The Systems Analysis and Design Course: An Educators' Assessment of the Importance and Coverage of Topics

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ABSTRACT

This study examines instructors' perceptions regarding the skills and topics that are most important in the teaching of a Systems Analysis and Design ("SAD") course and the class time devoted to each. A large number of Information Systems ("IS") educators at AACSB accredited schools across the United States were surveyed. Shannon's entropy is used to analyze the opinions and measure the agreement or disagreement among survey respondents. Findings suggest that object-oriented analysis and structured analysis are topics on which instructors spend the most time, and are also the topics for which there is the greatest disagreement regarding importance. Conversely, the greatest agreement among survey respondents occurs with topics that, on the whole, were perceived as less important and to which less class time is devoted. This analysis provides a basis for comparison to practitioner perceptions.

Keywords: Systems analysis and design, System development tools & methods, Structured analysis & design, Object-oriented SDLC.

1. INTRODUCTION

A Management Information Systems (MIS) curriculum should reflect the needs and expectations of industry, as this helps to ensure that students are adequately prepared for their employment. It is often quite difficult, however, to achieve this (Anandarajan and Lippert, 2006; Tang, Lee, and Koh, 2000). The "IS 2010 Curriculum Guidelines for Undergraduate Programs in Information Systems," established by the Association for Computing Machinery (ACM) and the Association for Information Systems (AIS), are designed to help with this alignment (Topi et al., 2010). The IS 2010 guidelines represent numerous perspectives of faculty and practitioners alike. Furthermore, they are developed with careful consideration of industry requirements and an understanding of organizational needs and expectations. Importantly, the IS 2010 Curriculum Guidelines identify the Systems Analysis and Design (SAD) course as a core in an MIS undergraduate curriculum Topi et al, 2010). Indeed, the suggested catalog description provided within the IS 2010 guidelines (Topi et al, 2010), shown below, amplifies the significance of the SAD course:

> *This course discusses the processes, methods, techniques and tools that organizations use to determine how they should conduct their business, with a particular focus on how computer-based technologies can most effectively contribute to the way business is organized. The course covers a systematic methodology for analyzing a business problem or opportunity, determining what role, if any, computer-based technologies can play in addressing the business need, articulating business requirements for the technology solution, specifying alternative approaches to acquiring the technology capabilities needed to address the business requirements, and specifying the requirements for the information systems solution in particular, in-house development, development from third-party providers, or purchased commercial-off-the-shelf (COTS) packages (p. 48)*
> .

In addition, employment projections are seemingly reflective of the importance of systems analysis and design.

According to the Bureau of Labor Statistics (2011), employment of systems analysts is projected to grow significantly between 2008 and 2018 as compared to the average growth of all other occupations. In fact, employment of systems analysts is projected to increase by 20% during this time frame. As more advanced technologies continue to emerge and as increasing numbers of organizations seek to embrace these new innovations, the demand for these workers is expected to continue rising (Bureau of Labor Statistics, 2011). It is necessary for IS professionals, and those training to become practitioners, to understand the complexities and uncertainties that exist in the utilization of these new technologies and applications for systems development. Thus, it is important for MIS students to have a good understanding of the systems development process, with sufficient knowledge of various methodologies, strategies, and techniques pertaining thereto.

What topics should be the focus in the SAD course? Presumably this question is important to those who teach the SAD course, as well as those who ultimately hire MIS graduates. This study examines instructors' perceptions regarding the skills and topics that are most important in the teaching of a Systems Analysis and Design course and the amount of class time devoted to each of the more traditional areas. This is an important step in determining if educational objectives related to SAD are in line with current industry needs. This paper begins with describing the motivation for the study, reviewing the literature on this topic, and presenting the research questions. The analysis, discussion, conclusions, and recommendations for future research follow.

2. MOTIVATION FOR STUDY

Anecdotal evidence suggests that Information Systems professionals seem to express more of an interest in using object-oriented modeling and analysis in the workplace. Many Systems Analysis and Design textbooks, however, appear to focus more on structured approaches. After reviewing a sample of available SAD textbooks (Shelly and Rosenblatt, 2012; Valacich, George, and Hoffer, 2009; Whitten and Bentley, 2008), we found that one or two chapters are devoted exclusively to the teaching of object-oriented analysis and design (e.g., analysis of use-case models, system sequence diagrams, class diagrams), with approximately four to five chapters focusing on traditional structured analysis and design methodologies and techniques (e.g., entity-relationship diagrams, data flow diagrams, decomposition diagrams, activity-dependency diagrams, fact-finding techniques). Recognizing that not all instructors of the SAD course will select these more traditional textbooks, one should understand the possibility of their selecting a book that exclusively focuses on the teaching of object-oriented and/or more agile approaches to systems analysis and design. Also, there is the possibility that IS educators will use some of their own material, either in addition to a more traditional SAD textbook or in lieu of one.

The IS 2010 Curriculum Guidelines do not explicitly suggest the use of specific methodologies or approaches in the SAD course; rather, the importance of introducing students to the structured Systems Development Life Cycle (SDLC), object-oriented approaches, and agile methodologies is encouraged (Topi et al., 2010). Given the time constraints in any given semester, however, it is often difficult to give proper attention to both structured- and object-oriented approaches to analysis and design, particularly if the instructor chooses to employ an experiential learning approach. Hence, the authors felt compelled to survey SAD instructors across the United States to learn more about what is actually being taught in this course. Is there some uniformity or do substantial perceptual differences exist?

