733	944	483	385	704	656	460	780
Number of chapters/ appendices	17	15	16	13	14	20	22	14/2	20/5	15/4	12/4	10/2	20
Is it Object-Oriented	Yes	No	Yes	No	Yes	No	No	No	Yes	Both	No	No	Both
UML chapters/ appendices	8	1	4	0	3	1	1	/1	8/2	4	1	/1	3
UML pages	349	41	120	0	89	49	22	15	181	99	38	18	86

Table 3: Overall UML coverage in SAD textbooks.

Several books talk about packages and system architecture, but only two textbooks (SCH and WBD) mention Component and Deployment diagrams with single illustrations. Therefore, we did not include these two diagrams in Table 4. The DWT and SJB textbooks have Package Diagrams. Since the Package Diagram becomes an official UML diagram in version 2.0 (7, 3), we did not include it in our detailed analysis. It is important to mention that UML 2.0 also introduced the Object Diagram and renamed the Collaboration into the Communication diagram.

The SJB textbook covers both traditional and object-oriented approaches in parallel throughout the book instead of having UML as one chapter at the end. That created difficulties for us in counting chapters dedicated to UML diagrams. Thus, we counted all the chapters with complete dual coverage as if they were dedicated to UML.

## DISCUSSION

Our overall findings support our initial observations. The BRO, DTW and GBVH textbooks looks like real object-oriented textbooks using UML at first sight. After deeper examination, we realized that those textbooks replaced the data-flow diagrams with Use Case diagrams, and ER diagrams with Class diagrams. All other behavior related diagrams are covered in one or two chapters without a sufficient level of detail to use them in students' projects. Among these three textbooks, Brown's textbook has an above average coverage of Class diagrams. The SJB and WBD are books that cover both traditional and object-oriented approaches. While WBD only successfully incorporated Use Case diagrams, the SJB textbook is an example of successful coverage of both approaches in parallel. This leads us to two textbooks (SCH and SJB) that have adequate coverage of six types of diagrams.

**Which UML diagrams are covered and how extensively are they covered?**

The Use Case, Statechart Diagram, Class, and Sequence Diagrams are covered in all six textbooks. The Collaboration and Activity Diagrams are covered in four textbooks. There are only three books (GBVH, SCH and SJB) that cover all six types of diagrams. As we mentioned before, the Component and Deployment diagrams are not sufficiently covered in any of the textbooks.

		BRO	DWT	GBVH	SCH	SJB	WBD
Use Case Diagram	Chapters	1	1	1	2	1	1
	Pages	31	35	25	52	9	33
	Unexplained	Include Extend			Use case generaliza- tion	Generaliza- tion	Use case generaliza- tion
	Illustrations	6	4	6	52	10	7
	Used in case study	Yes	Yes	Yes	Yes	Yes	Yes
Activity Diagram	Chapters						
	Pages			3	2	4	5
	Unexplained				Guard ex- pression		
	Illustrations			1	2	5	1
	Used in case study			No	No	No	No
Class Diagram	Chapters	3	2	1	2	1	
	Pages	176	61	29	41	6	17
	Unexplained	Association Class	Composition				Association class
	Illustrations	39	10	26	56	9	14
	Used in case study	Yes	Yes	Yes	Yes	Yes	Yes
Sequence Diagram	Chapters	1					
	Pages	26	4	6	17	13	1
	Unexplained	Creation Destruction	Return	Many		Destruction	Creation Destruction
	Illustrations	3	1	3	12	8	1
	Used in case study	No	Yes	No	Yes	Yes	No
Collaboration Diagram	Chapters						
	Pages		5	1	6	3	
	Unexplained						
	Illustrations		1	1	8	3	
	Used in case study		Yes	No	Yes	Yes	
Statechart Diagram	Chapters	1					
	Pages	39	5	1	10	15	2
	Unexplained	Super state Sequential Sub state	Super state Sub state	Many		Sequential sub state	Super state Sub state
	Illustrations	11	1	1	8	13	1
	Used in case study	Yes	Yes	No	Yes	Yes	No

Table 4: Detailed topical coverage for each UML diagram.

Only Use Case and Class diagrams are sufficiently covered in all six textbooks. Both diagrams have separate chapters and extensive page coverage. The Sequence and Statechart diagrams are appropriately covered in four textbooks and lightly covered in the other two textbooks. The Activity and Collaboration diagrams are lightly covered in four textbooks and not mentioned in the remaining two textbooks.

### **How well are the diagrams illustrated and incorporated into a continuing case study?**

Similarly, the Use Case and Class diagrams are sufficiently illustrated and are incorporated into a continuing case study in all six textbooks. The Sequence diagrams are well illustrated in four textbooks and lightly illustrated in two textbooks. They are incorporated into case studies in three books. The Statechart diagrams are well illustrated in three textbooks and used in case studies in four textbooks. The Collaboration diagrams are well illustrated in three textbooks and included into case studies of those three textbooks. The Activity diagrams are well illustrated only in one textbook, lightly illustrated in three textbooks, but are not included in a continuing case study in any of the textbooks.

### **Are the terms and concepts explained?**

Almost all books explain the majority of the concepts for the diagrams that they cover. The most frequently unexplained concept for Use Case diagrams is use case generalization, for Class diagrams it is association class, for Sequence diagrams it is object creation and destruction and for Statechart diagrams it is super and sub-states.

## **CONCLUSIONS**

This study reviewed the most frequently used System Analysis and Design textbooks with the intention to answer the following question. Do SAD textbooks provide an adequate source for teaching UML? This study is not intended to favor any of the textbooks. The intention was primarily to provide a comprehensive review for instructors, authors and publishers.

The result of our study indicated that current SAD textbooks provide some, but not a sufficient, source for teaching UML. Only six out of thirteen textbooks provide more than one chapter about UML. Among those six textbooks, only two provide adequate coverage of all six commonly used UML diagrams. In terms of diagram coverage, only Use Case and Class diagrams are extensively covered and included into case studies of all textbooks. The diagrams for detailed behavior specification are considerably deemphasized. Specifically, the Collaboration and Activity diagrams are inadequately covered. In addition, the Component and Deployment diagrams are not covered in any of the reviewed textbooks.

With the fast growing outsourcing and “offshore” development, the emphasis on detailed design and component design will be more and more important. That will require a significantly better coverage of those diagrams which are now deemphasized in the SAD textbooks.

The good news is that this study shows a significant trend towards the use of UML in SAD among newer books. Three out of four textbooks published this year are using UML. We may

proclaim 2004 as a year of UML's victory in SAD textbooks. Now instructors have significantly more choices in selecting a SAD textbook. At the same time, the authors are updating popular titles to embrace UML as a lingua franca of SAD.

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