JOURNAL OF BALTIC SCIENCE EDUCATION

ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

UNDERGRADUATE STEM AND NON-STEM STUDENTS' INTERPRETATION OF MEAN IN AN INFOGRAPHIC

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Abstract. *The use of infographics for presenting data in the media and on the Internet has become a widespread phenomenon. This study examines how well undergraduates interpret the mean when presented in infographic, their attitudes towards the misuse of statistics, and their perceptions of their knowledge and use of statistics. The infographic was intended for the general public. The questionnaire was developed in a pilot study and then it was presented to a sample of 270 students from universities in Serbia and the USA. The study showed that STEM undergraduates and those who attended a course in statistics interpreted the infographic better. However, between 46% and 65% of those misinterpreted the infographic which indicates that changes are needed in statistics education to improve statistical literacy. Concerning demographic characteristics, somewhat better results were achieved by the American students, while gender had weak significance. Students whose interpretations were more successful perceived their knowledge and use of statistics as better. An extremely low number of students, 7.5%, disagreed that statistics is often misused, while only 14.2% trusted the research results presented in the media. The results from this study can be useful for curriculum developers, teachers, and researchers on statistical education.*

Keywords: *infographics, mean interpretation, non-STEM students, statistical literacy, STEM students, students' attitudes*

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Introduction

The understanding of statistical information is essential in many aspects of everyday life. Individually and collectively, people make choices based on the analysis of data presented in common consumer practices as well as in social and political debates, where data analysis becomes an important tool for active citizenship (Carvalho & Solomon, 2012; Maass et al., 2019). Public health and climate change are two examples of areas where the wrong data interpretations may cause huge negative consequences (Faghmous & Kumar, 2014; Park et al., 2021). In many professions, the ability to interpret data is crucial and the desired competencies are recommended by professional organizations, governments, and research papers (AlMuraie et al., 2021; Dönmez et al., 2022; Erydice, 2016). Zilinski et al. (2014) summarized the required skills as follows: "identify problems through data collection, apply logical processes to analyze information and draw conclusions, identify inconsistent or missing information, critically review, analyze, synthesize, compare and interpret the information" (p.2). The 21st-century skills in the domain of mathematics include techno-mathematical literacies which consist of mathematical knowledge, workplace and software knowledge, multi-step calculation and estimation, the ability to interpret abstract data, and communication skills (Hoyles et al., 2002, Hoyles et al., 2013). Data literacy, as a category of techno-mathematical literacies, proposes that the students must be able to analyze and interpret technical data and graphical representations, draw conclusions and take action accordingly (Wal et al., 2019).

The ability to critically interpret the data is being developed at all levels of education but students in higher education as future leaders and decision-makers should be especially well prepared and confident in their knowledge. STEM (Science, Technology, Engineering, and Math) undergraduates typically take statistics courses (Kaplar et al., 2021; Zilinski et al., 2014), but non-STEM (Social Sciences) undergraduates also get training in interpreting the data and statistics. Standardized tests are often used to evaluate their knowledge of statistics gained in statistics classes (Chan & Ismail, 2014; Garfield, 2003; Maddens et al., 2021). In comparison, this study aims to evaluate how well their skills transfer outside of their field. The students were asked to analyze data about the basic statistical concepts of distribution and mean presented

https://doi.org/10.33225/jbse/22.21.638

in the infographic. The variability is a fundamental concept in statistics so the concept must be understood well (Franklin et al., 2007). The mean is often calculated and interpreted as a center and/or mode which, depending on the distribution, may be wrong. The misinterpretation of the mean with the respect to typicality and distribution happens the most in everyday life (Jacobbe & Carvalho, 2011; Leavy & Middleton, 2011). This is not surprising because even though calculating the mean is not a very demanding task, the higher-order tasks that include understanding and interpretation are challenging (Cooper & Shore, 2008). The misconceptions or superficial understanding of measures of the center have been cited at all levels of education (Cai et al., 2000; Chatzivasileiou et al., 2011; Cooper & Shore, 2008; Mokros & Russell, 1995).