The results of this study should be of interest to instructors of Systems Analysis and Design courses and IS practitioners. Many emails and requests were received from survey participants interested in obtaining a copy of the survey results. Thus, there seems to be a keen interest among IS faculty members, especially those teaching the SAD course, in what topic areas are of predominant interest and how much class time is devoted to each.

3. REVIEW OF LITERATURE

There is a lack of consensus in the literature regarding which topic areas should be covered in the SAD course. A study that is a forerunner to this research (Tastle and Russell, 2003) concluded that although instructors have little agreement regarding overall topic coverage in this course, some structured methods (i.e., data-flow diagramming and data modeling) were consistently perceived as being important. Further, the survey revealed that IS instructors have not yet embraced object-oriented analysis and design methodologies. And while theoretical evidence also exists to support the continued use of more structured modeling and design techniques (Chen, 1976; Chen 1977; Ng, 1981), some recent studies reveal the importance of teaching object-oriented systems development involving the use of Unified Modeling Language (UML) (Batra and Satzinger, 2006; Golden and Matos, 2006; Suleiman and Garfield, 2006; Wang, 2006). Some authors argue that object-oriented methods are more reliable and re-usable than structured approaches (see, for example, Bateveljic, Eastwood, and Seefried, 2006). Still, studies show that systems analysts view UML as particularly complex, as there are an extensive number of diagramming tools associated with its use (Siau, Erikson, and Lee, 2005; Dobing and Parsons, 2006). Others believe it is important to incorporate some sort of hybrid approach that emphasizes elements of both the structured and object-oriented paradigms when teaching SAD (Bateveljic, Eastwood, and Seefried, 2006; Carte, Jasperson, and Cornelius, 2006). For example, Bataveljic, Eastwood, and Seefried (2006) present an SAD course syllabus that combines elements of the object-oriented paradigm with some structurally-oriented modeling techniques (i.e., data-flow diagrams and entity-relationship diagrams). And although their results are promising, the authors point out that the object-oriented approach fails to provide a clear distinction between the analysis and design phases of the development process. This is potentially problematic, as it may result in an insufficient analysis and a less than adequate system design. As there are advantages and disadvantages to the coverage of any of these topics, separately or together, it is most important to take steps to ensure that topic coverage in this course is reflective of industry standards and preferences.

Historically, researchers have described the curriculum gaps between IS topics/skills taught in the classroom and those that are required by industry (Anandarajan and Lippert, 2006; Tang, Lee, and Koh, 2000; Todd, McKeen, and Gallupe, 1995). Additionally, research shows there is much diversity in SAD methods used by IS practitioners. With this, it may be quite challenging to gain a sufficient understanding of common practices, skills, and techniques that are currently being used in industry (Batra and Satzinger, 2006). This challenge, however, does not lessen the importance of continuing efforts to achieve a knowledge alignment.

Understanding the perceptions of IS faculty members regarding topic areas of most importance in the SAD course is an important first step in determining whether curriculum gaps continue to exist in this area. The current study involves the use of a survey for the analysis of opinions by a large number of educators at AACSB accredited schools across the United States. Because each survey question has its own empirical probability distribution defined by the number of respondents who select each of the answer choices for each survey question, application of Shannon's entropy (Shannon, 1948) is employed as a more intuitive way to visualize disagreement betweenn various probability distributions (Tastle and Russell, 2003).

4. RESEARCH QUESTIONS

From the preceding literature review and discussion, the following research questions are posed:

1. In general, what topic areas are given the most attention in the instruction of the SAD course?
2. Do IS instructors teach more structured- or object-oriented approaches to SAD?
3. What elements of structured approaches are given the most focus in the SAD course?
4. What elements of object-oriented approaches are given the most focus in the SAD course?

5. METHODOLOGY

All AACSB accredited schools of business in the United States were identified. The faculty survey was sent to all Information Systems faculty members at AACSB accredited business schools throughout the United States regardless of whether they were known to teach the SAD course or not. The authors felt it was important to include all IS faculty in the survey distribution list, as it was not possible to determine who is teaching (or has ever taught) the SAD class in all cases. Some school websites provide this level of detail and others do not. This methodology allowed for a greater likelihood of reaching all instructors of SAD courses.

A slight variation of an existing survey instrument was used for this study (Tastle and Russell, 2003). This variation involved additional and more general demographic questions pertaining to academic rank, AACSB faculty qualification status, and gender. Next, mirroring the original instrument, three sets of questions were posed to participants. In the first set, questions regarding the percentage of time spent on more traditional and general SAD topics were included. For these questions, an eight-point scale was employed with options ranging from "none" to ">= 50%," as participants were asked to select the approximate percentage of time spent on each of the listed topics in any given semester. In the second set of questions, participants were asked to be more specific about their perceptions regarding the importance of certain elements of a structured approach (only if they indicated they taught structured concepts). In the third set of questions, participants were asked to indicate their perceptions about the importance of object-oriented concepts (only if they indicated they taught object-oriented concepts). A Likert scale ranging from "definitely important" to "definitely unimportant" was used for the second and third sets of questions. Finally, survey participants were asked to list any CASE tools or other model-based software they use in the class and to provide any additional information they felt was important to share. The survey instructions assured strict confidentiality and anonymity. The Appendix contains the survey questions, as well as the number of responses in each answer category with which the entropy calculations are completed.

