JOURNAL OF EDUCATIONAL RESEARCH & PRACTICE

Journal of Educational Research & Practice
2022, Volume 12, Issue 1, Pages 72–84
DOI: 10.5590/JERAP.2022.12.1.06

Original Research

WALDEN UNIVERSITY

Assessing the Quantity of Information in SROIs by Major

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Abstract

In this paper, we demonstrate how to identify whether different groups of students (classified by their major) provide different quantities of information in their student ratings of instruction (SROIs). As a corollary, we identified specific groups of students who provided a greater/lesser quantity of information in their responses. All calculations were undertaken using Microsoft Excel, and no prior statistical training was required to create or interpret our information measures. We used SROI data taken from a first-year logical reasoning course for health professions majors and found that the quantity of information provided by pharmacy and other health majors in their SROIs exceeded the quantity of information provided by nursing majors for every single SROI question. We also found that specific majors gave relatively greater quantities of information (relative to other majors) for specific types of SROI items.

Keywords: *student ratings of instruction, entropy, information, logical reasoning, health professions*

Date Submitted: July 7, 2021 | Date Published: May 6, 2022

Recommended Citation

Friesner, D., & Schibik, T. J., (2022). Assessing the quantity of information in SROIs by major. *Journal of Educational Research and Practice, 12*, 72–84. https://doi.org/10.5590/JERAP.2022.12.1.06

Introduction

College-level introductory subject courses are unique in that the students who enroll in these courses often have a variety of different majors and backgrounds. As an example, students who earn an economics major/minor, a business major/minor (along with its various sub-fields of finance, management, etc.), and/or who wish to satisfy general education requirements often complete required coursework in principles of microeconomics and principles of macroeconomics. Similarly, first-semester calculus may be a required component of a mathematics major/minor, as well as a required component of engineering, biology, chemistry, physics, economics, and pre-professional majors (medicine, pharmacy, etc.), among a host of other majors and minors. Within a given introductory subject course, students completing the course may have learning styles; prior knowledge and experience relevant to the subject; learning goals; and expectations for the course that vary systematically by student major (or other salient demographic factor). And as a result, students likely develop dramatically

Note: The authors would like to thank the students whose anonymous student ratings of instruction form the basis for this manuscript. The authors would like to thank the editor and two anonymous reviewers whose insightful comments improved this manuscript.

different perceptions of instructor effectiveness throughout the duration of the same course, which also vary systematically by major, or other salient demographic factor (Hansen, 2014; Hoyt & Lee, 2002; Mazer et al., 2008; Yunker & Yunker, 2003). This makes it challenging for faculty and administrators who use student perceptual data to assess and improve instruction in these introductory subject courses. The challenge lies not so much in disaggregating student perceptual data by major (or other salient demographics) but rather in interpreting and using existing data (once disaggregated by student major or other salient demographic characteristics) more effectively to inform continuous improvement in the course.

The primary indicator of student perceptions of instructional effectiveness has, and continues to be, student ratings of instruction, known as SROIs (Benton & Cashin, 2014; Benton & Ryalls, 2016). For as long as SROIs have been used, educational researchers have assessed the reliability and validity of (including potential sources of bias in) SROIs and have used this information to design SROI questions that more appropriately and effectively characterize student perceptions of instructional quality (Beleche et al., 2012; Benton et al., 2013; Boring et al., 2016; Centra, 2009; Hativa, 2013a,b; MacNell et al., 2014; Marsh, 2007; Zhao & Gallant, 2012). In doing so, these researchers have attempted to characterize the *quality* of information contained in SROIs (Benton & Cashin, 2014; Benton et al., 2013; Benton & Ryalls, 2016; Dahl & Osteras, 2010; Marsh, 2007; Pallett, 2006; Zhao & Gallant, 2012). By the quality of information, we mean empirical inferences gained via traditional measures of statistical association, correlation, and/or multivariate analysis.

