COMESc Model Learning Effectiveness To Grow Student's Statistical Thinking Ability

1. Tan Hian Nio
   Mathematics education, S3 Student at Semarang State University
   Mathematics education, Indonesian Christian University
   hiannio.tan@gmail.com
2. Hardi Suyitno
   Mathematics education, Semarang State University Department
3. Kartono
   Mathematics education, Semarang State University Department
4. Scolastica Mariani
   Mathematics education, Semarang State University Department
5. Wardono
   Mathematics education, Semarang State University Department
6. Bitman Manullang
   Mathematics education, Indonesian Christian University

Abstract

The purpose of this development research is to produce a valid and effective COMESc learning model in the introductory learning of inferential statistics at the preparatory level of mathematics education students. To determine the validity and effectiveness of the model, expert verification sheets, questionnaire responses from lecturers and observers were used, as well as student learning outcomes tests. The results of data analysis show the average level of model validity from 92 experts which is classified as very valid. The COMESc learning model is effective with a learning achievement of at least 70 as seen from the gain normality index of 0.46. This result is strongly influenced by the learning model given with Cohen's D effect size value of 3.36. Thus, it can be concluded that COMESc learning is effectively used in introductory inferential statistics lectures to develop statistical thinking skills.

Keywords: Model, COMESc, Effective.

Introduction

Statistical thinking is needed in many areas of life. This thinking can be obtained by getting students used to upholding thinking as an initial activity to acquire correct knowledge (Suriasumantri, 2003). The emergence of gaps stems from the educational process (Kasali, 2013) which does not develop thinking processes among students. Snee (1993) states that statistical education is experiencing serious problems and needs to be changed. This change was necessary because in general, people do not understand statistical thinking, and as a result do not appreciate its use. People cannot appreciate what they don't understand, Belinda (2008).

The results of the researcher's study as preliminary research in the mathematics education study program at UKI which were carried out in five lectures at the beginning of the odd semester of the 2020/2021 academic year and the results of informal discussions conducted by researchers with teaching lecturers in statistics researchers summarized a number of real problems which were grouped into two parts, namely weakness of academic quality and weakness of learning (instructional). Academic weaknesses in the study material Introduction to Basic Statistics are classified in 6 terms. First, the weakness in understanding the basic concepts: probability distribution, central tendency, variability, analysis of variance, correlation, regression; Second, they do not understand what elements are known and their relation to what is being asked in the given problem; Third, has not been able to formulate problems and formulate hypotheses clearly; Fourth, have not been able to choose the right statistics to use including the reasons underlying the selection and use of statistics; Fifth, carrying out the mathematical calculation process to process quantitative data did not end well; Sixth, it has not been able to give meaning or interpretation to the statistical values (physical meaning) obtained from the calculation results. This is reinforced by the findings of a previous study, Hian Nio. T. (2021) by providing a statistical test conducted by researchers on 32 students of mathematics education study program at the Indonesian Christian University in Jakarta which showed that approximately 24 (75%) were weak in understanding the meaning of mean, median, mode; 18 (56%) were weak in interpreting the data variance; as many as 26 (81%) have not been able to choose and determine which statistics are appropriate to use in cases that arise in actual problems, such as the use of statistics z, t, r, R, F, weak in giving meaning or interpretation of the results of calculations from data, the characteristics of the sample as a representation of the population, recognizing the categorization of quantitative or qualitative data, giving meaning to the results of hypothesis testing based on the statistical data provided. This case is a basic problem in studying statistics courses. These ideas and thoughts are very interesting for researchers so that the phenomenon (symptoms) in the form of a lack of learning model references can be minimized through changes and improvements in the quality of the learning process. One of them is by changing the tendency of the conventional learning approach to the COMESc learning model, which can guide students in developing the quality of learning performance and learning outcomes in statistical learning. This learning model is thought to be able to bridge problems and provide improvements to improve the quality of learning performance and continuous statistical thinking skills (statistical thinking culture improvement).

Research Objectives (Purpose of study)

The purpose of developing the COMESc model is to produce a valid and effective learning model for introductory courses in inferential statistics at the level of preparation for mathematics education students.