A pilot survey was sent to eighty IS faculty members at AACSB accredited business schools in the state of Louisiana using Survey Monkey, an online survey tool. After several mechanical refinements, emails were sent to 2,643 IS faculty members. Of these, more than twenty emails were returned as "undeliverable" due to invalid, and probably expired or outdated, addresses. A total of two hundred fourteen (214) completed surveys were collected. A widely cited source on survey research indicates that "surveys with response rates over 30 percent are rare, and response rates are often 5 to 10 percent" (Alreck & Settle, 2004, p. 36). Ninety (90) respondents indicated they either never taught, or were uncertain if they ever taught, the SAD course, and others failed to complete the survey in its entirety. Those surveys were excluded from the analysis, leaving a total of 124 completed responses from at least 64 different schools. This total includes the usable responses from the pilot survey. Note that 52 respondents did not specify the name of their college or university, and so the exact number of schools and their locations cannot be determined.

The survey respondents represent a broad cross-section of SAD educators. The faculty rank of respondents includes 37.9% at rank of Professor, 29% at Associate Professor, and 21% at Assistant Professor for a total of 87.9% of respondents in a tenured or tenure-track position. For AACSB accreditation purposes, 82.3% are academically qualified with 10.5% professionally qualified and 7.2% unsure. In terms of experience teaching the course, 41.9% have taught the course 5 years or less, 45.2% have between 6 and 20 years of SAD teaching experience, and 12.9% have been teaching the course for 21 years or longer. The SAD course is taught at the undergraduate level (by 54.8% of respondents), at the graduate level (by 6.5% of the respondents), and at both levels (by 38.7% of the respondents). Among these educators, 21% are female, 75% are male, and 4% declined to answer.

Category	None	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>=50%
# responses	15	29	32	6	6	7	21	8
p_i	.121 *	.239	.258	.048	.048	.056	.169	.065
$\ln(p_i)$	-2.112	-1.431	-1.355	-3.037	-3.037	-2.882	-1.779	-2.733

*Found by (# responses)/n; for example 15/124 = .121

Table 6.1 Example of entropy calculation for Question 2

Cronbach's alpha was calculated for each of the three (traditional topics, structured analysis topics, and object-oriented topics) sets of questions. The generally agreed upon lower limit for Cronbach's alpha is .7 (Hair, Black, Babin, and Anderson, 2010). The values of Cronbach's alpha for the questions regarding traditional topics was .925, for structured analysis topics was .864, and for object-oriented analysis was .830. The internal reliability of the survey questions in the present study is therefore very strong.

6. ANALYSIS

6.1 Measuring Agreement Using Entropy

A common way to summarize and describe survey responses in MIS research is to calculate sample means and sample standard deviations and compare those across survey questions using t-tests (Downey, McMurtrey, and Zeltmann, 2008; Stevens, Totaro, and Zhu, 2011). As noted by Tastle and Russell (2003), an entropy measure such as Shannon's entropy (Shannon, 1948) is a more intuitive way to visualize disagreement between various probability distributions. In this context, each survey question has its own empirical probability distribution defined by the number of respondents who select each of the answer choices for that question. Tastle and Russell (2003) demonstrate the advantage of the entropy approach using a series of probability distributions with varying means and standard deviations, but the same amount of entropy. Since this research is a continuation and extension of theirs, it is logical to make comparisons using the same mathematical techniques.

Entropy measures the extent to which survey respondents agree or disagree. If all respondents answer a question in the same way, then they are in complete agreement, and the entropy measure for this question is zero. On the other hand, if the responses are equally distributed across all possible answers for a given question, then the entropy is at a maximum. The objective in this research is to determine those topics for which there is the greatest agreement. Not surprisingly given the large sample size in this research, perfect agreement among faculty did not occur with any of the survey questions.

This research has three categories of questions regarding content of the SAD course: traditional topics taught (which include structured analysis and object-oriented analysis), the importance of various structured analysis topics, and the importance of the object-oriented analysis topics. Entropy, H(p), is calculated for each of these 3 question sets using the natural logarithm function, ln(x), according to equation 6.1:

$$H(p) = - \sum p_i \ln(p_i), \quad (6.1)$$

Where $p_1 + \ldots + p_n = 1$, $0 \le p_i \le 1$, and $i = 1, 2, 3, \ldots, n$. In this case n = the number of possible answers in each question set. As noted above, the minimum value of entropy is always 0, and the maximum entropy is based on the number of answer choices for the question, rather than on the number of respondents answering the question. For example, the maximum entropy for a question with 8 choices is 2.079, regardless of number of survey respondents. The use of formula 6.1 is easily understood with an example. Consider the survey question 2, concerning the proportion of class time spent on structured analysis. Table 6.1 summarizes the respondent data and derived values required for the entropy calculation for this question.

For this question, as well as all other questions in this section, there were n = 8 possible responses. Using the values from Table 6.1 in equation 6.1, H(p) = 1.878. The dispersion of responses (note at least 6 responses in each category) indicate considerable disagreement about the time spent on structured analysis. Almost one-quarter of respondents, 29 out of 124 or 23.4%, spend 25% or more of class time on the topic, while 12.1% of respondents spend no time on the topic. More detailed analysis of each question follows in the next section.