When the data is presented visually that may introduce an additional level of difficulty. Many studies show that even students in primary and secondary schools had difficulties in reasoning about the data when it was provided in visual form (Friel et al., 2001; McClain, 1999; Watson et al., 2003; Watson & Moritz, 2000). Undergraduate students also had difficulties in understanding the mean and variability when the data was presented in graphical form (Cooper & Shore, 2008; Watson & Moritz, 2000). On the other hand, graphical representations often attract the attention of the reader and are increasingly used in many professions and everyday life (Jimerson et al., 2019; Pardo, 2018). Educators emphasize the importance of teaching students to interpret visual communication well (DiStaso et al., 2009; Kent et al., 2011; Kim & Chung, 2012; Manalo et al., 2013). Infographics are a type of visual interpretation of the data intended to present the information quickly, and in an accessible form (Delello & McWhorter, 2015; Sudakov et al., 2016). A good infographic tells the story according to data and attracts a reader to the presented data and information (Siricharoen, 2013). The wide usage of infographics is not questionable but the research on an understanding of infographics is relatively new (Siricharoen, 2013). Although there are studies that examine the student's understanding of the mean which is given in the visual form, no studies have been found on the interpretation of the mean presented in infographics as is the case in this study. Also, the peculiarity of this study is that the infographics used are given in a real context, i.e., the original infographics published by official institutions, intended for the general public. As the infographic was published for the general public, the students were also asked how much they trusted the media, and how confident they were in their knowledge and use of statistics.

The students from Serbia and the USA were included in the study. In Serbia, there is a mandatory 8-year primary and lower secondary education which, in the end, has a standardized national examination. The students then pick the upper secondary school which can be three or four years long. The three-year upper secondary schools are considered vocational. Only students who complete 4-year upper secondary school can apply to the university. There is no examination at the end of upper secondary schools. Serbia joined Bologna Convention for Higher Education in 2003. This means that the students at the beginning of their study choose one of the nationally accredited programs and after they finish it, they get an appropriate recognition of academic qualification.

In the USA the children first complete a 5-year primary and 3-year lower secondary education. The curriculum is based on a state and county level, so significant differences in covered topics between schools exist. Upper secondary schools last 3-4 years. Because the education levels may vary depending on the upper secondary school attended, some colleges require their prospective students to take standardized tests such as SAT and ACT. All students in the study completed a 4-year upper secondary school before they started their studies at the university.

Due to the differences in culture and educational systems between Serbia and the USA, in this study, the students' interpretations of the infographic and their attitudes about the misuse of data and perception of their statistical knowledge were analyzed by the country. Other factors considered are STEM and non-STEM orientation, gender, and previous training in statistics. Although both STEM and non-STEM students usually have some training in data analysis and/or statistics, STEM students often have a greater need to understand and apply concepts related to data processing and statistics in their profession (Kaplar et al., 2021; Zilinski et al., 2014). It is expected that STEM students possess higher competencies in that area. However, it is uncertain how STEM students interpret data in everyday life, and that is why students' orientation was included in this study. Some earlier studies have found that training in statistics can have positive effects on students' achievements in data interpretation (DelMas et al., 2007; Gauvrit & Morsanyi, 2014; Gigerenzer et al., 2007; Masel et al., 2015). That is why a previously taken course in statistics was included as a factor. Although the students from different fields take different statistical courses, they should be able to interpret the data intended for the general public.

The research questions were:

- How well do the students interpret the statistical data presented in the infographic and are there any differences in students' interpretation by the factors (STEM and non-STEM orientation, country, gender, and training in statistics)?

https://doi.org/10.33225/jbse/22.21.638

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

- How much do students trust the reporting in the media, believe that statistics is misused, and how do they perceive their knowledge and use of statistics? Are there any differences in their attitudes by the factors (STEM and non-STEM orientation, country, gender, and training in statistics)?

