



Study of ICT Integrated Challenge Based Learning on Statistical Thinking Ability

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Abstract

This article aims to examine the ICT integrated challenge based learning model on statistical thinking ability. The research method used is a literature study that uses secondary data with search keywords according to the purpose. The data analysis technique consists of three stages, namely organize, synthesize, and identify. The results achieved are the formation of stages of learning ICT integrated challenge based learning model based on the literature that has been analyzed and the relationship between ICT integrated challenge based learning models on statistical thinking ability. Based on the results and discussion, it was obtained that the ICT integrated challenge based learning model can be an innovative solution to develop statistical thinking ability. Learning with an ICT integrated challenge based learning model will facilitate students to carry out activities in a series of processes that are mutually sustainable, ranging from identification, characterization, measurement, control and reducing variation activities providing opportunities for improvement in the process to be able to solve problems related to data in real word problem as it becomes characteristic of statistical thinking. The suggestion proposed is that further research is needed on the development of learning instruments and media with an ICT integrated challenge based learning model that contains indicators of statistical thinking ability and the implementation of these models in mathematics learning.

Keywords:

Challenge Based Learning, Information Communication and Technologies, Statistical thinking ability

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1. Introduction

The 21st century demands competencies that must be possessed by every individual in order to improve the quality of human resources. The government determines steps to create students who are able to compete in the 21st century, one of which is by enacting *Kurikulum Merdeka* that supports the creativity of both teachers and students in learning activities by integrating projects to strengthen the profile of Pancasila students as character education. The government is also still enforcing the 2013 curriculum revised edition in 2017 where the curriculum requires to integrate Strengthening Character Education, Literacy, and HOTS. Today's curriculum development also focuses on developing students' abilities to improve the quality of human resources who are expected to be able to compete in 21st century competitions.

Based on the Decree of the Head of the Standards, Curriculum and Assessment Agency of the Ministry of Education, Culture, Research, and Technology number 088 / H / KR / 2022 concerning learning outcomes in *Kurikulum Merdeka*, mathematics is a science or knowledge about learning or logical thinking that is needed by humans to live underlying the development of modern technology. Mathematics is seen as a learning material that must be understood as well as a conceptual tool to construct and reconstruct the material, hone, and train the thinking skills needed to solve problems in life. Mathematics subjects equip students with ways of thinking, reasoning, and logic through certain mental activities that form a continuous flow of thinking and lead to the formation of a flow of understanding of mathematics learning materials in the form of facts, concepts, principles, operations, relationships, problems, and certain mathematical solutions that are formal-universal.

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One of the subjects of mathematics that plays an important role in life is statistics. Statistics is a subject in mathematics related to the process of data collection, data processing, and drawing conclusions from data from observations in the field. Statistics is the basis for research, research and observation in various fields of science.

Based on the Government Regulation of the Republic of Indonesia Number 19 of 2017 concerning Amendments to Government Regulation Number 74 of 2008 concerning Teachers, Article 1 states "Teachers are professional educators with the main task of educating, teaching, guiding, directing, training, assessing, and evaluating students in early childhood education pathways of formal education, basic education, and secondary education". According to Zuriah, et al. (2016), the core competencies that must be possessed by a teacher based on the competencies mentioned in the Law of the Republic of Indonesia Number 14 of 2005 concerning Teachers and Lecturers Article 10 are as follows: (1) developing a curriculum related to the field of learning that is being mastered, (2) organizing educational learning activities, (3) developing learning materials that are creatively capable and (4) utilizing information and communication technology to communicate and develop yourself.

Based on these demands and obligations, teachers need to be able to learn in accordance with the curriculum and learning designs that have been prepared. In the *Kurikulum Merdeka*, teachers are given the freedom to provide and prepare learning media that suit the needs of students. Teachers must be able to recognize the needs of students in order to prepare appropriate learning tools, in order to achieve the abilities needed in modern times.

In preparing, it is necessary to sort out learning models, learning methods and approaches that will be used in learning by recognizing the needs of students. The scope of the problem studied is the study of an ICT (Information and Communications Technology) integrated challenge based learning model on statistical thinking ability.

The 21st century demands competencies that must be possessed by every individual in order to improve the quality of human resources. The government determines steps to create students who are able to compete in the 21st century, one of which is by enacting *Kurikulum Merdeka* that supports the creativity of both teachers and students in learning activities by integrating projects to strengthen the profile of Pancasila students as character education. The government is also still enforcing the 2013 curriculum revised edition in 2017 where the curriculum requires to integrate Strengthening Character Education, Literacy, and HOTS. Today's curriculum development also focuses on developing students' abilities to improve the quality of human resources who are expected to be able to compete in 21st century competitions.