Since the survey results consist of the perceptions of the faculty respondents, we wish to determine on which topics there is most agreement, and which topics are most important. After ordering the distributions based on their degree of dissonance or entropy, specific values within each question's distribution of responses are examined to ascertain the importance of each topic as well as how much time is devoted to it.

6.2 Grouping Traditional Topics by Entropy

Each of the 22 questions in this section concerns a specific topic in the SAD course. The entropy calculations for questions in this section are summarized in Table 6.2, and are ordered from maximum entropy (least agreement among respondents) to minimum entropy (most agreement).

The degree of separation between entropy measures allows the topics to be mapped to natural groups. The column "% Diff" in Table 6.2 indicates the percent difference between element n and element n + 1. Element 1, which corresponds to survey question #3 (object-oriented analysis) has an entropy value which is 1.7% larger than element 2, which corresponds to survey question #15. When distributions of responses change little, those topics are naturally grouped. A visual inspection indicates that a difference of 2.4% or more appears to be a suitable value to distinguish groups, and the Section 1 response distributions are thereby divided into 7 groups, arranged from highest to lowest entropy. Tastle and Russell (2003) used similar logic to divide their questions into 6 groups. Seven groups seems quite appropriate since the 2^k rule for summarizing data suggests the number of

Element	Survey Ques #	Topic	Entropy	% Diff
1	3	Object-oriented analysis	1.927	1.7%
2	15	UML	1.895	0.9%
3	2	Structured analysis	1.878	3.0%
4	11	Process modeling	1.823	1.7%
5	14	Use case	1.792	0.5%
6	12	Data flow diagramming	1.784	0.5%
7	16	Class diagramming	1.775	0.8%
8	20	Systems design concepts	1.762	2.4%
9	8	Data modeling	1.720	2.1%
10	9	Entity relat. diagram	1.684	3.4%
11	17	Sequence diagramming	1.629	1.1%
12	21	Interface design	1.611	1.2%
13	6	Project management concepts	1.592	2.8%
14	5	Project initiation, data	1.549	0.5%
15	4	Overview of SA	1.542	2.9%
16	19	Cost-benefit and payback	1.498	0.6%
17	22	File and DB design	1.489	0.8%
18	13	Decomposition diagramming	1.477	0.9%
19	7	Overview of methodologies	1.463	1.0%
20	23	Program design	1.449	0.2%
21	10	Normalization	1.447	4.9%
22	18	State-transition diagramming	1.379	

Table 6.2 Ranking of Traditional Topics

groups = k, where k is the smallest integer such that $2^k > N$, where N = total number of data values (Lind, Marchal, Wathen, 2010). For Section 1 responses there were N = 124 respondents, and $2^7 = 128 > 124$.

Table 6.3 summarizes the entropy groupings and their associated ranges (difference between highest and lowest entropy values within the group). Group 1 represents the items with the greatest entropy (least agreement) and Group 7 represents the item with the least entropy and the most agreement. In addition, SPSS v17 calculates skewness which indicates the extent to which the distribution of a question's responses are positively skewed (i.e., pushed to the left: topics given less emphasis in class) or negatively skewed (i.e., pushed to the right: topics given greater emphasis). The possible range of skewness values is -3 to +3. Note that no questions exhibit negative skewness, which would indicate very strong agreement about the topic receiving a large proportion of class time. On the other hand, questions in groups 6 and 7 exhibit strong positive skewness, indicating agreement about the topics receiving little or no class time.

The column "Included ?" in Table 6.3 will be discussed later, and indicates the authors' recommendation regarding whether the topic should be included in a one semester SAD course.

6.3 Analysis of Traditional Topics

Separate description is provided for each group:
Group 1

- There is least agreement among time spent on *object-oriented analysis*, *UML*, and *structured analysis*. Instructors cover the entire range of possibilities, from spending no class time to spending considerable class time:
    - *Structured analysis* - 12.1% of respondents spend no time on it (i.e. "none"), 23.4% of respondents spend 25+% of class time, and 30.6% of instructors spend between 5-15% of class time

- *UML* - 16.1% spend none, 14.5% spend 25+% of class time, and 22.6% spend between 5-15% of class time
- *Object-oriented analysis* - 10.5% spend none, 8.1% spend 25-50% of class time, and another 12.1% spend more than 50% of class time

- These 3 topics are also covered most as reflected by the percentages of instructors that spend 25+% of class time. No other topic has as much as 10% of respondents devoting 25+% of class time.

Group 2

- *Process modeling* – 9.7% spend none, 32.3% spend none or less than 5% (i.e. "very little" time devoted)
- *Data flow diagramming* – 21% spend none, 39.5% spend very little
- *Use case* – 9.7% spend none, 38.7% spend very little
- *Class diagramming* – 25% spend none, 54% spend very little
- *Systems design concepts* – 4.8% spend none, 7.2% spend 25+% of time

Group 3

- *Data modeling* – 12.9% spend none, 34.7% spend 5-10%, 6.4% spend 25+%
- *Entity relationship diagramming* – 19.4% spend none, 51.7% spend very little

Group 4

- *Sequence diagramming* - 27.4% spend none, 57.2% spend very little
- *Interface design* - 11.3% spend none, 48.4% spend very little
- *Project management concepts* – 8.9% spend none, 39.5% spend 5-10%

