

A Revised Bloom's Taxonomy: An Essential Approach to Constructing Assessment Questions for the Probability and Statistics Course

Faiz Zulkifli

Faculty of Computer and Mathematical Sciences Universiti Teknologi MARA, Perak Branch,
Tapah Campus, 35400 Tapah Road, Perak Malaysia

Rozaimah Zainal Abidin

Faculty of Computer and Mathematical Sciences Universiti Teknologi MARA, Perak Branch,
Tapah Campus, 35400 Tapah Road, Perak Malaysia

To Link this Article: <http://dx.doi.org/10.6007/IJARBS/v12-i3/13001>

DOI:10.6007/IJARBS/v12-i3/13001

Published Date: 17 March 2022

Abstract

Malaysia's education system has taken action to implement Malaysia's Education Development Plan 2015-2025 in response to the needs of the latest economic and educational revolution. The plan emphasises critical thinking abilities and STEM knowledge as key factors. However, an assessment approach that does not contain both parts is one factor contributing to the plan's lack of accessibility. Bloom's taxonomy is presented as a technique for determining the level of difficulty of assessment in STEM disciplines. One of the statistics courses was chosen to represent STEM. An essential approach has been implemented, which includes a qualitative method. The quality of an assessment question can be determined using a document analysis technique that involves reviewing a collection of question items, as well as revising Bloom's guidelines, verbs, and taxonomy descriptions for the course.

Keywords: Assessment Questions, Level of Difficulty, Revised Bloom's Taxonomy, Statistics Education, STEM.

Introduction

Bloom's theory strengths over other educational theories have been a contentious issue in various study perspectives. Revised Bloom's taxonomy was compared to various ideas and frameworks that can affect teaching, learning, and assessment processes in mathematics education (Radmehr & Drake, 2018). In its broadest-based approach, Bloom's theory has significant potential to be utilised to study teaching, learning, and assessment, according to the findings of the comparison. Bloom's idea can be used to align aspects of other theories and frameworks. However, there are still aspects of Bloom's theory that perhaps the theory and framework do not address.

The revised Bloom theory has a two-dimensional structure, which seems to be a benefit (Radmehr & Drake, 2018). These two dimensions typically have their own set of cognitive processes and knowledge that can be used independently or in tandem. Furthermore, the theory incorporates metacognitive information while rejecting tight hierarchies. The latest findings are likely to assist individuals involved in mathematics education in increasing the quality of teaching, learning, and evaluation in a subject whereby Bloom's theory is less often applied than in other fields.

There are still, however, studies that look back at the impact of Bloom's taxonomy on educational goals. Based on Piotr Galperin's research, Arievitch (2020) studied general ideas in contemporary psychology and education in terms of a teaching and learning development framework (TLD). Piotr Galperin developed a number of hypotheses for the development of intellectual action that can be used in education. According to the TLD approach, Bloom's taxonomy includes a number of conceptual flaws. The issue stems from a pervasive misunderstanding of how the human mind functions, how students learn, and how teachers are intended to educate.

Bloom's taxonomy is influenced by old mentalist assumptions and the "information processing" mechanism paradigm for human cognition (Arievitch, 2020). The most significant issue influencing education is this assumption. The TLD refutes the assertion that knowledge is not "information", but rather a set of actions that may be developed, manufactured, and replicated rather than being saved and retrieved. In terms of activities, one's thoughts on the mind and cognitive capacities of students are inextricably linked to one's deeds. It's not just the terminology issue of "information processing objectives" being divided into levels and levels. The concept of level words alters the entire conversation about teaching, learning, and educational goals.

As a consequence, the aim of the study is to reflect back on how to identify a question's level of difficulty using the revised Bloom's taxonomy and thus improve the quality of question items for STEM-related courses.