Research Methodology

General Background

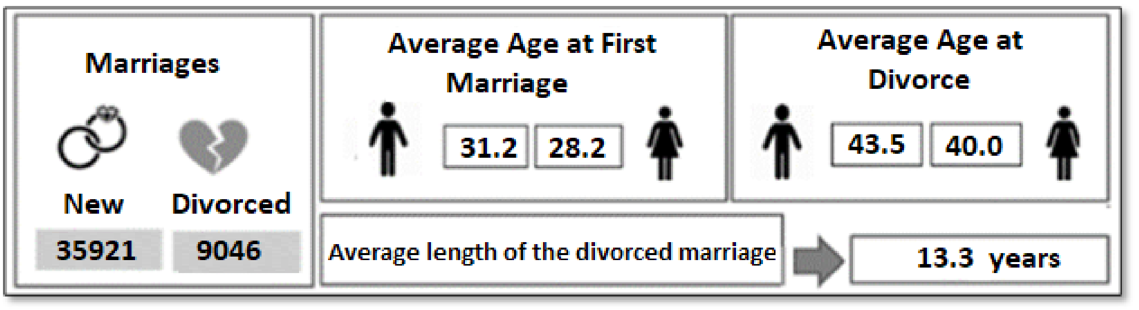
In this cross-sectional exploratory study, the current ability of undergraduates to interpret statistical data has been evaluated. Although the sample was large to include undergraduates from different study orientations and from two countries, for more general results, the sample must be even larger and include more countries. Students were asked to analyze the mean because the mean is a commonly used statistical measure that all undergraduates know about as opposed to many other statistical topics that require specific training in statistics. The mean was presented in infographics to attract the students' attention. The infographics are also commonly used, and the students should be able to interpret them well.

To answer the research questions, the study was conducted in two phases. In the first phase, the questionnaire was developed in a pilot study. The questionnaire consisted of demographic data, a four-question about the statistical infographic, statements about the students' attitudes related to the possible misinformation in the media reporting and misuse of statistics, and statements about students' perceptions of their knowledge and use of statistics. In the second phase, the questionnaire was filled out in the fall term of the academic year 2019-2020 at two public universities in Serbia and USA. Participants were STEM and non-STEM students.

Pilot Study

The pilot study was conducted during the spring term in 2018 at the University of Novi Sad, Serbia. 35 students who were in their final year of study in teaching mathematics were asked to choose one of the nine infographics about the population in Serbia and write an essay based on the chosen data. All participants previously completed the course in probability and statistics and were expected to be quite skilled in reading and interpreting the data. The infographics were published by the Statistical Office of the Republic of Serbia, and they cover different aspects of the population such as births, deaths, marriages, and divorces. The infographics can be viewed at the link[1] below. The pilot study was qualitative because it provided insight into students' thinking (Bogdan & Biklen, 1992; Groth, 2005). The purpose was to see how these students interpreted the public data. The greatest number of students chose the infographic about marriages and divorces. The infographic presents the number of new and divorced marriages, the average age of men and women at first marriage, the average age of men and women at divorce, and the average length of the divorced marriage. The data is from the year 2016. The infographic is shown in Figure 1.

Figure 1
Infographic about Marriages and Divorces for 2016.



[1] https://github.com/marijakaplar/Infographics

https://doi.org/10.33225/jbse/22.21.638

The qualitative analysis of the students' essays showed that out of nine essays, six included unfounded conclusions, while five had wrong conclusions. Another misconception was missing the fact that the data is reported for one year only (for the year 2016). The high number of wrong or unfounded conclusions indicates that even students who are majoring in mathematics tend to conflate the average with the mode. The examples of students' conclusions are in Table 1.

Table 1
The Examples of Students' Conclusions

Unfounded conclusions	Wrong conclusions
• Based on the demographic statistics of Serbia, the person should marry as late as possible, so that the person is mature enough to pick a partner well and thus reduce the number of divorces. • In the present times, the people got more freedom, so they marry more often but they divorce often too. • As the average age for men is 31.2 years and for women 28.2, we can conclude that divorces are not due to marrying too early.	• In 2016, out of 35921 marriages, 9046 got divorced. • Based on the results presented, already after 13 years, divorce follows.

The students' essays related to the infographic were analyzed and the most frequent poor interpretations were formulated as statements. Four of the most frequent incorrect statements are presented in Table 2.

Table 2
Students' Statements about the Infographic

No	Students' Statements
Q1.	In 2016 were 35921 marriages of which 9046 ended up in divorce.
Q2.	The average age at first marriage for men is 31.2 and for women, it is 28.2. Based on that we can conclude that divorces are not the consequence of getting married at a young age.
Q3.	Most men who got married had around 31.2 years and women had around 28.2 years.
Q4.	The average marriage lasts 13.3 years. Women most often get divorced at 40, while men get divorced at 43.5 years.