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Statistics is a subject in mathematics related to the process of data collection, data processing, and drawing conclusions from data from observations in the field. Statistics is the basis for research, research and observation in various fields of science. Delmas (2002) explained several statistical developments, include: 1) statistical literacy, 2) statistical reasoning, and statistical thinking. Statistical thinking ability refers to students' cognitive activities which include the ability to understand how data analysis and interpretation are implemented on real-world problems (Meylasari, et al., 2021). So it can be concluded that statistical thinking ability is an ability that includes a continuous thinking process starting from understanding problems, searching for data, processing data, to solving problems. The statistical thinking ability plays an important role in 21st century life where everything is based on data.

Challenge-based learning is a learning model that focuses on a multidisciplinary approach that encourages students to leverage the technology they use in their daily lives to solve real-world problems (Johnson, et al., 2009). Challenge-based learning requires students to construct knowledge actively and

independently to solve their problems or challenges. The development of challenge-based learning is also accompanied by the application of ICT which grows and develops in everyday life. The combination of challenge-based learning and ICT provides facilities for students to independently explore and construct knowledge by utilizing technology to search for data, process data, and produce conclusions from the data found, which is related to statistical thinking ability.

In preparing for learning, teachers need to sort out learning models, learning methods and approaches that will be used in learning by recognizing student needs. Based on the above exposure, innovation in learning is needed to be able to improve statistical thinking ability. One of the learning innovations that is thought to improve students' statistical thinking ability is challenge-based learning combined with ICT. So that the scope of the problem studied is the study of ICT (Information and Communication Technologies) integrated challenge-based learning models on the statistical thinking ability.

2. Discussion

This research uses literature studies by collecting literature data such as scientific journals and books. This is done to answer the purpose of research related to the study of ICT (Information and Communications Technology) integrated challenge based learning model on statistical thinking ability. The data analysis technique consists of three stages, namely organize, synthesize, and identify.

2.1. Challenge Based Learning

Challenge Based Learning by Johnson, et al. (2009) is a multidisciplinary approach to education that encourages students to utilize the technology they use in their daily lives to solve real-world problems. Challenge Based Learning also giving students the opportunity to focus on challenges of global significance and apply themselves to developing local solutions and Challenge Based Learning creates a space where students can direct their own research and think critically about how to apply concept what they learn.

Challenge Based Learning is a learning and teaching model with the aim of helping students find ways to present or solve problems. This Challenge Based Learning model usually can also be used through websites and mobile phones. The purpose of this device in learning activities is to support students to share knowledge and search for information, as well as to encourage students to study in their area of interest (Apple, 2010).

The Challenge Based Learning framework is divided into three interconnected parts, namely Engage, Investigate, and Act, as shown in figure 1. Each phase includes activities that prepare students to move to the next stage. In the Engage phase, through the Essential Question process, students move from abstract Big Ideas to concrete, actionable Challenges. In the Investigate phase, students plan and participate in journeys that build the foundation for Solution and meet academic requirements through Guiding Questions, Guiding Activities and Guiding Resources. In the Act phase, evidence-based solutions are developed, implemented with an authentic audience, then evaluated based on the results.



Figure 1. Challenge Based Learning framework according to (Nichols, et al; 2016).

2.2. Information and Communications Technology (ICT)

Teaching and learning activities are inseparable from the learning tools that accompany learning activities in order to achieve learning objectives. In 21st century learning activities, there is often the use of ICT-based learning media. Perienen (2020) states that mathematics teachers are regular users of technology. Math teachers go beyond personal use and channel their computer skills to facilitate or improve activities related to their work as teachers, for example in digitally processing their lesson plans and test papers, recording student grades and scouring the internet for innovative teaching methodologies. Such computer-based activities are often interpreted as the use of ICT, but the integration of technology includes other implications and includes using appropriate computing tools such as PCs, laptops, tablets, OHPs and the like to explain, discuss and exemplify mathematical concepts in learning activities.

Currently, the use of learning management systems and e-learning in the world of education is something that helps in learning activities. Szabo & Flesher (2002) defines the learning management system as a framework that handles all aspects of the learning process. A learning management system is an infrastructure that delivers and manages instructional content, identifies and assesses individual and organizational learning or training objectives, tracks progress towards meeting these goals, and collects and presents data to oversee the learning process of an organization as a whole. Piotrowski (2010) defines the e-learning functionality of the platform to include access to learning content and tests, communication and collaboration tools for students, as well as management facilities and assessment facilities for instructors. Several applications have been developed to support learning activities so that ICT-based learning activities can be carried out, including the use of *Google Classroom*, *Ms. Teams*, and so on. The app is a platform that provides workspace chat and video conferencing features, file storage, and app integration. So it can be known that the use of ICT in learning activities has the aim of facilitating the process of organizing both pre-learning, during learning, and post-learning. In addition, ICT is used to make it easier for students to explore the concept of the material being studied.