Literature Review

In evaluating the level of difficulty of a question, most test assessment providers nowadays choose to use Bloom's taxonomy (Grundspenkis, 2019). However, concerns about the construction method arose, and the questions were evaluated to guarantee that the level of difficulty of the questions that had been constructed was isolated. Based on Bloom's taxonomy, Sagala and Andriani (2019) suggested a process for producing high-level questions in probability theory courses. The procedure began with three experts in the field validating the questions. The findings revealed that two questions needed to be restructured. Following that, five students will be tested on questions that have been evaluated by experts. In addition, the results of the reading and practical tests were both excellent. Finally, utilising high-level questions generated against two classes, a field test was performed. The results of the students' average HOTS score are satisfactory.

The latest scholars in their studies have given attention to automation methods in the production of quality questions. The method is known as the intelligent guidance system (IGS). IGS is capable of automating pedagogical functions, problem selection and managing

assessments through the application of artificial intelligence, machine learning, multi-layer systems, ontology, semantic web and emotional computing (Grundspenkis, 2019). Grundspenkis has successfully developed an IGS that implements concept maps. Concept maps offer a fair balance between the determination of high-level knowledge based on Bloom's taxonomy and the complexity of an evaluation system. The system that has been developed is able to operate in a self-assessment mode as well as motivate students to improve their performance. However, the system is still incomplete where there are still small systems that have not been able to be integrated together.

An appropriate method of measurement needs to be determined in order to measure the quality of an assessment resulting from the revised Bloom's taxonomy. Talib et al (2018) employed the Rasch measurement model in measuring student performance on the final examination for the basic information technology course. The measurement model developed is based on the marks obtained from students on their final examination performance in the second year. Students' knowledge and understanding were measured based on three revised Bloom's taxonomy levels. The results show that students can be classified into weak, moderate, good, and excellent categories in accordance with the three taxonomy levels that have been set. In addition, the quality of the questions generated is adequate for the students being examined.

Zulkifli et al (2019) presented a recent study in which they provided a novel strategy for measuring the quality of final examination questions. To meet the study's principal goals, a multidimensional item response theory model, which is a more complicated method, has been presented. The model fit comparison, on the other hand, is based on log-likelihood, SE, AIC, and BIC statistics. These statistics, in conjunction with the Zh statistic, are required for identifying improper items and persons. The results of the model fitting revealed that all of the models utilised produced values for all acceptable and almost equivalent statistics. However, five items were deemed unacceptable. The study also recommended that the probability course's questions be enhanced in terms of quality by increasing the number of problems that require higher-order thinking skills.

Although there are more advanced methods for creating high-quality assessment questions, this study just looks at the basics of establishing the level of difficulty of questions for study subjects. This is due to a lack of studies or rules describing how a question is created early in the Bloom's taxonomy based on guidelines, verbs, and taxonomy descriptions.

Methodology

The document analysis approach, which is a qualitative research method, was used in this study. Document analysis is a process that uses content analysis to measure the features of a text or document (Cohen et al., 2018). The research data collected was an assessment question document for one of the statistics courses, specifically statistics and probability, which was obtained from lecturers who had taught. The selection of statistics courses as study subject is because the field of statistics also plays an equally important role in STEM education (Whitney et al., 2018). Furthermore, exposing students to statistical training at all stages of education can aid the country in expanding the number of STEM graduates. The collected question documents will undergo a review process to determine the difficulty level of the

questions using the six revised Bloom's taxonomy levels. Tables 1 and 2 show the level of difficulty in using the revised Bloom's taxonomy definitions and verbs.

To improve the teaching, learning, and assessment of mathematics courses, a revised Bloom's taxonomy is required (Radmehr & Drake, 2018). Table 1 shows the level differences between the traditional and contemporary Bloom's taxonomy (Sagala & Andriani, 2019).