Q1 is about the relation and dependency between two numbers, Q2 is about the interpretation of the mean, while Q3 and Q4 are about the difference between the mean and the mode. These four false statements were included as True/False questions in the survey questionnaire. Since in True/False questions some answers may be correct by chance, an open-ended paragraph was added to each question where students had to justify their choice. This provided insight into students' answers and their reasoning (Hubbard et al., 2017; Kaplar et al., 2021) instructors must understand the affordances and limitations of available question formats. Here, we use a crossover experimental design to identify differences in how multiple-true-false (MTF. The reliability of the four questions was measured by Chronbach's Alpha. For completed 270 surveys, Chronbach's Alpha was .66, which is adequate (Taber, 2018).

The four True/False questions about infographics represent the main part of the questionnaire but four 5-point Likert questions were added to gain insight into students' attitudes towards the research presented in the media, possible misuse of statistics, and students' perception of their statistical knowledge. The statements evaluated on the Likert scale are presented in Table 3. Likert scale used is 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree).

https://doi.org/10.33225/jbse/22.21.638

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Table 3
The Statements about Students' Attitudes

No	Statements
S1	I believe the research results presented in the media.
S2	Statistics is often misused.
S3	My statistical knowledge helps me to critically read the results of published research.
S4	I use my statistical knowledge to better interpret any data.

S1 and S2 are about the possible misuse of statistics in media while S3 and S4 are about students' perceptions of their knowledge and use of statistics. The established questionnaires about the students' attitudes toward statistics such as the Attitudes Toward Statistics Scale (Wise, 1985) or Survey of Attitudes Toward Statistics Scale (Schau et al., 1995) consist of various sub-scales which measure a wide range of students' attitudes. Some of these subscales exceed the need of this explanatory study and that is why the number of questions related to students' attitudes and perceptions is limited to four. The general questions such as information about students' gender, and whether students took at least one course in statistics during their study at the university were also added to the questionnaire.

The questionnaire was tested at the end of the pilot study for clarity and completeness. 43 students completed the questionnaire. These students did not take part in the main research. The questionnaire was recognized as clear and interesting so minimal changes were made before the main research in phase two.

Sample

The sample consisted of 285 students from whom 270 were included in the study. About 6% of the sample were excluded from the study due to blank or incorrectly completed questionnaires. The sample was collected in the academic 2019-2020 year. The sample size was determined by the procedure of the sample-variable ratio increased by 20% due to the possible withdrawal of students. In the study, the sample-variable ratio was 60:1, which was higher than the minimum of 20:1 (Hair et al., 2018; Memon et al., 2020). 55.6% of the participants are from Serbia (University of Novi Sad) while 44.4% of participants are from the USA (Kent State University). The convenience sampling was implemented as the instructors from different fields conducted the survey in their classes voluntarily but because STEM and non-STEM orientation of students was expected to make a difference, every attempt was made to ensure that both orientations are represented well. The sample is presented in Table 4 by the factors of STEM and non-STEM orientation, gender, and country.

Table 4
The Sample

Orientation	Gender	State		Total gender	Total orientation
		Serbia	USA		
STEM	Female	17	18	35	88
	Male	33	20	53	
Non-STEM	Female	66	55	121	182
	Male	34	27	61	
Total		150	120		270

https://doi.org/10.33225/jbse/22.21.638

Out of 150 students from Serbia, 55.3% are female, while 44.7% are male. 33.3% are STEM students recruited from university departments related to electrical engineering. 66.7% are non-STEM students recruited from university departments related to economy and legal studies.

Out of 120 students from the USA, 60.8% are female, while 39.2% are male. 31.7% are STEM majors and 68.3% are non-STEM majors.

Procedure

The research for the participants in the USA was approved by Kent State Institutional Review Board, Kent State University, IRB log number: 19-047. In Serbia, the office of Mathematics vice-dean approved the research. The approval was also obtained from the offices of vice-deans of the colleges where the study was conducted. The survey in both countries included a paragraph about the purpose of the study and voluntary and anonymous participation. Data were collected during the 2019-2020 academic year, as a voluntary activity before, after, or during regular college classes at both universities. Anonymity was guaranteed to all students, and no rewards were offered for the survey completion. The data were collected by researchers or by trained instructors who explained the purpose of the research to students and who ensured that there were no instances of collusion. Most students completed the questionnaire well before the 20-min time limit.