However, researchers working in this field have failed to account for a more fundamental issue—namely, the quantity of information in SROIs. By the *quantity* of information, we mean the realized underlying distribution of student responses relative to a course instructor's (or any other interested individual's) prior expectations for the distribution of responses (Dahl & Osteras, 2010). A positive quantity of information was realized if the empirical data generated by student responses differed from the instructor's (or other interested individual's) prior expectations about the distribution of responses. The greater the difference, the greater the quantity of information that was gained from collecting the data. The greater the quantity of information, the more appropriately empirical techniques can be used to assess trends and interrelationships in the data (i.e., the quality of information) that characterized the realized distribution of responses. Conversely, if the realized distribution of responses exactly matched the instructor/researcher's prior expectations for the distribution, there was no quantity of information gained because the information was already included in prior expectations. Within the context of SROIs, there is little that can be gained from subsequently analyzing the quality of information from SROIs if students did not provide a meaningful quantity of information in their responses in the first place.

The quantity of information in SROIs is especially important to instructors who teach introductory subject courses (or other interested individuals) precisely because students with a variety of different majors and backgrounds complete these courses (Hansen, 2014; Hoyt & Lee, 2002; Mazer et al., 2008; Yunker & Yunker, 2003). If students in a course had different learning styles; prior knowledge and experience relevant to the subject; learning goals; and expectations for the course that varied systematically by major (or other salient demographic factor), it is also possible that the quantity of information provided by students in their SROIs also varied systematically by major (or other salient demographic factor). If this is the case, the instructor must (a) determine whether different student groups provided greater or lesser quantities of information in their SROI responses, and (b) if there is a difference, identify which groups of students provided greater/lesser quantities of information in their SROI responses. This allows the instructor to glean greater insights into which student group responses might be afforded lesser or greater consideration when using SROIs (in conjunction with other measures of teaching effectiveness) to adjust the course (whether overall or in certain parts of the course) to improve both learning outcomes and student satisfaction.

There is a small—but growing—group of researchers who have assessed the quantity of information in various forms of survey data (Friesner et al., 2021; Friesner et al., 2016). Still fewer researchers have specifically analyzed the quantity of information, specifically in SROIs. In one study, Schibik et al. (2012) found that the quantity of information in SROIs varied from question to question. The authors also found that student overall course evaluations and overall instructor effectiveness items contained largely similar quantities of information—and were redundant. Information about assignments and instructor impartiality contained unique, substantial quantities of information, justifying their inclusion in the SROI.

Since only a few researchers have assessed the quantity of student information in SROIs (both in general and across student groups), it is unreasonable to expect that instructors and administrators include analyses of the quantity of information in SROIs and their differences across groups, in triangulated methods of teaching effectiveness and instructional development (Arreola, 2006; Benton & Ryalls, 2016; Burdsal & Harrison, 2008). This is especially unfortunate since an analysis of the quantity of information in SROIs can be conducted very simply using spreadsheet modeling in Excel. The only data required are the aggregate distributions of responses for a class, or combination of classes, that instructors typically receive at the conclusion of a course. If an analysis was conducted at the level of the class, and only a handful of classes (i.e., SROIs for a given semester or quarter) were analyzed, no statistical analysis would be necessary, although it would be straightforward to incorporate such tests should more extensive and detailed data become available.

In this manuscript, we used SROI data obtained from an introductory course to identify whether different groups of students provided different quantities of information in their SROIs. As a corollary, if different student groups provided different quantities of information, we identified those groups who provided a greater/lesser quantity of information in their responses. Should other instructors apply our methods within their own introductory subject courses, they will have an additional tool that allows them to make deeper inferences from their SROIs, and to more appropriately triangulate SROI data with other measures of teaching effectiveness.