Table 1. Differences between Traditional and Contemporary Versions of Bloom's Taxonomy

Traditional Version (Bloom, 1956)	Contemporary Version (Anderson et al., 2001)
Knowledge	Remembering
Understanding	Understanding
Application	Applying
Analysis	Analysing
Synthesis	Evaluating
Evaluation	Creating

According to Table 1, the differences between the two versions begin early. The remembering aspect has taken the role of the knowledge aspect in the previous version. Students are asked to remember topics in addition to learning them, which improves cognitive processes (Sagala & Andriani, 2019). Furthermore, the traditional version's synthesis feature has been merged into the new version's analysing feature. The parts of evaluating and creating have been moved to levels five and six in the new version. The new version of analysing, evaluating, and creating has improved the quality of high-level thinking.

The most difficult part of implementing Bloom's taxonomy is interpreting the level of the taxonomy in the context of cognitive processes that necessitate a comprehensive set of questions covering the full course topic. The first stage, as demonstrated in Table 2 with the revised Bloom's taxonomy verbs, is to define Bloom's level in a statistical context.

Table 2. Definitions and Verbs for Aspects of Revised Bloom's Taxonomy

Aspects	Definitions	Verbs
Remembering	Facts, terminology, basic concepts, and answers from learning materials are remembered by memory.	<i>Cite, Reproduce, Recall, Name, List, Describe, State, Recognise, Present, Match, Find, Underline, Relate, Quote, Memorise, Know, Define, Select, Recite, Organise, Locate, Extract, Tell, Record, Pronounce, Measure, Identify, Write.</i>
Understanding	By arranging, comparing, translating, interpreting, explaining, and stating essential ideas, the student expresses his or her understanding of facts and ideas.	<i>Account, Explain, Perform, Discover, Justify, Convert, Illustrate, Clarify, Find, Recognise, Exemplify, Paraphrase, Describe, Interpret, Comprehend, give examples, Change, Extend, Present, Distinguish, Match, Depict, Infer, Compare, Generalise, Alter, Express, Predict, Discuss, Locate, Defend, Indicate, Classify, Formulate, Relate.</i>
Applying	Individually, solving new problems using knowledge, facts, procedures, and rules is required.	<i>Apply, Manage, Verify, Modify, Illustrate, Demonstrate, Prepare, Change, Schedule, Paint, Make, Utilise, Dramatise, Classify, Sketch, Predict, Build, Manipulate, Evidence, Use, Discover, Produce, Operate, Assess, Manifest, Choose, Show, Direct, Present, Employ, Compute.</i>
Analysing	Analyse the information and determine the motivations or justifications for your actions. Make deductions and collect information to support your hypothesis.	<i>Analyse, Differentiate, Investigate, Debate, Illustrate, Classify, Examine, Associate, Distinguish, Outline, Diagram, Inspect, Criticise, Identify, Calculate, Evaluate, Ascertain, Dissect, List, Determine, Inquire, Contrast, Find, Break down, Divide,</i>
Evaluating	By evaluating information, the validity of ideas, or the quality of work based on particular standards, you can express and defend your opinions.	<i>Appraise, Recommend, Interpret, Describe, Criticise, Choose, Score, Justify, Estimate, Decide, Conceive, Support, Rate, Explain, Defend, Consider, Assess, Revise, Judge, Determine, Critique, Compare, Summarise, Measure, Evaluate, Deduce, Conclude, Value.</i>
Creating	Organize information in a variety of ways, as well as merge pieces into new forms and propose alternate solutions.	<i>Account, Devise, Modify, Construct, Initiate, Combine, Generalise, Arrange, Enlarge, Originate, Develop, Manage, Conceive, Image, Categorise, Formulate, Argue, Engender, Organise, Derive, Invert, Compose, Hypothesis,</i>

		<i>Begin, Explain, Alter, Elaborate, Order, Create, Integrate, Compile, Generate, Assemble, Expand, Pattern.</i>
--	--	--

The verbs are too imprecise to be used effectively, despite the fact that their stated definition is obvious for each level. As a result, the proposed second step is to provide a description for each topic at each level. Table 3 shows a breakdown of the revised Bloom's levels for the statistics and probability course based on the five topics. In the meantime, the analysis section will explore sample questions for each question difficulty level.