Group	Element	Survey Ques #	Entropy	% Diff	Range	Skewness	Included? *
1	1-3	3	1.927	1.7%	0.049	0.673	I
		15	1.895	0.9%		0.788	I
		2	1.878	3.0%		0.553	I
2	4-8	11	1.823	1.7%	0.062	0.806	I
		14	1.792	0.5%		0.898	I
		12	1.784	0.5%		0.818	I
		16	1.775	0.8%		1.105	U
		20	1.762	2.4%		1.065	I
3	9-10	8	1.720	2.1%	0.035	1.187	U
		9	1.684	3.4%		1.215	U
4	11-13	17	1.629	1.1%	0.037	1.515	N
		21	1.611	1.2%		1.161	U
		6	1.592	2.8%		1.346	I
5	14-15	5	1.549	0.5%	0.007	1.329	I
		4	1.542	2.9%		1.575	I
6	16-21	19	1.498	0.6%	0.051	1.604	U
		22	1.489	0.8%		1.886	N
		13	1.477	0.9%		1.82	N
		7	1.463	1.0%		1.856	I
		23	1.449	0.2%		1.848	N
		10	1.447	4.9%		1.902	N
7	22	18	1.379		0.000	2.194	N

* Indicates suggested coverage of topic: (I)nclude, (N)ot include, (U)nable to determine

Table 6.3 Groupings of Section 1
(Questions by Entropy Value)

Element	Survey Question #	Entropy	Skewness	Topic	Definitely Important	Somewhat Important	Undecided	Somewhat Unimportant	Definitely Unimportant
1	36	1.494	0.321	Use CASE tool to implement business model	21	28	13	21	5
2	26	1.457	0.698	Normalize data model to 3rd normal form	31	27	7	14	9
3	30	1.440	0.255	Draw activity dependency diagram	11	30	27	16	4
4	35	1.401	0.674	Interviewing techniques	22	36	15	12	3
5	25	1.331	1.126	Entity relationship diagramming	37	30	6	9	6
6	28	1.283	1.079	Balancing data flow diagram	37	31	10	8	2
7	33	1.226	1.308	Data collection, survey, & interviewing skills	38	34	5	8	3
8	24	1.154	1.493	Data modeling concepts	49	24	4	8	3
9	32	1.148	1.519	Project management skills	47	27	7	5	2
10	27	0.981	2.025	Drawing a complete data flow diagram	49	32	2	3	2
11	31	0.958	2.107	Using both data & process modeling skills	58	21	3	4	2
12	34	0.910	2.316	Complete a project as a team	60	20	4	2	2

Table 6.4 Ranking of Structured Analysis Topics by Entropy

Group 5

- *Project initiation and data collection* - 5.6% spend none, 46% spend 5-10%
- *Overview of systems analysis* - 3.2% spend none, 39.5% spend 5-10%

Group 6

- *Cost-benefit and payback* - 11.3% spend none, 52.4% spend very little
- *File and database design* - 26.6% spend none, 66.1% spend very little
- *Decomposition diagramming* - - 37.9% spend none, 70.2% spend very little
- *Overview of various systems methodologies* - 4.8% spend none, 37.9% spend 5-10%
- *Program design* – 33.9% spend none, 73.4% spend very little
- *Normalization concepts* – 35.5% spend none, 73.4% spend very little

Group 7

- *State-transition diagramming* – 40.3% spend none, 77.4% spend very little

For these questions, skewness increases as entropy increases. This indicates that there is more agreement among instructors for those topics on which there is less class time spent. When instructors spend 25-50% or 50+% of class time on a topic, there is greatest disagreement about those topics (all topics on which 10% or more respondents spend 25% or more class time are in Group #1). Conversely, when more than 30% of respondents spend no time on a topic, those topics have the greatest agreement, and are predominantly found in group #6 and #7. Implications of these findings are discussed in section 7.

6.4 Structured Analysis Topics by Entropy

Each of the 12 questions in this section concerns the importance of a specific structured analysis topic. For these questions, respondents had 5 answer choices (n = 5 in equation 6.1): "Definitely Important", "Somewhat Important", "Undecided", "Somewhat Unimportant", and "Definitely Unimportant". The maximum entropy value for a question with 5 choices is 1.609, regardless of the number of responses to the question. Table 6.4 lists the number of responses for each answer to each question, together with the skewness measure and entropy value. As before, the questions are ordered from maximum to minimum entropy.The interpretation of the values in Table 6.4 is exactly analogous to the interpretations from the earlier table of entropy values of the traditional topics. The total number of respondents for this group of questions was 88 (since all respondents had not taught the SAD course.) These questions asked the respondent to indicate the importance of each topic, rather than the amount of time spent on each topic, as with the first section questions on traditional SAD topics. Note again that no questions exhibit negative skewness, which would indicate strong agreement about the topic being very unimportant. Conversely, larger positive skewness here indicates most respondents believed the topic to be either definitely important or somewhat important.

Element	Survey Question #	Entropy	Skewness	Topic	Definitely Important	Somewhat Important	Undecided	Somewhat Unimportant	Definitely Unimportant
1	42	1.495	0.515	Model-based tools to implement design	26	18	17	11	5
2	39	1.410	0.423	State-transaction diagramming	12	29	23	10	3
3	40	1.330	0.933	Project management skills	27	30	10	8	2
4	38	1.254	1.313	Sequence diagramming	32	30	7	5	3
5	41	1.217	1.164	Cost-benefit analysis	23	39	6	7	2
6	37	1.058	1.973	Class diagramming	44	24	3	2	4

Table 6.5 Ranking of Object-Oriented Topics by Entropy

6.5 Importance of Object-Oriented Topics

This section consists of 6 questions concerning the importance of various object-oriented concepts, and consisted of responses from 77 instructors who had taught OO concepts. As with the second set of questions, respondents were asked to rank the importance of each topic on the 5-point scale ranging from definitely important to definitely unimportant.