Method

A guiding principle in our case study was parsimony. We wanted to create a simple example that illustrated how to assess the quantity of information in SROIs and in a manner that did not rely on complex statistical analyses. Thus, we emphasized simple methods that abstract from hypothesis tests or other forms of statistical analysis. Indeed, since most SROIs utilize methods of administration that attempt to create a census of data rather than a random sample, it is uncertain as to whether statistical tests can be appropriately applied to SROI data. Researchers who have verified that their SROI data met all necessary sampling assumptions, and who wish to apply statistical tests to measures of the quantity of information, are directed to the methodology established in Friesner et al. (2021). To ensure that this study's methods can be replicated and/or adapted by other instructors, we included in all tables both information entropy results (Tables 1 and 2), as well as Excel worksheets with cell-specific calculations (included as an icon after each table). These worksheets were also made available at: https://www.ndsu.edu/pubweb/~dfriesne/CaseStudyTables.xlsx.

The authors chose to characterize the quantity of information using the concept of information entropy. Jaynes (1957, 1982), Shannon (1948), and Shannon and Weaver (1949) initially developed the concept of information entropy to address problems of interest to physicists and engineers. Researchers working in a number of other fields—most notably in the field of information economics—have since adapted the information entropy concept to address a variety of other information-related problems (Golan, 2008; Golan, Judge & Miller, 1996; Golan, Judge & Perloff, 1996).

Since the current manuscript focuses on its applicability to SROIs, it adapted the notation of Schibik et al. (2012), who applied similar methods to analyze SROI data. Consider a single SROI question that allowed j = 1,...,J mutually exclusive and collectively exhaustive possible responses. We further assumed that the instructor did not participate in the collection of SROI data and, at the conclusion of the data collection process, received results that were aggregated to the level of the course. We specifically assumed that the instructor received a tabulation showing the number of students who provided a particular response to a given SROI item. Each of these possible responses (very poor, poor, average, good, very good) was mutually exclusive and collectively exhaustive. In such cases, absolute frequencies/counts were converted into proportions. Given these proportions, entropy was characterized as:

$$\text{Entropy} = -n\sum_{j=1}^{J} p_j log_2(p_j) \qquad (1)$$

where n was the sample size and p was the proportion of students in the sample who gave a particular response to the survey item (Golan, 2008; Golan, Judge & Miller, 1996; Jaynes, 1982). Golan, Judge, and Miller (1996, p. 7) also noted that $p_j log_2(p_j) = 0$ when pj = 0. Unlike measures of information quality, entropy placed no emphasis on the numerical magnitudes of interpretations of the J response categories. Rather, it focused on the distribution of responses across the possible categories. The entropy function was essentially a weighted average that assigned disproportionately greater weight to probabilities that deviated more from uniform. The greater deviation, the greater the quantity of information that was uniquely contained in the data. Entropy was maximized when the pjs were uniformly distributed, which simultaneously implied that the quantity of information contained in the data was minimized, since the data told us little more than what would be assumed theoretically about the distribution of responses. To make the entropy function (1) more easily interpreted, entropy was converted to a normalized information index by dividing the observed entropy value by its theoretical maximum value, multiplying this value by 100%, and subtracting the value from 100% (Golan, Judge, & Miller, 1996, p. 27):

$$\text{Normalized Information Entropy Index (NIEI)} = \left(1 - \frac{Observed\ Entropy}{Theoretic\ Maximum}\right) * 100\% \qquad (2)$$

where: Theoretic Maximum is the value of entropy as given by (1) when the pjs were all uniformly distributed (i.e., p1 = p2 = ... = pJ = 1/J), and all other variables were as defined previously. The NIEI, which was bounded between 0% and 100%, represented the percentage of available information captured by the data. NIEI values closer to 100% indicated that the data contained a larger quantity of information, while values closer to 0% indicated the opposite.

The entropy concept was further extended to address relative comparisons across groups. Suppose, for example, that the same SROI question was administered to two groups. The first group's responses were characterized by pj, j = 1,...,J, while the second group's responses were characterized by qj, j = 1,...,J. The cross-entropy between the two variables was characterized by:

$$\text{Cross-Entropy} = \sum_{j=1}^{J} p_j log_2\left(\frac{p_j}{q_j}\right) \qquad (3)$$

where all variables were as defined previously and $p_j log_2\left(\frac{p_j}{q_j}\right) = 0$ if pj = 0 (Golan, 2008; Golan, Judge, & Miller, 1996; Golan, Judge, & Perloff, 1996). Larger values for cross entropy indicated that the two groups provided substantially different quantities of information to the same survey item. Unfortunately, cross-entropy values did not (and do not) have a consistent, unique maximum, and thus cannot be normalized to a percentage or unit interval basis. Instead, we compared the magnitudes of a cross-entropy value between the groups and identified the group(s) with the highest and lowest cross-entropy values, which identified the groups providing the most and least informative responses, respectively.