Significance of the research

The findings of this research and development provide a positive contribution for students and lecturers to develop statistical thinking skills that will be used in mathematics education and everyday life. The research results are important in improving the quality of mathematics education.

Research Question

1) What is the strategy used to develop the COMESc learning model in order to produce a valid and effective model?
2) How to implement the COMESc learning model in order to produce a minimum of 70 statistical thinking learning outcomes?

Literature Review

The COMESc learning model was developed by researchers based on constructivist learning theory (Constructivist), meaningful learning theory (Meaningful), and scientific approach (Scientific). These three theories in an abbreviated phrase COMESc. The COMESc learning model is a learning concept to (1) help students to be able to develop statistical thinking skills, (2) relate the practical meaning of statistical thinking to real situations, and (3) develop the ability to communicate the statistical knowledge gained. The COMESc learning model developed by researchers can help and develop students' statistical thinking. The COMESc learning model has special characteristics that distinguish it from existing learning models and conventional learning. The characteristics of the COMESc model are (1)) developing knowledge schemas, (2) building schema associations with the reality they face, (3) developing communication skills and skills, (4) understanding statistical thinking concepts while seeing practical benefits in life. These main characteristics are developed in the COMESc model.

This model will make changes and differences in the learning process that adapts the thinking of the millennial generation (smartphones) who are connected (networked), curious (wanted to know), customize (habits), crackers (available) (Kasali, 2013).

The COMESC learning model is a thinking model or construction that describes a systematic procedure in administering, organizing, implementing, and evaluating learning activities based on the process of adjusting initial knowledge to new knowledge and its development and mapping its meaning through a scientific approach in real life.

Initial knowledge in this case is knowledge possessed by students which is obtained either through experience in previous education or through social experience. Meanwhile, new knowledge is intended as material for inferential statistical studies that are taught during research and model development.

According to Gagne (1985) human behavior is very varied and different resulting from learning. Gagne suggests that behavior can be observed in the form of abilities (capabilities) and skills as a result of internal and external learning conditions. Internal conditions relate to what abilities are obtained from previously studied or in other words what is known before new (instructional) learning is received. External conditions deal with externally given stimuli such as what instructions are given to students. In order to develop students' statistical thinking skills, the researchers developed the COMESc learning model. The development of the COMESc model uses the development of the Plomp learning model (1997) which consists of phases: initial investigation, design, realization or construction, test, evaluation and revision and model implementation.

Statistical thinking according to Garfield (2003) is the ability to understand statistical processes in data which consists of: recognizing the context of a problem, the activities carried out starting from collecting data through instruments, selecting analyzes to testing assumptions to obtain conclusions.

Statistical thinking operational words based on Delmas (2002) are associated with the appropriate operational verb indicators in Bloom's taxonomy (Anderson-Kathrowl, 2001) used in statistical thinking indicators as shown in the table below:

Table .1. Statistical Thinking Indicator

Statistics Thinking	Scoring, comparing, rating, estimating, making decisions.
Apply	Select, formulate, apply, use
Criticize	Give consideration to the process of right or wrong, accept or reject.
Evaluate	Verbs used in each indicator
Make conclusions.	Make statistical conclusions based on data or information.

According to Joyce and Weil (1980) a model has the following parts: syntax, reaction principle, social system, support system.

The COMESc learning model must have a clear goal of what will be achieved in the design of the model. The purpose of the design of the COMESc learning model is to develop students' statistical thinking skills which consist of the ability to: (a) apply, (b) criticize, (c) evaluate, (d) draw conclusions from existing data and information.

In Permendikbud Number 3 of 2020 Article 11 it is stated that the characteristics of the learning process include being effective, scientific, collaborative, and student-centered.

Effective means that the learning outcomes of graduates are achieved effectively by emphasizing the internalization of the material properly and correctly in an optimum period of time. This states that the effectiveness of learning outcomes in three categories of learning outcomes (attitudes, knowledge, skills) is important to be internalized (understood, mastered, internalized, inspired) in value and applied in the practice of solving problems encountered with maximum and effective results.