The entropy calculations for questions in this section are summarized in Table 6.5, and are ordered from maximum to minimum entropy.

The "% Diff" values for elements 1 through 5 (not shown in the table due to space limitations) are 6.1%, 6.0%, 6.0%, 3.0%, and 15.0%, respectively. Using 6.0% as a group cutoff, 5 groups are obtained with each question in its own group, with the exception of questions 38 and 41 being combined into group 4. Very clear distinctions between each of these elements are obvious because of the percentage changes in entropy values for successive elements. Note that increasing positive skewness also indicates this same basic order of topics (with only the first 2 items switching places in the ordering). Creating a single "important" column by adding the "definitely" and "somewhat" values together, and creating a single "unimportant" category by adding the "somewhat" and "definitely" columns together also produces the same basic order of topics (again, with only the first 2 topics switching places in the ordering).

7. DISCUSSION

Discussion is provided for each of the 3 sets of questions separately, and then overall.

7.1 Discussion of Traditional Topics

Each topic is classified in one of three ways, depending on whether it should be included in the SAD course: (I)ncluded, (N)ot included, (U)nable to determine. The following guidelines, together with the ratings for other topics within the same entropy grouping were used to categorize each topic:

- 7.1a) If less than 10% of respondents devote no time to the topic, then the topic *is included*,
- 7.1b) If more than 25% of respondents devote no time to the topic, then the topic *is not included*,
- 7.1c) If 50% or more of respondents devote no time or <5% of class time, then the topic *is undecided* (i.e. unable to determine whether it should be included),
- 7.1d) If 10% or more of respondents devote 25+% of class time, then the topic is *included*.

From group 1, *Object-oriented analysis* and *structured analysis* were also the topics with the most disagreement in the earlier study by Tastle and Russell (2003). This indicates that there has been little change in faculty perceptions of these two topics over the past 8 years, and that those faculty perceptions are quite diverse. The 3 topics in this group have the greatest entropy but also the highest percentage of respondents devoting considerable time, and so each receives the rating of "I" (to be included in the SAD course) based on criteria 7.1d. Note that these ratings are in the last column of Table 6.3.

From group 2, *Process modeling, Use case,* and *Data flow* all have less than 10% of respondents spending no class time, so each is rated "I". At this point, there is a logical division of topics in Table 6.3. The first 6 topics all have skewness values less than .818, the next 10 topics all have skewness values between 1.105 and 1.604, and the final 6 topics each have skewness values of 1.886 or larger. Using this gap in skewness together with condition 7.1c above, no determination can be made for *Class diagramming.* The final topic in this group, *Systems design concepts*, is rated "I" using criteria 7.1a. All topics in this group are design-related, and 4 of the 5 are specifically concerned with modeling.

Both topics in group 3 are modeling-related. *Data modeling* is a more general topic and an *Entity relationship diagram* is a type of data model. *Entity relationship diagram* receives a rating of "U" based on criteria 7.1c. Since *Data modeling* has a larger entropy rating and smaller skewness, it also receives a rating of "U".

Group 4 consists of 2 design topics: *Sequence diagramming* which is rated "N" based on criteria 7.1b, and

Interface design rated "U" because none of the other criteria apply. The last topic in this group, *Project management concepts* has the smallest entropy in the group and is rated "I" by criteria 7.1a.

Group 5 consists of 2 topics outside the design domain, and both are included based on very small proportions of instructors indicating they spend no time, criteria 7.1a. These 2 topics are *Project initiation and data collection analysis* and *Overview of the systems analysis process*.

Groups 6 and 7 consist of the topics with which there is the greatest agreement among instructors. Interestingly, this agreement is primarily that these topics are not important at all. Other than *Cost-benefit and payback analysis* which receives the "U" rating because of criteria 7.1c, and *Overview of the various methodologies* which receives the "I" rating because of criteria 7.1a, every other topic receives "N" because 66.1 – 77.4% of instructors spend very little time: either no time at all or less than 5% of class time. And, for these 5 topics, the percentages spending no time and the percentages spending less than 5% of class time are approximately equal.

There is no clear consensus on which topics are most important: at least 2.4% of respondents rate each topic as deserving of 25+% of class time. Each of the topics providing an "overview" or with a project management focus is included. (One exception here is the "U" rating for *Cost-benefit analysis*). In summary, eleven topics should definitely be included, 6 topics are not included, and 5 other topics are borderline or undecided. These conclusions provide a rationale for instructors to spend additional time on the 11 most important topics.