Data Analysis

Three researchers independently reviewed and coded the student answers. The discrepancies were found in 3% of the questionnaires and these were reviewed and resolved. All four statements in the questionnaire were false. To count the answer as correct, the student had to circle "False" and give a good justification for his/her choice. Answers with "False" circled and with the wrong justifications were counted as wrong. Answers with "False" circled and no justification were omitted. There were only a few omitted answers. If the student marked the statement as "True", it counted as a wrong answer regardless of the existence of justification. This was done because in the pilot study was found that when students marked the statement as "True", they usually gave typical comments such as "It is obvious" or "I see it in the infographics". For this reason, justification wasn't required for the statements marked "True".

Students' answers per question were analyzed as a function of the students' STEM or non-STEM orientation, country, gender, and an earlier completed course in statistics. Logistic regression was conducted for the analysis of questions. Students' attitudes were analyzed using a student's t-test. In both cases, the R programming language was used for statistical computing (Version 3.5.1).

Research Results

Students' Interpretation of the Infographic

The total percent of correct answers for each question is 37.4% for Q1, 20% for Q2, 29.3% for Q3, and 25% for Q4 (Table 5).

Table 5
Students' Correct Answers with Correct Justification

	Serbia non-STEM	Serbia STEM	USA non-STEM	USA STEM	Total non-STEM	Total STEM	Total
	%	%	%	%	%	%	%
Q1/correct	21.0	50.0	40.2	57.9	29.7	53.4	37.4
Q2/correct	3.0	22.0	32.9	34.2	16.5	27.3	20.0
Q3/correct	21.0	46.0	20.7	47.4	20.9	46.6	29.3

https://doi.org/10.33225/jbse/22.21.638

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

	Serbia non-STEM	Serbia STEM	USA non-STEM	USA STEM	Total non-STEM	Total STEM	Total
	%	%	%	%	%	%	%
Q4/correct	19.0	34.0	20.7	36.8	21.4	35.2	25.0
Average	16.0	38.0	28.7	44.1	22.1	40.6	27.9

When students marked the correct answer and provided a wrong justification such answers were counted as wrong. There were 8 correct answers with the wrong justification in Q1, 28 in Q2, 20 in Q3, and 28 in Q4. The wrong justifications were caused either by the wrong mathematical conclusion or by justifying the answer based on personal belief rather than data. Justifications based on personal beliefs occurred mostly in Q2, Q3, and Q4.

Students' Interpretations of the Infographic with Respect to Factors

The analysis of the students' answers per question with respect to STEM and non-STEM orientation, country, gender, and statistics courses taken is presented in Table 6. The difference between STEM and non-STEM students was statistically significant in all questions except Q2. STEM students did significantly better in Q1, Q3, and Q4. The differences between countries were statistically significant in Q1 and Q2 where the students from the USA did better. Regarding gender, the only statistically significant difference was in Q2 where males did better than females. Students who earlier had a statistics course did better in Q1 and Q2.

Table 6
Students' Correct Answers by the Question, with Respect to Factors

Factor	Model Q1		Model Q2		Model Q3		Model Q4	
	B (SE)	Odds	B (SE)	Odds	B (SE)	Odds	B (SE)	Odds
Orientation								
non-STEM	-0.928*** (0.297)	0.395	-0.373 (0.363)	0.689	-1.076*** (0.306)	0.341	-0.566*** (0.316)	0.568
Country								
Serbia	-0.688*** (0.267)	0.503	-1.901*** (0.387)	0.150	-0.017 (0.281)	0.983	-0.041 (0.286)	0.960
Gender								
Male	-0.220 (0.280)	0.803	0.967*** (0.360)	2.631	-0.042 (0.292)	0.959	0.050 (0.297)	0.951
Course								
No	-0.575** (0.277)	0.563	-1.250*** (0.350)	0.287	-0.407 (0.294)	0.666	-0.435 (0.301)	0.647
Const	0.886 (0.330)		-0.159 (0.396)		0.054 (0.335)		-0.454 (0.343)	
Goodness of fit	**Statistic**	***p***	**Statistic**	***p***	**Statistic**	***p***	**Statistic**	***p***
-2LL	330.7	<.001	221.1	<.001	306.2	<.001	298.6	<.001
HL	5.1	.648	6.923	.437	8.8	.265	2.2	.904

Note. *B*- parameter estimate, *SE*-Standard error, Const.-intercept, -2LL-2Log-likelihood statistic (deviance), HL- Hosmer and Lemeshow's test, Statistic-value of chi-square statistic.
*$p < .05$. **$p < .01$. ***$p < .001$.