Collaborative means that the learning outcomes of graduates are achieved through a joint learning process that involves interaction between individual learners to produce the capitalization of attitudes, knowledge, and skills.

Student-centred means that graduate learning outcomes are achieved through a learning process that prioritizes the development of creativity, capacity, personality, and student needs, as well as developing independence in seeking and finding knowledge.

Akker (1999) states that the effectiveness of a learning model refers to the level of experience and the outcome of the intended intervention. This means that the effectiveness of a learning model is seen from the quality of learning outcomes, attitudes, and motivation of students.

To see the learning effectiveness of the COMESc model, the researcher uses the opinion of Cashin in Moody and Sindre (2003:3) which states that theoretically the best way to evaluate the effectiveness of learning is to see a comparison of the achievement of increasing achievement test results in the final exam between one year and the following year or in one year. years of study at the university.

The effectiveness of a learning model is seen from the quality of learning outcomes obtained through a comparison of the achievement of increasing achievement test results on the exam one unit time to the next,

Framework of thinking

By exploring the causes of difficulties experienced by students in studying statistics and their impact, studying theories of model development, observing the existing findings, encouraging researchers to be determined to develop the COMESc learning model as an alternative for learning statistics.

The steps for developing the COMESc learning model and its tools are based on the educational model development theory from Plomp (1997) which contains five phases of activity, namely: initial investigation phase, design phase, realization/construction phase, limited test phase, evaluation and revision, and implementation phase. model (in a limited way) to meet a valid and effective learning model.

To meet the criteria for the validity of the COMESc model theoretically, this research and development is supported by mathematics education experts. When the model and its devices according to expert judgment are declared theoretically valid, the model is tested.

To test the criteria for the effectiveness of the model, the researcher conducted a formative test and a final test at the location of the model development trial. The model trial was assisted by mathematics education lecturers, each 2 lecturers implementing the learning model and 4 lecturers as observers, as well as informants of the test subject as many as 26 students at the Semarang State University (UNNES).

Learning with the COMESc model has special characteristics, namely: exploring prerequisite knowledge at the beginning of the lecture. By discussing and understanding the prerequisite material on each new topic appropriately and well, it will greatly help facilitate students in constructing new concepts and understanding the study materials presented next.

Then solve problems with the help of Worksheets and Discussions (LKMD) to work on problems or questions. The learning format in the LKMD creates dynamic learning conditions and provides sufficient activity space for students to study. grow and create learning activities to share knowledge

with each other by following the sequence of problem solving given. Therefore, statistical problems can be solved very well or even very well.

With this learning strategy, student learning progress becomes controlled and measurable which is displayed in worksheets and then further presented and the quality of learning performance is getting better, learning progress is growing, increasing in a directed, measurable way which has implications for increased academic achievement (outcomes), the better and even very good as expected by the lecturer. The criteria for validity are very good and are ready to be tested in lectures.

Methodology

In this research, research and development (R&D) is used. The strategy for developing the COMESc learning model for the purpose of producing a valid and technically effective model uses a manual prepared by researchers to guide lecturers in teaching, Worksheets that contain the sequence of activities carried out by students and the student team achievement development (STAD) method to condition and familiarize students with work. together to solve problems in a work team of 3-4 students.

Participants in this model development research consisted of 26 students as respondents and 2 lecturers as implementers of model testing. Implementation of a limited trial for six months starting in October 2020 at the Semarang State University (UNNES) Mathematics Education Study Program. Development data were obtained through questionnaires to validators, lecturers and students as well as through tests. The statistical thinking test and instrument have been validated by the Expert. The data obtained were analyzed with the normality of gain and size effect of Cohen's D.

Results and discussion.

Results

The results of data analysis obtained from validators regarding the validity of the model indicate that the COMESc learning model is declared valid with an average score of 92.