Data

Entropy was characterized within the context of a natural experiment that occurred at a land grant university in the upper-Midwestern U.S. during the Fall 2019 semester. One of the authors was a faculty member in a health professions college. The college offered programs in nursing, pharmacy, and an array of other allied health programs. The faculty member team-taught a course entitled "Critical Thinking and Academic Success," a required, two-credit logical reasoning course for first-year college students who intended to pursue a health-related major. Students were required to register for one of 18 sections that were specific to their major. The course met two days per week. One day per week, students met with their academic advisor (in one of the aforementioned 18 very small sections) to focus on academic skill development. During the other day of the week, students met in one of four larger sections (each of which was evenly populated across the various majors), and one of the paper's authors taught logical reasoning (i.e., "critical thinking") skills. The university administered SROIs for each instructor independently. For the faculty whose SROIs provided the context for this study, the university reported SROIs across all 18 sections but aggregated the results based on the student declared majors (i.e., groups of the 18 sections that were major-specific). Thus, anonymous SROI information was aggregated into three student groups: nursing majors (n = 116), pharmacy majors (n = 50, of which 49 students responded to all survey items), and other "allied sciences" health majors (n = 55).

This analysis focused on the six SROI items required by the university for promotion, tenure, and annual evaluations: Your satisfaction with instruction in this course (Course); The instructor as a teacher (Instructor); The ability of the instructor to communicate effectively (Communication); The quality of the course (Quality); The fairness of procedures for grading this course (Fairness); and Your understanding of course content (Understanding). All items used a 5-point response scale: Very Poor, Poor, In Between, Good, and Very Good. When calculating cross-entropies, it was necessary to choose a student group that served as a reference category (i.e., the qjs in equation Number 2). The choice of a reference group was arbitrary and was determined by the preferences of the study's authors. In this study, all cross-entropy calculations used nursing majors as the reference category, under the rationale that (a) it was the largest of the three student groups and (b) that for each SROI item, at least one student provided a response for each possible option (that is, no qj = 0).

SROI information was reported to the instructor at the level of the course section(s) and/or major, rather than at the level of the student. Moreover, the SROIs were collected by the university for normal business practices. De-identified information was shared with the instructor at the end of the semester. Because the unit of observation was not the student, and because this case study undertook a secondary analysis of existing, de-identified data (which was not collected by the researchers), the study was not considered to constitute human subjects research per the author institutional research board (IRB) guidelines. Therefore IRB approval was not required for this study.

Results

We described the calculations used to characterize the NIEI for each SROI item, and for each student group, in Tables 1–4. For a given student group, we used the first column to indicate the SROI item being analyzed. We used the next five columns in Table 1 to summarize the absolute frequencies/number of students who provided a given rating for that item. We converted each of those absolute frequencies to a proportion (or relative frequency) by dividing each absolute frequency by the total number of students in the group (Table 2). As noted by the "Total" category, to be mutually exclusive and collectively exhaustive, we ensured that each of these proportions must have been between 0 and 1, and must have collectively summed to 1.