Table 3. Revised Bloom's Level Description

Topics	Descriptions
Remembering level	
Continuous random variable	Recall the definitions and formulas for density function, cumulative function, mean, standard deviation, quartile, and moment-generating function, as well as how to recognise graph for continuous variable.
Normal distribution	Recall the definitions and formulas for density function, mean, standard deviation, and moment-generating function, as well as the normal distribution's graph.
Special continuous distribution	Recall the definitions and formulas for density function, cumulative function, mean, standard deviation, and moment-generating function, as well as the graph for special continuous distribution.
Multivariate distribution	Recall the definitions and formulas of discrete and continuous multivariate distribution, conditional probability, marginal distribution, independent variable, mean, standard deviation and covariance.
Distribution function of random variable(s)	Recall the three techniques of the distribution function of one and two variables.
Understanding level	
Continuous random variable	Identify graph for continuous variable and explains and defines the principles of density function, cumulative function, mean, standard deviation, quartile, and moment generation function.
Normal distribution	Explains and defines the terms density function, mean, standard deviation, and moment generation function, as well as the normal distribution graph.
Special continuous distribution	Identify graphs for special continuous distribution and explains and clarifies the principles of density function, cumulative function, mean, standard deviation, and moment generation function.
Multivariate distribution	Explains and defines discrete and continuous of multivariate distribution, conditional probability, marginal distribution, independent variable, mean, standard deviation, and covariance.

Distribution function of random variable(s)	Explains and defines the techniques of the distribution function for one and two variables.
Applying level	
Continuous random variable	For continuous variable, calculate and find the values of density function, cumulative function, mean, standard deviation, and quartile.
Normal distribution	Calculate and find the values of the mean, standard deviation, and density of a normal distribution through a standard normal distribution.
Special continuous distribution	For special continuous distribution, calculate and find the values of density function, cumulative function, mean, and standard deviation.
Multivariate distribution	Calculate and find the values of discrete and continuous multivariate distribution, conditional probability, marginal distribution, independent variable, mean, standard deviation and covariance.
Distribution function of random variable(s)	Find the distribution function for one and two new variables.
Analysing level	
Continuous random variable	For continuous variable, identify density function, cumulative function, and moment-generating function.
Normal distribution	Identify the density function, mean, standard deviation and moment-generating function for normal distribution.
Special continuous distribution	Identify density function, cumulative function, mean, standard deviation and moment-generating function for special continuous distribution.
Multivariate distribution	Identify marginal distribution and independent variables.
Distribution function of random variable(s)	Identify the distribution function of one and two variables.
Evaluating level	
Continuous random variable	For continuous variable, evaluate the principles of density function, cumulative function, mean, standard deviation, quartile, and moment-generation function.
Normal distribution	For a normal distribution, evaluate the principles of density function, mean, standard deviation, and moment-generation function.
Special continuous distribution	For a special continuous distribution, evaluate the concepts of density function, cumulative function, mean, standard deviation, and moment-generation function.
Multivariate distribution	Evaluate the principles of discrete and continuous multivariate distribution, conditional probability, marginal distribution, independent variable, mean, standard deviation, and covariance.

Distribution function of random variable(s)	Compare the concepts of the distribution function of one and two variables.
Creating level	
Continuous random variable	Derive density function, cumulative function, mean, standard deviation, quartile, and moment-generating function for continuous variable.
Normal distribution	For the normal distribution, derive the density function, mean, standard deviation, and moment-generating function.
Special continuous distribution	Derive the density function, the cumulative function, mean, standard deviation, and moment-generating function for a special continuous distribution.
Multivariate distribution	Generates multivariate distribution of discrete and continuous variables, conditional probability, marginal distribution, independent variable, mean, standard deviation, and covariance.
Distribution function of random variable(s)	Derive the distribution function of one and two variables.

