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Undergraduate Students' Statistical Literacy: A survey study

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Abstract

Statistical literacy has been recognized as essential knowledge that all citizens need to possess in today's information-driven society. Undergraduate students require statistical knowhow and skills to apply in their studies and everyday's life. The aim of this study was to assess the level of statistical literacy among undergraduate students in Thailand. The two element model of statistical literacy by Gal (2004), knowledge component (comprised of five cognitive elements: literacy skills, statistical knowledge, mathematical knowledge, context knowledge, and critical questions) and a dispositional component (comprised of two elements: critical stance, and beliefs and attitudes), was used. A survey was administered to 103 undergraduate students of Faculty of Education, Chulalongkorn University. The results revealed that the undergraduate students had moderate level of overall statistical literacy, knowledge component and a dispositional component. In the knowledge component, the students had high level of literacy skills and mathematical knowledge, moderate level of statistical knowledge and critical questions, and low level of context knowledge. Additionally, in the dispositional component, the students had moderate level of critical stance, and beliefs and attitudes. The practical implications for educators to improve students' statistical literacy were discussed.

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Keywords: Statistical Literac; Statistics Knowledge; Attitude toward Statistics

1. Introduction

Statistical literacy has been recognized as essential knowledge that all citizens need to possess in today's information-driven society. In today's data driven world, information is readily available and easily obtained. Some of this information may be misleading or inaccurate. People often assume a statistic appearing in print or reported on the news is true, so it can lead to decision mistake (Ben-Zvi & Garfield, 2004). Being statistically literate enables one to consume and critically digest the wealth of information being produced in today's society (Rumsey, 2002).

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Therefore the need for a statistically literate citizenry is vital. Introductory statistics course is generally a way to enhance knowledge of statistics focused on concepts and process of statistics. However, this method did not confirm that student have statistical literacy focused on critically evaluate statistical results (Gaise et al., 2005). Furthermore, assessment in introductory course is only knowledge of concept and process of statistics but it cannot assess the level of statistical literacy. The aim of this study was to assess the level of statistical literacy among undergraduate students in Thailand. This research can provide the foundation for other studies to optimize factors such as teaching method or course format in order to help students develop the knowledge, strategies, and insights to challenge statistical claims and develop statistical literacy. Results from this study may facilitate development of future courses focused on enhancing the aspect of statistical literacy as well as aid in the further development of instrument to assess components of statistical literacy.

2. Statistical literacy

Statistical literacy encompasses a number of ideas. Wallman (1993) defined that it is the ability to understand and critically evaluate statistical results that permeate our daily lives—coupled with the ability to appreciate the contributions that statistical thinking can make in public and private, professional and personal decisions. For Schield (1999), statistical literacy is the ability to read and interpret data: the ability to use statistics as evidence in arguments. In addition statistical literacy is a competency: the ability to think critically about statistics. Similarly Gal (2004) stated that statistical literacy is the ability to interpret, critically evaluate, and communicate about statistical information and messages. The Element of statistical literacy Gal (2004) provided an initial model that posits that statistically literate behaviour comprises both a knowledge component (comprised of five cognitive elements: literacy skills, statistical knowledge, mathematical knowledge, context knowledge and critical questions) and a dispositional element (comprised of critical stance, beliefs and attitudes). This study applied Gal's (2004) model of statistical literacy to examine statistical literacy in undergraduate student.

3. Methodology

3.1. Partipants

Selection of participants was accomplished by using a purposive sampling method. Participants, 103 undergraduate students, 39 males and 64 females, were students who had taken statistics and mathematics courses at least one time. . The sample was 42.7% first year students, 39.8% second year student, 10.7% the fourth year student and 4.9% second year student. Grade point average as reported by participants that fell between 3.01 to 3.50 was at 33.0%), 2.51 to 3.00 at 21.4%, less than 2.50 at 15.5% and 3.51 to 4.00 at 14.6% respectively.

3.2. Instruments

The seven instruments that used to examine statistical literacy in this study encompassed the seven elements of Gal's (2004) model of statistical literacy. The elements were separated into two categories, knowledge and dispositional elements. There were five knowledge elements: literacy skills, mathematical knowledge, statistical knowledge, context knowledge and critical questions; and two dispositional elements: critical stance, and beliefs and attitudes. (As seen in table 1). The first four instruments examined four knowledge elements: literacy skills, mathematical knowledge, statistical knowledge and context knowledge. These instruments were adapted questions from Gal(2004) and Wade(2009). The first instrument comprised 5 questions from the literacy skills topic, the second 10 questions from statistical knowledge topic, the third 5 questions from mathematical knowledge, and the forth 5 questions from context knowledge. Each question was designed to be answered from four choices. One mark was given for each correct answer and zero mark for an incorrect answer. Marks were summed up in each section for comparative analysis. The fifth instrument examined critical questions. This instrument was constructed by using a combination of published research from newspapers with Gal's worry questions and measured students' ability to critically question published research. To evaluate students' critical questioning skills, a short research article that was published in national newspapers was handed out and the list of worry questions posed by Gal (10 questions) were provided. A higher score on the SCS indicated a higher level of critical questions. The sixth instrument was