Table 1. *SROI Data*

Pharmacy Students	Number of Student Responses					
SROI Item	Very Poor	Poor	In Between	Good	Very Good	Total
Your satisfaction with instruction in this course	0	1	13	22	14	50
The instructor as a teacher	0	2	9	17	22	50
The ability of the instructor to communicate effectively	0	3	5	16	26	50
The quality of this course	0	1	18	14	17	50
The fairness of procedures for grading this course	0	1	3	16	30	50
Your understanding of course content	0	1	19	18	11	49

Nursing Students	Number of Student Responses					
SROI Item	Very Poor	Poor	In Between	Good	Very Good	Total
Your satisfaction with instruction in this course	2	14	19	47	34	116
The instructor as a teacher	2	10	25	38	41	116
The ability of the instructor to communicate effectively	2	10	21	41	42	116
The quality of this course	4	15	27	33	37	116
The fairness of procedures for grading this course	2	1	13	50	50	116
Your understanding of course content	7	12	24	43	30	116

Allied Sciences Students	Number of Student Responses					
SROI Item	Very Poor	Poor	In Between	Good	Very Good	Total
Your satisfaction with instruction in this course	1	2	7	23	22	55
The instructor as a teacher	2	1	6	25	21	55
The ability of the instructor to communicate effectively	2	2	7	25	19	55
The quality of this course	2	3	4	30	16	55
The fairness of procedures for grading this course	1	1	2	26	25	55
Your understanding of course content	2	4	9	22	18	55

Table 2. *SROI Data in Proportional Form*

Pharmacy Students	Proportion of Student Responses					
SROI Item	Very Poor	Poor	In Between	Good	Very Good	Total
Your satisfaction with instruction in this course	0.00	0.02	0.26	0.44	0.28	1.00
The instructor as a teacher	0.00	0.04	0.18	0.34	0.44	1.00
The ability of the instructor to communicate effectively	0.00	0.06	0.10	0.32	0.52	1.00
The quality of this course	0.00	0.02	0.36	0.28	0.34	1.00
The fairness of procedures for grading this course	0.00	0.02	0.06	0.32	0.60	1.00
Your understanding of course content	0.00	0.02	0.39	0.37	0.22	1.00
Nursing Students	**Proportion of Student Responses**					
SROI Item	Very Poor	Poor	In Between	Good	Very Good	Total
Your satisfaction with instruction in this course	0.02	0.12	0.16	0.41	0.29	1.00
The instructor as a teacher	0.02	0.09	0.22	0.33	0.35	1.00
The ability of the instructor to communicate effectively	0.02	0.09	0.18	0.35	0.36	1.00
The quality of this course	0.03	0.13	0.23	0.28	0.32	1.00
The fairness of procedures for grading this course	0.02	0.01	0.11	0.43	0.43	1.00
Your understanding of course content	0.06	0.10	0.21	0.37	0.26	1.00
Allied Sciences Students	**Proportion of Student Responses**					
SROI Item	Very Poor	Poor	In Between	Good	Very Good	Total
Your satisfaction with instruction in this course	0.02	0.04	0.13	0.42	0.40	1.00
The instructor as a teacher	0.04	0.02	0.11	0.45	0.38	1.00
The ability of the instructor to communicate effectively	0.04	0.04	0.13	0.45	0.35	1.00
The quality of this course	0.04	0.05	0.07	0.55	0.29	1.00
The fairness of procedures for grading this course	0.02	0.02	0.04	0.47	0.45	1.00
Your understanding of course content	0.04	0.07	0.16	0.40	0.33	1.00
Theoretic Maximum Entropy	-0.20	-0.20	-0.20	-0.20	-0.20	

We transformed each proportion (or each p_j in equation Number 1) identified in Table 2 by taking that proportion and multiplying it by the base 2 logarithm of the proportion (Table 3). That is, we calculated $p_j log_2(p_j)$ for each of the (j = 1,...,5) proportions. As an aside, if no students provided a given response to an SROI item (i.e., the $p_j = 0$), we followed Golan, Judge, and Miller (1996, p. 7) and set $p_j log_2(p_j) = 0$. When calculating these values in Microsoft Excel, we used the "If (.)" conditional logic term, which produced a zero if zero students gave a particular response (i.e. "Very Poor") and the $p_j log_2(p_j)$ if it was not zero.