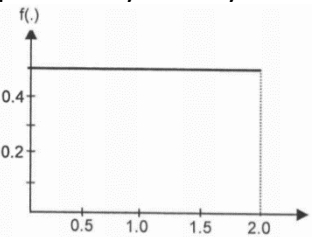
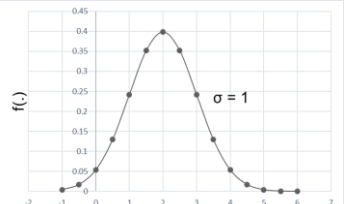
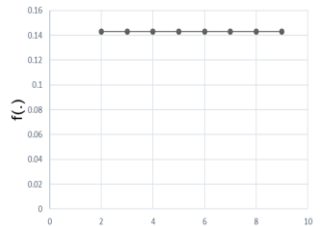
Discussion

According to Radmehr and Drake (2018), instructors use a level of "remembering" to determine whether students can recall definitions or solutions they have previously learned. It is seen when students can articulate or describe a definition or solution to a learning topic, they have studied using their own ideas or ways of working, as relating to the level of "understanding" (Tekkumru-Kisa & Stein, 2017). Meanwhile, the level of "applying" is done by the instructor to test the ability of students to apply the definitions and formulas that have been learned correctly. At this level, skills from the "remembering" and "understanding" levels are necessary (Fleckenstein et al., 2016).

Students must perform logical steps to discover the most acceptable strategy to use for a certain circumstance based on ways they have seen before at the "analysing" level (Watan & Sugiman, 2018). The "evaluating" level requires students to assess information gathered from a variety of sources without any guidance or linkages to build. Students must be able to assess, criticise, and compare existing methodologies or measures (Tai et al., 2017). Meanwhile, the "creating" level encourages students to use what they've learned to come up with new approaches, techniques, or models for solving an issue (Koretsky et al., 2018). The revised Bloom level sequence's highest levels, "evaluating" and "creating," require HOTS from students and are rarely assessed at the diploma or degree level, especially the "creating" level (Dunham et al., 2015).

Table 4 shows examples of questions for the statistics and probability course that have undergone document analysis according to each topic and level of difficulty.

Table 4. Sample Questions Organised by Topic and Difficulty Level

Topics	Sample of questions
Remembering level	
Continuous random variable	<p>Identify whether the figure below could be the graph of the probability density function (pdf), $f(.)$. Give your reason.</p> 
Normal distribution	<p>The following figure is the graph of pdf, $f(.)$ of continuous random variable. Identify and name of the distribution with its parameter(s).</p> 
Special continuous distribution	<p>The following figure is the graph of pdf, $f(.)$ of continuous random variable. Identify and name of the distribution with its parameter(s).</p> 
Multivariate distribution	<p>Suppose that the joint probability distribution function of X and Y is:</p> $P(X = x, Y = y) = \begin{cases} \frac{x + y}{48}, & x = 0, 1, 2, 3; y = 0, 1, 2, 3 \\ 0, & \text{elsewhere} \end{cases}$ <p>Present the joint probability distribution table of X and Y.</p>
Distribution function of random variable(s)	<p>Name three techniques to find the distribution function of random variable.</p>
Understanding level	
Continuous random variable	<p>The length of time Y in days required for a Zika's virus to be active in human body from has density function as follows:</p> $f(y) = \begin{cases} \frac{1}{4} e^{-\frac{y}{4}}, & 0 \leq y < \infty \\ 0, & \text{elsewhere} \end{cases}$