7.2 Discussion of Structured Analysis Concepts

Since these are the common structured analysis topics found in SAD texts, it was expected that the distributions would be positively skewed, with most respondents indicating either definitely or somewhat important. However, there are a surprising number of responses in the "undecided" category, ranging from 2 to 27. At least 2 instructors were undecided about the importance of each topic, and question #30 regarding the activity-dependency diagram was the topic with most undecided at 27 out of 88, or 30.7%. The final 8 topics in Table 6.4, the ones with the lowest entropy values, are believed to be important (either "definitely or somewhat") by at least 76% of respondents. These are *teaching students to draw entity relationship diagram*, *teaching students to balance a data flow diagram*, *requiring students to learn data collection*, *teaching data modeling concepts*, *requiring students to complete a project requiring project management skills*, *teaching students to draw a complete data flow diagram*, *teaching students to complete a project that requires the use of both data and process modeling skills*, and *requiring students to complete a project as a team*. Furthermore, of the final 8 topics, the last 3 questions were believed important by at least 89.7% of respondents These 8 topics also have the smallest numbers of instructors who believe them to be unimportant (either "somewhat or definitely"). The consensus is that these 8 topics are the most important structured analysis topics. The single most important topic with the highest overall agreement is question #34: *requiring students to complete a project as a team*.

On the other end of the entropy list are the first 4 topics: *requiring students to use a CASE tool*, *teaching students to normalize a data model to 3rd normal form, teaching students to draw an activity dependency diagram*, and *requiring students to actually exercise interviewing techniques*. These topics have the largest unimportant scores (either "somewhat or definitely"), have the least agreement concerning their importance, and are skewed less positively (towards the unimportant end of the spectrum). However, at least 46.6% of respondents (41 or more out of 88) believed each of these 4 topics to be important (either "definitely or somewhat"). In summary, for those teaching structured analysis concepts, each of the 12 topics is considered important. The entropy and skewness ratings provide a rationale for spending more time on the topics at the bottom of the list.

7.3 Discussion of OO Concepts

For those who teach OO Concepts, the first 2 elements in Table 6.5 (with largest entropy) also have the largest proportion of instructors undecided about their importance, with 22.1% undecided about *teaching students to use a model-based software tool to implement a design*, and 29.9% undecided about *teaching students to use state-transaction diagramming*. These proportions of undecided instructors are approximately double those of the other 4 topics. Although these topics also receive the largest proportions of "unimportant" responses, they each have at least 53% of respondents describing them as "important" (either "definitely" or "somewhat").

A majority of instructors believe each of the 6 topics in Table 6.5 are important, but among them the most important topics are the last 4, for which 74% of the respondents, or more, list the topic as being "important". These topics include question 40: *requiring students to complete an entire object model using project management skills,* question 38: *teaching students to use sequence diagramming,* question 41: *teaching students to perform cost-benefit analysis,* and question 37: *teaching students to use class diagramming*. There is greatest agreement among question 37 with 68 of the 77 instructors or 88.3% listing it as important. This is the same result obtained by Tastle and Russell (2003) in their analysis of OO topics. However, the actual and relative rankings of the other 5 topics are different between the two studies. Their study included responses from 14 instructors who had taught OO concepts, while the present study includes 77 such responses.

8. CONCLUSIONS AND FUTURE RESEARCH

Every question had at least 1 respondent select every possible choice, with one exception: question 18, *State-transition diagramming*, had 0 responses for the 25-50% category. These results are quite different than those obtained in the earlier study, and are not surprising since the sample sizes in this research were 3 to 5 times larger for each section, and responses were obtained from faculty at 64 different accredited schools across the United States. *OO analysis* and *Structured analysis* are topics on which instructors spend the most time, and are also the topics for which there is the greatest disagreement regarding importance. For those who teach structured analysis concepts, a majority of instructors believe each topic to be important. Similarly, for those who teach object oriented analysis concepts, a majority of educators believe each topic to be important. In the last 8 years since the Tastle and Russell (2003) study, *UML* has joined the list of most covered topics, but *OO analysis* and *Structured analysis* are still most controversial in terms of time devoted to each, and still have the most time devoted to their coverage.

Unified Modeling Language (UML) has become the industry standard language for software blueprints (Castro, J. F. B., Silva, C. T. L. L., and Mylopoulos, J., 2003; Dobing and Parsons, 2006; Topi et al, 2010), which suggests that future research should involve greater inclusion of UML. Similarly, as Agile continues to increase in popularity (Cao, Ramesh, and Abdel-Hamid, 2010), there should be a concomitant increase in empirical studies that focus on developing a better understanding about the degree to which academics and practitioners make use of such methods.

Conversely, the greatest agreement among survey respondents was associated with topics that, on the whole, were perceived as less important and to which less class time is devoted. These topics, which represent both structured and OO topics, include the following: c*ost-benefit and payback; file and database design; decomposition diagramming; overview of various systems methodologies; program design; normalization concepts; state-transition diagramming.*

Future research could provide an in depth analysis of demographic differences as they pertain to each survey question. Such differences could be investigated using the t-test approach. Further research is necessary to determine which SAD methodologies and techniques are most widely used by IS practitioners, and further, the results of this study should be compared with these industry requirements and expectations. Although this study alone does not provide all of the information necessary to make curriculum decisions or modifications, such future and extended research will help to provide a basis for sound decisions regarding IS curricula. Importantly, systems development methodologies and tools change and improve over time, creating an ever-increasing need to look at the alignment of IS educational objectives and IS industry requirements and specifications. The question of whether curriculum gaps exist deserves attention by researchers, as both academicians and practitioners will benefit from these investigations. Further, such research is necessary to support a sufficient knowledge alignment.