Table 3. *Entropy Calculations*

Pharmacy Students	Entropy Calculations				
SROI Item	Very Poor	Poor	In Between	Good	Very Good
Your satisfaction with instruction in this course	0.00	-0.11	-0.51	-0.52	-0.51
The instructor as a teacher	0.00	-0.19	-0.45	-0.53	-0.52
The ability of the instructor to communicate effectively	0.00	-0.24	-0.33	-0.53	-0.49
The quality of this course	0.00	-0.11	-0.53	-0.51	-0.53
The fairness of procedures for grading this course	0.00	-0.11	-0.24	-0.53	-0.44
Your understanding of course content	0.00	-0.11	-0.53	-0.53	-0.48
Nursing Students	**Entropy Calculations**				
SROI Item	Very Poor	Poor	In Between	Good	Very Good
Your satisfaction with instruction in this course	-0.10	-0.37	-0.43	-0.53	-0.52
The instructor as a teacher	-0.10	-0.30	-0.48	-0.53	-0.53
The ability of the instructor to communicate effectively	-0.10	-0.30	-0.45	-0.53	-0.53
The quality of this course	-0.17	-0.38	-0.49	-0.52	-0.53
The fairness of procedures for grading this course	-0.10	-0.06	-0.35	-0.52	-0.52
Your understanding of course content	-0.24	-0.34	-0.47	-0.53	-0.50
Allied Sciences Students	**Entropy Calculations**				
SROI Item	Very Poor	Poor	In Between	Good	Very Good
Your satisfaction with instruction in this course	-0.11	-0.17	-0.38	-0.53	-0.53
The instructor as a teacher	-0.17	-0.11	-0.35	-0.52	-0.53
The ability of the instructor to communicate effectively	-0.17	-0.17	-0.38	-0.52	-0.53
The quality of this course	-0.17	-0.23	-0.28	-0.48	-0.52
The fairness of procedures for grading this course	-0.11	-0.11	-0.17	-0.51	-0.52
Your understanding of course content	-0.17	-0.28	-0.43	-0.53	-0.53
Theoretic Maximum Entropy	-0.46	-0.46	-0.46	-0.46	-0.46

We presented the final NIEI calculations in Table 4. The column entitled "Base Entropy" summed each of the $p_j log_2(p_j)$ values from Table 3 and multiplied the result by -1. This column represented the traditional base entropy value. To calculate the NIEI in equation (2), we identified the theoretic maximum value for our entropy calculation. As discussed in the methods section, the maximum entropy value was attained when each of the p_j were uniform. Since we had five (5) possible response items for each SROI item, this implied that a uniform set of p_js was equal to 1/5 for every survey item. The theoretic maximum value for entropy was calculated by repeating the traditional entropy value, using 1/5 for each response category. As noted in Table 4, we found that the theoretic maximum was approximately 2.32. We used the second column in Table 4 to express the ratio of the observed and theoretic maximum entropy values, and in the final column, we subtracted this ratio from one and converted it to a percentage.

Table 4. *Normalized Information Entropy Index (NIEI) Calculations*

Pharmacy Students

SROI Item	Base Entropy	Base Entropy Divided by Maximum Entropy	NIEI
Your satisfaction with instruction in this course	1.65	0.71	28.79
The instructor as a teacher	1.68	0.72	27.59
The ability of the instructor to communicate effectively	1.59	0.69	31.42
The quality of this course	1.69	0.73	27.35
The fairness of procedures for grading this course	1.32	0.57	42.95
Your understanding of course content	1.66	0.71	28.54

Nursing Students

SROI Item	Base Entropy	Base Entropy Divided by Maximum Entropy	NIEI
Your satisfaction with instruction in this course	1.94	0.84	16.29
The instructor as a teacher	1.94	0.84	16.42
The ability of the instructor to communicate effectively	1.91	0.82	17.60
The quality of this course	2.08	0.90	10.40
The fairness of procedures for grading this course	1.56	0.67	32.79
Your understanding of course content	2.09	0.90	10.05