Overall, for all four questions, the average of correct answers for non-STEM students was 1.17 while for STEM students was 2.02. A Kruskal-Wallis test showed that such a difference is statistically significant $H(2)= 25.814$, $p < .001$.

https://doi.org/10.33225/jbse/22.21.638

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

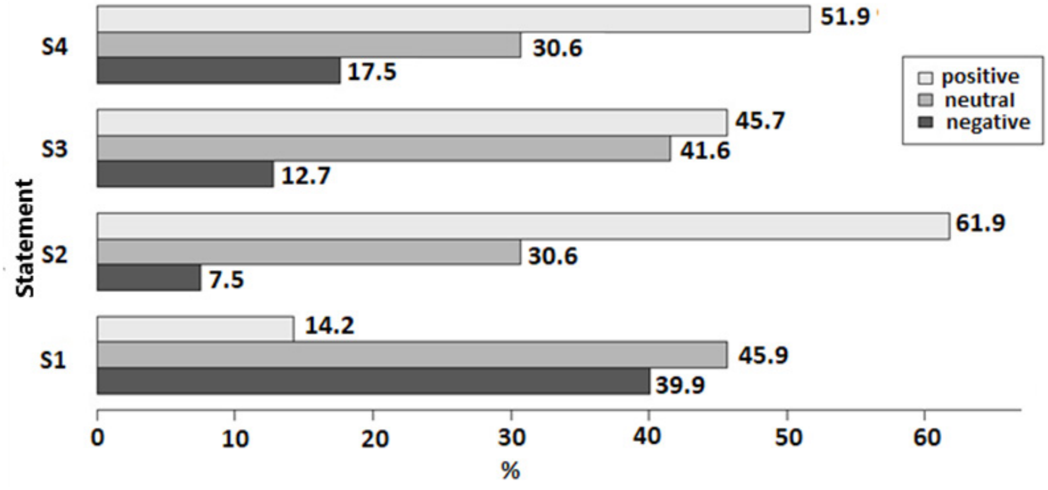
Students' Attitudes with Respect to Factors

The four statements about students' attitudes and percentages related to them are presented in Figure 2. In statement 1, "I believe the research results presented in the media.", 39.9% of students disagreed or strongly disagreed, 45.9% were neutral, while only 14.2% agreed or strongly agreed. There was no statistical difference between students' scores on the four-question assessment about the infographic and positive or negative student attitudes presented in S1 ($t = 0.70$, $p = .48$).

In statement 2, "Statistics is often misused.", 61.9% of students agreed or strongly agreed, 30.6% were neutral, while only 7.5% disagreed or strongly disagreed. These potentially alarming results showed the prevalence of negative perceptions of the media and the use of statistics in the media. There was no statistical difference between students' scores on the four-question assessment about the infographic and positive or negative student attitudes presented in S2 ($t = 1.92$, $p = .056$).

Students were mostly confident about their knowledge of statistics. In statement 3, "My statistical knowledge helps me to critically read the results of published research." 45.7% agreed or strongly agreed, 41.6% were neutral, while only 12.7% disagreed or strongly disagreed. The generally positive attitude towards their knowledge of statistics was confirmed in statement 4, "I use my statistical knowledge to better interpret any data.", where 51.9% of students agreed or strongly agreed, 30.6% were neutral, while 17.5% disagreed or strongly disagreed. There was a statistical difference between students' scores on the four-question assessment about the infographic and positive or negative student attitudes presented in S3 ($t = 2.04$, $p = .043$) and S4 ($t = 3.08$, $p = .002$). Students who had a positive perception of their knowledge also had higher scores on the four-question assessment than students with negative attitudes.

Figure 2
Students' Attitudes toward Misuse of Data and Students' Perception of their Knowledge



Note. Positive – students' answers agree (4) or strongly agree (5), neutral – students' answers neutral (3), negative – students' answers disagree (2) or strongly disagree (1)

The analysis of student attitudes with respect to different factors is presented in Table 7. In statement 1, "I believe the research results presented in the media.", there was a statistical difference between countries, and based on gender. Students from Serbia were more suspicious of the media than students from the USA. Males were more suspicious than females.

In statement 2, "Statistics is often misused.", there was a statistical difference between STEM and non-STEM orientation, gender, and previously taken courses in statistics. STEM students thought that statistics is misused more than non-STEM students. Males thought that statistics is misused more, as well as students who previously took a course in statistics.