	Clarify that the above pdf is a continuous probability distribution.
Normal distribution	Given the pdf of a random variable Y is $f(y) = \frac{1}{\sqrt{4\pi}} \exp\left(-\frac{(y-1)^2}{4}\right), -\infty < y < \infty$. Find the mean and variance of Y .
Special continuous distribution	The number of emergency calls received by a Hospital in a randomly chosen day can be modelled by a Poisson distribution with mean 6. Let X denotes the waiting times the next 3 calls received. Recognise the distribution of X with its parameter(s).
Multivariate distribution	A box contains 3 lemons and 2 oranges. Suppose that two pieces of fruits are picked randomly one by one with replacement. Let X denotes the number of lemons and Y denotes the number of oranges picked. Present the joint probability distribution table of X and Y .
Distribution function of random variable(s)	Describe the steps involve for determine distribution function of random variable using the mgf technique.
Applying level	
Continuous random variable	Let the continuous random variable, Y denote the length of time to failure (in hundreds of hours) for a transistor with pdf given by: $f(y) = \begin{cases} \frac{y}{4}, & 0 \leq y < 2 \\ \frac{4-y}{4}, & 2 \leq y < 4 \\ 0, & \text{elsewhere} \end{cases}$ Compute the probability that the transistor operates for between 50 and 350 hours.
Normal distribution	Given the weights of Malaysian women are normally distributed with mean 70 kg and variance 25 kg. Compute the probability of Malaysian women who are less than 75 kg.
Special continuous distribution	A lecturer is assigning an assignment to his students. The time of students will finish their assignment has an exponential distribution. The probability of students will finish their assignment in the first 3 days is 0.4. Compute the probability that the students will not finish their assignment in the first 5 days.
Multivariate distribution	Suppose that the joint probability distribution function of X and Y is: $P(X = x, Y = y) = \begin{cases} \frac{2y+x}{42}, & x = 0,1,2,3; y = 0,1,2 \\ 0, & \text{elsewhere} \end{cases}$ Compute the expectation of X and Y .

Distribution function of random variable(s)	Given the pdf of a random variable Y is $f(y) = \begin{cases} 2e^{-2y}, y > 0 \\ 0, \text{ elsewhere} \end{cases}$. By using the distribution function technique, find the pdf of $X = 2Y + 1$.																
Analysing level																	
Continuous random variable	If the probability density of a random variable is given by: $f(x) = \begin{cases} \frac{3}{16}x^2, -c \leq x \leq c \\ 0, \text{ elsewhere} \end{cases}$ Find the constant c so that $f(x)$ is a pdf.																
Normal distribution	Given that $X \sim N(\mu, \sigma^2)$, $P(X < 2) = 0.0668$ and $P(X > 4) = 0.1587$. Determine μ and σ .																
Special continuous distribution	Given the mean and variance of a random variable Y are $E(Y) = 8$ and $Var(Y) = 16$, respectively. Identify its possible pdf and mgf.																
Multivariate distribution	Suppose that X and Y are two independent discrete random variables. The marginal distributions of X and Y is given as follows: <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>x</td> <td>2</td> <td>4</td> <td>6</td> </tr> <tr> <td>$P(X=x)$</td> <td>0.4</td> <td>0.1</td> <td>0.5</td> </tr> <tr> <td>y</td> <td>1</td> <td>3</td> <td>5</td> </tr> <tr> <td>$P(Y=y)$</td> <td>0.25</td> <td>0.35</td> <td>0.4</td> </tr> </table> Find the joint probability distribution table of X and Y .	x	2	4	6	$P(X=x)$	0.4	0.1	0.5	y	1	3	5	$P(Y=y)$	0.25	0.35	0.4
x	2	4	6														
$P(X=x)$	0.4	0.1	0.5														
y	1	3	5														
$P(Y=y)$	0.25	0.35	0.4														
Distribution function of random variable(s)	Let X and Y are independent Binomial random variables, $X \sim Bin(n, p)$ and $Y \sim Bin(m, p)$. By using the mgf technique, find the pdf of $W = X + Y$.																
Evaluating																	
Continuous random variable	The cumulative distribution function of a random variable Y is given by: $F(y) = \begin{cases} 0, y < 0 \\ \frac{y}{5}, 0 \leq y \leq 5 \\ 1, y > 5 \end{cases}$ Determine the moment generating function (mgf) of Y .																
Normal distribution	Suppose the pdf of a random variable X is $f(x) = \frac{1}{\sqrt{18}\Gamma(1/2)} \exp\left(-\frac{(x-2)^2}{18}\right), -\infty < x < \infty$ $-\infty < x < \infty$. Determine the mgf of X .																