Allied Sciences Students

SROI Item	Base Entropy	Base Entropy Divided by Maximum Entropy	NIEI
Your satisfaction with instruction in this course	1.71	0.74	26.26
The instructor as a teacher	1.68	0.72	27.86
The ability of the instructor to communicate effectively	1.77	0.76	23.64
The quality of this course	1.67	0.72	27.95
The fairness of procedures for grading this course	1.41	0.61	39.18
Your understanding of course content	1.93	0.83	16.78
Theoretic Maximum Entropy		2.32	

Having calculated the NIEI, we also identified the percentage of information contained in each SROI item by major. For the Course question, the percentage of normalized information for nursing students, pharmacy students, and allied sciences students were, respectively, 16.3%, 28.8%, and 26.6%. Analogous percentages for the Instructor question (16.4%, 27.6%, and 27.9%, respectively, for the three groups) and the Communication question (17.6%, 31.4%, and 23.6%, respectively, for the three groups) were similar to the Course question. Information percentages for the Quality question were 10.4% (nursing), 27.3% (pharmacy), and 27.9% (all other) for the three groups, while for the Fairness item, the percentages were 32.8%, 43.0%, and 39.2%, respectively. Lastly, the percentages for the Understanding question across the three groups were 10.0%, 28.5%, and 16.8%. Clearly, for all of the SROI items, the pharmacy and allied sciences students provided a greater quantity of information than the nursing students. For the Fairness SROI item, all three groups provided relatively similar quantities of information, although the pharmacy students provided slightly more information than nursing and allied sciences students. For the remaining SROI items, the pharmacy and allied sciences students provided nearly twice the available quantity of information than the nursing students.

We summarized the calculations used to generate cross-entropy metrics in Table 5. In this table, we used the information identified in Tables 1 and 2 as a starting point for the analysis. More specifically, in Table 1, the first column indicated the SROI item being analyzed, the next five columns provided the absolute frequencies of possible student responses for that item. For the information in Table 2, we converted each of those absolute frequencies to proportions (or relative frequencies) by dividing each absolute frequency by the number of students in the group. As before, we ensured that the "Total" column summed to one.

Table 5. *Cross Entropy Calculations*

Pharmacy Students	Entropy Calculations					
SROI Item	Very Poor	Poor	In Between	Good	Very Good	Cross Entropy
Your satisfaction with instruction in this course	0.00	-0.05	0.17	0.05	-0.02	0.16
The instructor as a teacher	0.00	-0.04	-0.05	0.02	0.14	0.07
The ability of the instructor to communicate effectively	0.00	-0.03	-0.09	-0.05	0.27	0.11
The quality of this course	0.00	-0.05	0.23	-0.01	0.03	0.20
The fairness of procedures for grading this course	0.00	0.02	-0.05	-0.14	0.29	0.12
Your understanding of course content	0.00	-0.05	0.35	0.00	-0.05	0.25
Allied Sciences Students	**Entropy Calculations**					
SROI Item	Very Poor	Poor	In Between	Good	Very Good	Cross Entropy
Your satisfaction with instruction in this course	0.00	-0.06	-0.05	0.02	0.18	0.09
The instructor as a teacher	0.04	-0.04	-0.11	0.21	0.04	0.15
The ability of the instructor to communicate effectively	0.04	-0.05	-0.06	0.16	-0.02	0.07
The quality of this course	0.00	-0.07	-0.12	0.51	-0.04	0.29
The fairness of procedures for grading this course	0.00	0.02	-0.06	0.06	0.03	0.06
Your understanding of course content	-0.03	-0.04	-0.06	0.04	0.11	0.04