In statement 3, "My statistical knowledge helps me to critically read the results in published research.", there was a statistical difference between countries and previously taken course in statistics. Students from the USA were

https://doi.org/10.33225/jbse/22.21.638

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

more confident in their knowledge of statistics than students from Serbia. Students who previously took a course in statistics were also more confident in their knowledge of statistics.

In statement 4, "I use my statistical knowledge to better interpret data.", there was a statistical difference between countries and previously taken courses in statistics. Students from the USA thought that they used their knowledge of statistics more than students from Serbia, as well as students who previously took a course in statistics.

Table 7
Students' Attitudes on Four Statements with respect to Factors

Factor	Group	Statement S1		Statement S2		Statement S3		Statement S4	
		M (*SD*)	*p*	*M* (*SD*)	*p*	*M* (*SD*)	*p*	*M* (*SD*)	*p*
Orientation									
	STEM	2.52 (0.97)	.283	4.2 (0.87)	<.001	3.53 (0.83)	.235	3.39 (1.06)	.120
	non-STEM	2.65 (0.91)		3.61 (0.94)		3.39 (0.94)		3.60 (0.93)	
Country									
	Serbia	2.36 (0.9)	<.001	3.89 (0.95)	.088	3.33 (0.96)	.033	3.29 (1.12)	.001
	USA	2.92 (0.88)		3.69 (0.96)		3.57 (0.82)		3.68 (0.83)	
Gender									
	Female	2.75 (0.84)	.004	3.65 (0.95)	.003	3.34 0.89	.052	3.37 (1.01)	.075
	Male	2.41 1.01		4.02 (0.93)		3.57 (0.93)		3.59 (1.02)	
Course									
	Yes	2.61 (0.94)	.962	4.13 (0.83)	<.001	3.62 0.81	.011	3.36 (1.09)	.033
	No	2.61 (0.92)		3.6 (0.98)		3.32 (0.95)		3.61 (0.89)	

Discussion

The four-question assessment about infographics measured how well undergraduates interpret the mean when they analyze the data published for the general public. The percent of correct answers that were well justified was low for all four True/False questions and that is a big concern. In Q1 there were 37% correct answers that also had a correct justification, 20% in Q2, 39% in Q3, and 25% in Q4. The low percentage of correct answers and the analysis of students' justifications of their choices suggest that, when reading infographics, students often misinterpret the mean and variance and/or conflate the mean and the mode. The lack of a deep understanding of the mean is a pervasive problem. Previous studies have shown that undergraduates are prone to mistakes when interpreting the mean given in a visual form through histograms, stem-and-leaf plots, and bar graphs (Cooper & Shore, 2008; Cui & Liu, 2021; Watson & Moritz, 2000). Similar to Kaplar (2022), superficiality and reasoning based on personal beliefs rather than analyzing the presented data were observed in this study as well. Weak skills in interpreting the mean were also reported in lower secondary and upper secondary education (Watson & Moritz, 2009). This implies that improvement in teaching statistics is needed at all educational levels, not only in higher education.

The lack of knowledge (in this case statistical knowledge), misunderstandings, misconceptions, and a superficial approach to answering questions are the barriers to critical thinking. To be able to think critically about the statistical data, the students must be trained well. Although in this study, the students who previously took a course

https://doi.org/10.33225/jbse/22.21.638

in statistics did better, the results were still disappointing because the scholarly knowledge was poorly transferred to the real-life situation. Similar conclusions were made in other studies where real-life statistical context was used (Castro Sotos et al., 2007; DelMas et al, 2007; Lavigne et al., 2008). How to ensure that students are trained well and that the statistical course is effective? A well-designed course can have positive effects on overcoming misconceptions (DelMas et al., 2007; Gauvrit & Morsanyi, 2014; Gigerenzer et al., 2007; Masel et al., 2015). The use of real-life data, context, and examples as well as simulations and animations help students to overcome misunderstandings of basic statistical concepts (Cui & Liu, 2021; Jamie, 2002; Kaplar, 2022; Neumann et al., 2011; Wang et al., 2011). The infographics engaged students well, so they have a strong educational potential and should be included in statistics courses.

Although different majors may include courses in statistics that differ in the topics covered, all undergraduates should be better prepared for interpreting the statistical data intended for the public. Repeated studies like this one should be able to detect the changes in students' ability to analyze the data.