Formative test results data obtained during the implementation of learning consisted of scores of pre-test, test 1, test 2, test 3, and final test. Analysis of test scores in Table 2 illustrates that there is an increase in academic achievement starting from the pre-test, Tf 1, Tf 2, Tf 3, respectively 72.31, 90.2, 91, 91.5 and 85.2. The average formative test was 90.0. These results illustrate that there is an increase in academic results from the pre-test to the formative test, and to the final test. While the average formative test and the final test there is a slight difference. This difference in results is possible because the questions given at the final test are far more than the formative tests. However, both of them are still above the expected learning achievement limit of 70.

Table 2. Results of Formative Tests and Post-test UNNES

Test	Pre test	Tf 1	Tf 2	Tf 3	Pos tes
Average score	72,31	90,2	91	91,5	85,20
Standard deviation	4,523		-		5,389
Formative test average	-		90.0		-
<n-gain >			0.47 (medium)		
Cohen,s D			3.36 (strong)		

Tf: formative test

The description of progress and improvement in academic results reached the results of the moderate or effective category, namely with <n-gain> 0.47. These results indicate that learning is effective. The effect size analysis of Cohens D shows that D of 3.36 provides an illustration of the effect (effect) of the COMESc model is quite strong on the improvement and progress of statistical thinking learning outcomes.

Discussions.

This is in line with what Paul Eggen (2012, p.8) said that in starting learning after setting learning outcomes, it is necessary to choose a learning model as a blueprint that provides structure and direction to help lecturers achieve the planned goals. The learning model chosen must be suitable to be used to convey study material so that students more easily understand it in introductory courses in inferential statistics.

The learning phases in the COMESc model aim to help informants achieve specific learning objectives, namely the ability to grow statistical thinking designed at the beginning of the learning process.

The effectiveness of the learning model is seen from three indicators, namely: 1) student activity, 2) student response to learning, and 3) progress and improvement in academic achievement results obtained through pre-test, formative test, and final test during model testing. .

1). Student Activities (Informants)

The activities of the informants in this case are:

a) The presence of informants attending lectures is very high, assessed from the average attendance of lectures reaching 100 percent.

b) Involvement of informants in active learning as seen from: responses and questions asked by informants during lectures; the results of the participant's participation in the formative assessment of learning 4 times which are classified as very good;

c) Informant participation in the formative test is classified as good as seen from the test results. The involvement of informants in the study group discussions was carried out well even though there were some group members who did not all have to participate in group presentations;

d) The involvement of learning informants according to the lecturers is very active in learning which can be seen from the collection of group assignments that are done well; and according to the lecturers, the learning observers carried out very well.

e) The participation of the informants in the final test (post test) is considered very good with the maximum result that can be achieved on average above 70.

f) formative 3 times with an average above the minimum limit specified, namely the value of 70.

2) The responses or opinions of students (informants) on learning indicate that the COMESc learning model is very attractive to informants, it is very good if it is developed as one of the learning models in the Introduction to Inferential Statistics course. This is indicated by the results of filling out the questionnaire that the COMESc learning model is very interesting, informant,

very helpful and makes it easier to solve statistical problems encountered, very useful for students who provide problem solving sequences that are easy to implement, systematic, and understand how to make a sequence of activities in solving problems. inferential statistical thinking questions to obtain good or even very good academic learning outcomes.

3) Progress and improvement of academic achievement results obtained through pre-test, formative test, and final test during the model trial was carried out. This is indicated by the results of the analysis and interpretation of the test results data during the model trial, namely pre-test, formative test three times, and final test.

Conclusion

In this research and development the development of the COMESc . learning model concluded that;

1. The strategy used to develop the COMESc learning model is by introducing the COMESc learning model and providing guidance for statistics teaching lecturers, as well as mathematics education students at the research site. Learning through the COMESc model which was carried out through a limited trial by researchers to mathematics education students resulted in a valid and effective learning model.
2. The COMESc learning model which is implemented in introductory inferential statistics lectures results in a minimum student learning achievement of 70 at the location where the research takes place.
3. The learning phases developed in the COMESc model show the results and findings in the field that the informants stated that it was helpful and made it easier for them to learn statistics and improve learning outcomes.

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