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APPENDIX

Survey of Skills Perceived as Important in Systems Analysis and Design

1. Name of college/university (optional):
2. Which of the following most closely represents your current academic rank?:
   (Professor, Associate Professor, Assistant Professor, Lecturer, Instructor, Adjunct Instructor, None of these)
3. For AACSB accreditation purposes, are you considered:
   (Academically qualified (AQ), Professionally qualified (PQ), Unsure)
4. Have you ever taught the Systems Analysis & Design course? (Yes, No, Unsure)
5. The Systems Analysis & Design course is taught:
   (Within the College (or School) of Business, Outside of the College of Business)
6. Level of Systems Analysis & Design course (or other similar course taught):
   (Undergraduate, Graduate, Both Undergraduate and Graduate)
7. How long have you been teaching (to the nearest year) the Systems Analysis & Design course?
8. Gender (Female, Male, Prefer not to answer)

Note: In Sections I, II, and III, the number of survey responses for each answer category is also provided for those researchers who are interested in entropy calculations.

Section I: Pick one course that most closely approximates the Systems Analysis & Design course. If you teach both undergraduate and graduate, limit answers to the undergraduate course.

1. Have you ever taught the Systems Analysis and Design course? (If response is ‘yes’, respondent sees remaining questions in this section, otherwise survey is ended.)

In a given semester/term, what is the approximate percentage of time spent on each of these traditional Systems Analysis and Design topics?

2. Structured analysis

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
15	29	32	6	6	7	21	8

3. Object-oriented analysis

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
13	30	31	10	8	7	10	15

4. Overview of the Systems Analysis process

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
4	34	49	23	5	3	2	4

5. Project initiation and data collection analysis

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
7	28	57	14	10	2	4	2

6. Project management concepts

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
11	34	49	14	9	3	1	3

7. Overview of the various systems methodologies

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
6	47	47	10	7	1	2	4

8. Data modeling (in general)

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
16	32	43	14	7	4	5	3

9. Entity relationship diagramming

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
24	40	28	18	7	2	3	2

10. Normalization concepts

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
44	47	17	8	2	2	3	1

11. Process modeling (in general)

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
12	28	31	27	12	3	8	3

12. Data flow diagramming

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
26	23	29	27	8	2	7	2

13. Decomposition diagramming

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
47	40	21	6	1	3	5	1

14. Use case

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
12	36	32	20	9	8	5	2

15. UML

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
20	41	16	12	9	8	11	7

16. Class diagramming

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
31	36	22	15	5	8	4	3

17. Sequence diagramming

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
34	37	31	9	2	5	3	3

18. State-transition diagramming

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
50	46	13	7	3	2	0	3

19. Cost-benefit and payback analysis

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
14	51	35	15	5	1	1	2

20. Systems design concepts

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
6	39	32	18	15	5	3	6

21. Interface design

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
14	46	33	17	8	3	2	1

22. File and database design

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
33	49	27	4	4	1	4	2

23. Program design

none	<5%	5-10%	11-15%	16-20%	21-25%	25-50%	>= 50%
42	49	18	5	4	3	2	1

Section II: Those instructors who answer that they do teach structured analysis topics complete this section. All other instructors skip to Section III.

24. Teaching data modeling concepts is:

Definitely Important	Somewhat Important	Undecided	Somewhat Unimportant	Definitely Unimportant
49	24	4	8	3

25. Teaching students to draw entity relation diagrams is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
37	30	6	9	6

26. Teaching students to normalize a data model at least to 3rd normal form is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
31	27	7	14	9

27. Teaching students to draw a complete data flow diagram is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
49	32	2	3	2

28. Teaching students to balance a data flow diagram is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
37	31	10	8	2

29. Teaching students to draw a process hierarchy diagram is: (This question from the original survey was omitted based on feedback from the pilot study which indicated this skill was more appropriate for an advanced course in systems analysis and design.)

30. Teaching students to draw an activity dependency diagram is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
11	30	27	16	4

31. Teaching students to complete a project that requires the use of both data and process modeling skills is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
58	21	3	4	2

32. Requiring students to complete a project that requires project management skills is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
47	27	7	5	2

33. Requiring students to learn data collection, survey, and interviewing skills is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
38	34	5	8	3

34. Requiring students to complete a project as a team is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
60	20	4	2	2

35. Requiring students to actually exercise interviewing techniques is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
22	36	15	12	3

36. Requiring students to use a CASE tool to implement a business model is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
21	28	13	21	5

Section III: Those instructors who answer that they do teach object-oriented analysis complete this section. All other instructors skip to Section IV.

37. Teaching students to use class diagramming is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
44	24	3	2	4

38. Teaching students to use sequence diagramming is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
32	30	7	5	3

39. Teaching students to use state-transaction diagramming is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
12	29	23	10	3

40. Requiring students to complete an entire object model using project management skills is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
27	30	10	8	2

41. Teaching students to perform cost-benefit analysis is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
23	39	6	7	2

42. Teaching students to use a model-based software tool to implement a design is:

Def Important	Somewhat Imp	Undecided	Somewhat Unimp	Definitely Unimp
26	18	17	11	5

Section IV: These questions deal with the use of CASE or model-based tools.

1. What CASE tool (e.g. MS Visio) or other model-based software do you use in conjunction with your systems class?

2. Optional: Please provide any additional comments/feedback regarding this survey or your teaching of the Systems Analysis & Design course here.

3. If you wish to receive a copy of the survey results, please provide your preferred email address here.

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