STEM students outperformed non-STEM students in all questions but the percentage of correct answers for STEM students is still low. On the other hand, STEM students are increasingly expected to analyze information and draw conclusions based on it (Hoyles et al., 2002; Hoyles et al., 2013; Kriesberg et al., 2013; Zilinski et al., 2014). This brings up the significant gap between the students' preparedness and the expectations of what they can do. The differences between countries are significant in Q1 and Q2, both times in favor of the students from the USA. Non-STEM students in Serbia are the weakest group and need the improvement most.

Infographic used in the study was effective in attracting the students' attention so the use of infographics should be prominent in statistics education. The infographics must leave as little room for misinterpretation as possible. For example, infographics intended for the general population may include a text explanation along with infographics that would dispel the most common misinterpretations.

In the age of big data, statistical literacy is crucial. Training in statistics is an integral part of many curricula around the world and that is the reason why students' attitudes towards statistics are of more interest as well (Emmioğlu & Capa-Aydin, 2012; Hilton et al., 2004; Judi et al., 2011; Nolan et al., 2012). The majority of published studies investigated the students' attitudes toward a certain course in statistics (Donohue & Richards, 2009; Griffith et al., 2012; Mills, 2004; Rhoads & Hubele, 2000). In comparison, in this study, similar to Kaplar (2022), general students' attitudes were measured. The students generally do not trust the media and believe that statistics is often misused. They are fairly confident in their knowledge and use of statistics when interpreting data. STEM students believe that statistics is misused more than non-STEM students. Students from the USA are more confident about their knowledge of statistics and claim that they use that knowledge more. Students from Serbia are less trusting of the statistical reports in the media, and they feel that they use their knowledge of statistics less. Females trust the media more than males. Males think that they use their knowledge of statistics more than females. Students who previously took a statistics course at the university believe that statistics is often misused, and they believe that they use their knowledge of statistics more.

The earlier studies have shown that the students' attitudes toward data and statistics were often related to student achievement (Fullerton & Umphrey, 2001; Papanastasiou, 2008; Tapia & Marsh, 2001). This was confirmed in this study as well because students who did better in interpreting the infographic were also more confident in their knowledge and use of statistics.

Conclusions and Implications

The results of this study show that undergraduates interpreted statistical data presented in the infographic poorly. On the four-question assessment about the mean, on average, there were only 27.9% correct answers. Since the infographic represented the data intended for the general public, the results are even more alarming. They call for more and better training in statistics and critical thinking at all educational levels with a special emphasis on STEM orientation where the gap between the students' abilities and expectations of what they can do is the largest.

On some questions, STEM students performed better than non-STEM students, the USA students performed better than students from Serbia, and students, who previously had a course in statistics, performed better than students who did not.

With the respect to students' attitudes, the students mostly did not trust the media and believed that statistics is often misused. They were fairly confident in their knowledge and use of statistics when interpreting data. Students from the USA were less suspicious of media reporting, and they were more confident in their knowledge and use of

https://doi.org/10.33225/jbse/22.21.638

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

statistics than students from Serbia. Females were less suspicious of media reports and misuse of statistics. Males were more confident in their knowledge of statistics.

The general conclusion is that the skill of critically reading and interpreting statistical data needs to be developed more in both STEM and non-STEM students. The infographics that represent statistical data are effective at attracting attention and are expected to be used even more in the future both at work and in everyday life. The students need to be trained to read and interpret them well. As the students increase their knowledge and general skills, it can be expected that their confidence in the knowledge and use of statistics will grow.

Limitations

This study was conducted with a limited number of students and only at two universities. For cross-cultural differences, more universities and more countries need to be included. The students analyzed only one infographic and that is a limitation. The number of factors taken into the consideration is limited to STEM vs non-STEM, country, gender, and previously taken courses in statistics. Similar studies can be conducted at different educational levels.

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Received: *May 30, 2022*   Revised: *July 10, 2022*   Accepted: *July 29, 2022*

Cite as: Lužanin, Z., Kaplar, M., & Hrubik-Vulanovic, T. (2022). Undergraduate STEM and non-STEM students' interpretation of mean in an infographic. *Journal of Baltic Science Education*, *21*(4), 638-650. https://doi.org/10.33225/jbse/22.21.638

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https://doi.org/10.33225/jbse/22.21.638