designed to examine the first of two dispositional elements of statistical literacy and critical stance by using the Scale of Critical Stance (SCS; Wade, 2009). This instrument contained 10 statements to measure individuals' perception of how they responded to statistical messages in the media. The scale consisted of 10 statements and used a Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). A higher score on the SCS indicated a higher level of critical stance in student. Finally, the seventh instrument examined the second of two dispositional elements of statistical literacy: belief and attitudes, and was accomplished by using the Survey of Attitudes Toward Statistics (SATS; Schau, Dauphinee, DelVecchio & Stevens, 1995), in combination with an extension of students' open-ended responses. Responses on the SATS (28-item) were measured on a 7-point Likert scale, with 1 meaning strongly disagree, 4 neither disagree nor agree, and 7 strongly agree. Some of the items were positively worded, while others are negatively worded. The negative scores were had reversed before data analysis was performed. A higher score on the SATS indicated a more positive attitude toward statistics (Schau, et al., 1995). The overall total scores form seven instruments were used to measure the students' statistical literacy. A higher score on overall total scores indicates a higher level of statistical literacy in student.

Table 1. The survey instrument in study

Indicators	Definitions	Measures
Knowledge elements		
Literacy skills	Ability to understand the reading of various non-prose texts, for example, graphs, tables or symbols.	Adapted from Gal(2004)
Statistical knowledge	Ability to understand why data are needed and how data can be produced, familiarity with basic terms and ideas related to descriptive statistics, graphical and tabular display, understanding the basic notions of probability, and understand how statistical conclusions or inferences are reached.	Adapted from Gal(2004) and wade(2009)
Mathematical knowledge	Ability to understand the sum of a large number of observations by a concise quantitative statement (e.g. percent and mean).	Adapted from Gal(2004) and Wade(2009)
Context knowledge	Ability to place the statistical messages in context.	Adapted from Gal(2004) and Wade(2009)
Critical Question	Ability to critically question published research.	Adapted from Gal(2004) and Wade(2009)
Dispositional elements		
Critical stance	Individuals' perception of how they respond to statistical messages in the media.	CSC by Wade(2009)
Belief and attitude	Individuals' attitudes toward statistics shape their behavior toward statistics (e.g. studying habits, importance of, etc.), which affect their belief systems.	STATS by Schau, et al. (1995.

4. Analysis and Results

The statistical analysis of this study involved descriptive statistics, mean and standard deviation. Table 2 shows undergraduate students having moderate level of overall statistical literacy, knowledge component and a dispositional component. In the knowledge component, the students had high level of literacy skills and mathematical knowledge, moderate level of statistical knowledge and critical questions, and low level of context knowledge. Additionally, in the dispositional component, the students had moderate level of critical stance, and beliefs and attitudes. In addition, female and male students had similar levels of statistical literacy. The non-significant differences in overall and sub-components of statistical literacy between female and male students were evident with p-value more than 5% significance levels.

Table 2. Mean and standard deviations of Statistical literacy

Statistical literacy	**overall**			**Gender**					
				Male		**Female**		**t**	**p-value**
	Mean	**S.D.**	**Level**	**Mean**	**S.D.**	**Mean**	**SD**		
Knowledge component	20.38	3.02	Moderate	20.31	2.68	20.42	3.23	0.185	0.853
Literacy	3.40	.90	Moderate	3.62	.85	3.27	.91	1.938	0.055
Statistics knowledge	6.01	1.87	High	5.98	1.65	6.04	2.01	0.116	0.908
Mathematics knowledge	3.31	.87	Moderate	3.18	.82	3.39	.90	1.191	0.237
Context knowledge	1.92	1.13	Moderate	1.74	1.09	2.03	1.15	1.251	0.214
Critical Question	6.15	1.95	High	6.12	1.94	6.18	1.98	0.199	0.843
Disposition component	7.84	2.40	Moderate	7.57	2.68	8.00	2.22	0.885	0.378
Critical stance	3.94	.88	Moderate	3.93	.95	3.94	.84	0.069	0.945
Belief and attitude	4.62	.81	Moderate	4.58	.83	4.65	.80	0.359	0.721
Overall	**28.22**	**3.95**	Moderate	**27.88**	**3.50**	**28.43**	**4.22**	**0.679**	**0.499**

5. Discussion

This study examined level of statistical literacy in undergraduate students. The results revealed that the students had high level of literacy skills and mathematical knowledge, but had low level of context knowledge and moderate level of statistical knowledge and critical questions. This result provided evidence that undergraduate students had high ability to understand the reading of graphs, tables or symbols, and high understand the sum of a large number of observations by a concise quantitative statement (Wade, 2009). A Reason that students had high level of statistics knowledge may be the students had taken introductory statistics course taught concepts and process of statistics However, this course did not focused on placing the statistical messages in context. It may lead to low context knowledge. The findings suggested that for teachers who are currently teaching statistics topics, they are expected to pay more focus on context knowledge and should be encouraged to diversify their teaching methods to allow students to practice their statistics literacy through hands-on practical work and exercises.

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