As noted above, the nursing students represented the baseline against which the other two groups were compared. Thus, the nursing student responses represented the qjs in equation (3), and we did not calculate cross entropy values for the nursing students. We only characterized cross entropy for the pharmacy and allied sciences students, each of which was measured relative to nursing students. Since not all pharmacy students provided ratings of "Very Poor" for each SROI item, we continued to assume that $p_j log_2\left(\frac{p_j}{q_j}\right) = 0$ if pj = 0. We implemented this restriction using the "If(.)" conditional logic command in Microsoft Excel. As an example, consider the cross-entropy calculations comparing pharmacy and nursing students. For each response option (for example, the "Very Poor" option), we took the proportion of pharmacy students who reported that an instructor performed "Very Poor" for a given SROI item, divided this by the proportion of nursing students who reported "Very Poor" for the same SROI item, and then took the base 2 logarithm of this fraction. This value was subsequently multiplied by the proportion of pharmacy students who reported a "Very Poor" response to the same SROI. This calculation represented $p_j log_2\left(\frac{p_j}{q_j}\right)$ in equation (3). We repeated this exercise for the other response options (i.e., "Poor," "In Between," etc.) for a given SROI item and summarized the results in the next columns in the table. In the final column, we took the sum of these calculations over all five response options, and in doing so we characterized the cross-entropy metric for this particular SROI item. For each row in the table, we repeated the exercise in its entirety for a different SROI item.

Examination of the cross-entropy calculations in Table 5 yielded some interesting results. For the Course question, cross-entropy values for the pharmacy and allied sciences majors (relative to the nursing majors) were 0.155 and 0.09, respectively. The analogous calculations for the Instructor question were 0.066 and 0.148, respectively, while those for the Communication question were 0.109 and 0.071, respectively. For the Quality question, the cross-entropy values were 0.198 and 0.286, respectively, while for the Fairness question the cross-entropy values were 0.119 and 0.060, respectively. Lastly, the values for the Understanding question were 0.253 and 0.036, respectively, for pharmacy and all other majors (relative to the nursing majors). Thus, the pharmacy majors (relative to nursing majors) provided much more informative responses for the Course, Communication, Fairness, and Understanding SROI items. Allied sciences majors (relative to nursing majors) provided the most information in the Instructor and Quality SROI items.

Conclusions, Discussion, and Suggestions

In this manuscript, we presented a case study demonstrating how instructors can use information entropy to assess the quantity of information in SROIs. Our case study also demonstrated how to use cross-entropy to assess whether specific groups of students provided greater or lesser quantities of information in their SROI responses. All calculations were undertaken in a simple manner using Microsoft Excel, and no prior statistical training was required to create or interpret entropy and/or cross-entropy metrics. The simplicity and parsimony inherent in these techniques ensured that the vast majority of instructors teaching college-level courses (or other interested parties) would be able to adapt our methods for use with their own SROI data.

We drew several practical inferences from the analysis of our SROI data. First, the quantity of information provided by pharmacy and other health majors in their SROIs exceeded the quantity of information provided by nursing majors for every single SROI question. The magnitude of the overall quantity of information (as measured by the traditional entropy measure) was consistent in magnitude between pharmacy and all other health majors.

Second, when using cross-entropy to compare the responses of different majors in a relative format, we made several, more nuanced inferences. Pharmacy students provided much higher quantities of information than nursing students to the Course, Quality, Fairness, and Understanding questions. Allied sciences majors provided more informative responses to the Instructor and Communication questions. This suggested that, not only did students provide different quantities of information, but they also did so for different SROI questions, which covered various aspects of instruction. Overall, we concluded that this course instructor gleans a greater quantity of information from their SROIs if they are disaggregated by student major. In this course (and only this course), the instructor may be advised to place greater emphasis on the responses of the pharmacy and allied sciences students and relatively less emphasis on those of the nursing students.

Our primary goal in this case study was to provide a template for instructors (or other interested parties) that allowed them to assess the quantity of information contained in their SROIs and to assess the quantity of information across different student groups. In general, the quantity of information likely varies by context, including (but not limited to) how the instructor aggregated students across majors, the subject matter of the course, how the instructor presented the subject matter, and which groups of student majors completed the course. We acknowledge that our results may not translate to other courses that have different contexts and learning environments. More specifically, the reader should avoid concluding that pharmacy and allied sciences students always give more information in their SROIs or that nursing students always provide lower SROI information in every situation. We encourage others to replicate our work in their own courses, to identify situations or contexts in which corroborate or refute the work we presented in this manuscript.

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