Special continuous distribution	<p>Let X represents time (in hours) taken to repair a certain type of machine have a gamma distribution with the following pdf:</p> $f(x) = \frac{xe^{-\frac{x}{3}}}{9}, x > 0$ <p>Suppose $P = 5X + 3X^4$ be profit (in RM) due to this time taken. Determine the average profit.</p>
Multivariate distribution	<p>Suppose that the joint probability density function of X and Y is given by:</p> $f(x, y) = \begin{cases} 2, & 0 < x < y < 1 \\ 0, & \text{elsewhere} \end{cases}$ <p>Determine the covariance between X and Y. Interpret the value obtained.</p>
Distribution function of random variable(s)	<p>Given the pdf of a random variable X is $f(x) = \begin{cases} \frac{3}{2}x^2, & -1 < x < 1 \\ 0, & \text{elsewhere} \end{cases}$.</p> <p>By using the transformation technique, determine the pdf $Y = X^2$.</p>
Creating level	
Continuous random variable	<p>The probability density function of a random variable X is given by:</p> $f(x) = \begin{cases} \frac{1}{5}, & 0 \leq x \leq 5 \\ 0, & \text{elsewhere} \end{cases}$ <p>Derive the mean of X by using the mgf method. [Hint: Use Taylor series to expand the mgf first]</p>
Normal distribution	<p>Given the pdf of a random variable X is $f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right), -\infty < x < \infty$. Derive that $\int_{-\infty}^{\infty} f(x) dx = 1$.</p>
Special continuous distribution	<p>Given the pdf of a random variable Y is $f(y) = \frac{1}{2^{\frac{v}{2}} \Gamma(\frac{v}{2})} y^{\frac{v}{2}-1} e^{-\frac{y}{2}}, y > 0$. Derive the mgf of Y.</p>
Multivariate distribution	<p>Expand the definition of the variance, $Var(X + Y) = E[(X + Y)^2] - [E(X + Y)]^2$.</p>
Distribution function of random variable(s)	<p>Let X_1, X_2, \dots, X_{10} be independent random variables from a standard normal distribution. By using the mgf technique, derive the expected of $W = \sum_{i=1}^{10} X_i$.</p>

As demonstrated in Tables 1 to 4, the entire procedure can provide a collection of questions that have been verified for their difficulty levels along with revised Bloom's taxonomy guidelines, verbs, and taxonomy descriptions. The question bank might serve as a resource for novice instructors attempting to create assessment questions of varying levels of complexity.

Conclusion

This research has proposed an essential approach to developing assessment questions for STEM-related courses. The revised Bloom taxonomy, which contains guidelines, verbs, and descriptions, is used to check the level of complexity of the assessment questions using document analysis, which is a qualitative method. Despite the fact that some academics have used Bloom to determine the level of difficulty for statistics courses, no studies have focused on statistics and probability course as STEM disciplines. The authors feel that the key processes proposed can be extended to other STEM-related courses with a higher cognitive component. As previously stated, instructors can use Bloom's taxonomy to help them develop assessment questions that incorporate multiple levels of mastery and are of varying degrees of difficulty.

The generated question bank may be used as a teaching aid as well as to assist in the process of writing examination questions. Students should be exposed to the breadth of cognitive processes required to solve statistical and probability problems, and their attitudes about learning the subject should be changed as a result. Furthermore, it is hoped that this study's attempt to describe and pseudo-objectively categorise the depth of thought processes required for problem solving in theoretical statistics can also help teachers refine their curriculum and assessment tools, as well as students develop their meta-cognitive skills toward the course.

The method proposed in the study, on the other hand, is only suited for use in the early stages of the development of assessment items with varying levels of difficulty. As a result, more complex approaches such as expert evaluations, field testing, and measuring techniques that can assess how closely the questions generated match the students' actual abilities are required. All of the further research that has been offered is more scientific and holistic in nature.

Acknowledgement

The authors would like to express their gratitude to all parties involved in the production of this work, especially Universiti Teknologi MARA. The authors also wish to express their gratitude to the reviewers and editor of the journal.

Corresponding Author

Faiz Zulkifli

Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, 35400 Tapah Road, Perak, Malaysia

Email: faiz7458@uitm.edu.my.

References

- Anderson, L. W., Krathwohl, D. R., P.W., A., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Wittrock, M. C. (2001). *A Taxonomy for Learning, Teaching, and Assessing: a Revision of Bloom's Taxonomy of Educational Objectives*. New York: Longman.
- Arievitch, I. M. (2020). The Vision of Developmental Teaching and Learning and Bloom's Taxonomy of Educational Objectives. *Learning, Culture and Social Interaction*, 25, 100274.
- Bloom, B. S. (1956). *Taxonomy of Educational Objectives – Handbook 1 Cognitive Domain*. London: Longman.
- Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods in Education* (8th ed.). Routledge.
- Dunham, B., Yapa, G., & Yu, E. (2015). Calibrating the Difficulty of an Assessment Tool: The Blooming of a Statistics Examination. *Journal of Statistics Education*, 23(3).
- Fleckenstein, J., Leucht, M., Pant, H. A., & Köller, O. (2016). Proficient Beyond Borders: Assessing Non-native Speakers in a Native Speakers' Framework. *Large-Scale Assessments in Education*, 4(1).
- Grundspenkis, J. (2019). Intelligent Knowledge Assessment Systems: Myth or Reality. *Frontiers in Artificial Intelligence and Applications*, 315, 31-46.
- Koretsky, M., Keeler, J., Ivanovitch, J., & Cao, Y. (2018). The Role of Pedagogical Tools in Active Learning: a Case for Sense-making. *International Journal of STEM Education*, 5(1).
- Talib, M. A., Alomary, F. O., & Alwadi, H. F. (2018). Assessment of Student Performance for Course Examination Using Rasch Measurement Model: A Case Study of Information Technology Fundamentals Course. *Education Research International*, 2018, 1–8.
- Radmehr, F., & Drake, M. (2018). Revised Bloom's Taxonomy and Major Theories and Frameworks That Influence the Teaching, Learning, and Assessment of Mathematics: a Comparison. *International Journal of Mathematical Education in Science and Technology*, 50(6), 895-920.
- Sagala, P. N., & Andriani, A. (2019). Development of Higher-Order Thinking Skills (HOTS) Questions of Probability Theory Subject Based on Bloom's Taxonomy. *Journal of Physics: Conference Series*, 1188(1), 1–13.
- Tai, J., Dawson, P., Panadero, E., Boud, D., & Ajjawi, R. (2017). Developing Evaluative Judgement: Enabling Students to Make Decisions About the Quality of Work. *Higher Education*, 467–481.
- Tekumru-Kisa, M., & Stein, M. K. (2017). A Framework for Planning and Facilitating Video-based Professional Development. *International Journal of STEM Education*, 4, 28.
- Watan, S., & Sugiman. (2018). Exploring the Relationship Between Teachers' Instructional and Students' Geometrical Thinking Levels Based on Van Hiele Theory. *Journal of Physics: Conference Series*, 1097(1).
- Whitney, B. M., Cheng, Y., Brodersen, A. S., & Hong, M. R. (2018). The Scale of Student Engagement in Statistics: Development and Initial Validation. *Journal of Psychoeducational Assessment*, 37(5), 553-565.
- Zulkifli, F., Abidin, R. Z., & Mohamed, Z. (2019). Evaluating the quality of exam questions: A multidimensional item response. *International Journal of Recent Technology and Engineering*, 8(2 Special Issue 11), 606–612.