2.3. Statistical Thinking Ability

Statistics is an auxiliary branch of science for other fields of sciences, especially often used in research, both in the process of model preparation, collection in and drawing conclusions based on data examples. Statistics discusses three things, namely (1) procedures for collecting data either through experiments, surveys, or investigations; (2) procedures for analyzing data either with graphs, images, tables, sizes, or drawing conclusions from the data collected; and (3) procedures for measuring the level of trust in drawing conclusions for a wider scope (Lubis, 2021). In particular statistics are used to decipher and predict phenomena using collections of results from measurements.

Moore (1998) envisions statistics as belonging to the liberal arts because our discipline offers tools and ideas for deliberation and a framework for evaluating evidence. Drawing conclusions from observations and data, understanding variations, and reasoning about coincidences are important skills for today's world. Robert C. delMas (2002) states statistical thinking is promoted when instruction challenges students to apply their understanding to real-world problems, to criticize and evaluate study designs and conclusions, or to generalize the knowledge gained from class examples to new and somewhat new situations.

Statistics is an important science and continues to develop. delMas (2002) discusses several definitions of three statistical developments, namely (1) statistical literacy, (2) statistical reasoning, and (3) statistical thinking. delMas (2002) also provides illustrations in combining these three parts in teaching, learning and interpretation of statistics. Statistical literacy, statistical reasoning and statistical thinking are parts that stand alone even though at one time complement each other. Statistical literacy, statistical thinking, and statistical reasoning have characteristics that distinguish one another as described by delMas (2002) in table 1.

Table 1. Differences in the domain of instructional statistical literacy, statistical thinking, and statistical reasoning by delMas (2002)

Basic Literacy	Statistic	
	Reasoning	Thinking
Identify	Why?	Apply
Describe	How?	Critique
Rephrase	Explain	Evaluate
Translate	(The process)	Generalize
Interpret		

Britz et al (1997) established Deming's Theory of Knowledge as the original source of the definition of statistical thinking. In-depth knowledge has 4 parts, namely: 1) Appreciation for the system; 2) Knowledge of variations; 3) Theoretical knowledge; and 4) Psychology. Furthermore Briz et.al (1997) says that: There are three principles of statistical thinking, namely: 1) All work takes place in a process system"; 2) There is variation in all processes; and 3) Understanding and reducing variation is the key to success. Statistical thinking is a thought process that tests that variations are all around us and are present in everything we do, all the work of a series of processes that are interconnected and identify, characterization, measurement, control, and reducing variation provide opportunities for improvement (Snee, 1990).

Shaughnessy et al. (1997) state that there are four statistical thinking processes, abbreviated as DORA, namely: 1) Describing Data Displays; 2) Organizing and Reducing Data; 3) Representing Data; and 4) Analyzing and Interpreting Data. Furthermore, each statistical thinking process consists of four levels, abbreviated as ITQA, namely: 1) Idiosyncratic; 2) Transitional; 3) Quantitative; and 4) Analytical.

Statistical thinking ability is used to explain a thought process that recognizes the nature that there are variations everywhere, performs identification, characterization, qualification, control and reduction to provide a unique opportunity in an improvement (Waru & Minggu, 2015). So it can be concluded that statistical thinking is a continuous thinking process starting from understanding problems, looking for data, data processing, to the evaluation process in an effort to solve problems.

2.4. ICT integrated Challenge Based Learning on Statistical Thinking Ability

The 21st century demands competencies that must be possessed by every individual in order to improve the quality of human resources. The government is setting steps to create students who are able to compete in the 21st century. Statistics is the basis for research, research and observation in various fields of science.

become the basis for research, research and observation in various fields of science. Statistical ability is divided into three types, namely statistical literacy, statistical thinking and statistical literacy. Statistical thinking is a continuous thinking process starting from understanding problems, looking for data, data processing, to the evaluation process in an effort to solve problems. Statistical thinking ability can be developed through challenging reasoning tasks in the learning process.

Challenge Based Learning is a learning and teaching model with the aim of helping students find ways to present or solve problems (Apple, 2010). Challenge Based Learning according to Johnson, et al. (2009) is a multidisciplinary approach to education that encourages students to utilize the technology they use in their daily lives to solve real-world problems. In Challenge Based Learning, students are directed to utilize ICT in the process of solving the problems faced.

ICT is any form of activity related to Information and Communications Technology. ICT refers to the form of technology used to transmit, process, store, create, display, share, or exchange information by electronic means. This broad definition of ICT includes technologies such as radio, television, video, DVDs, telephones (both fixed-line and mobile phones), satellite systems, and computer and network hardware and software, as well as equipment and services related to these technologies, such as video conferencing, email, and blogs (ICT UNESCO 1). The learning process on an ICT basis becomes unlimited by time and space. The use of ICT is a challenge for teachers to create innovations in teaching styles or methods.

The use of ICT in Challenge Based Learning can be a good combination in learning activities, especially in an effort to improve statistical thinking ability. Challenge Based Learning raises everyday problems to be used as big ideas or scope of material to be studied. In the process of solving these problems, the use of ICT is an inseparable thing because the problems faced are 21st century problems that are synonymous with the development of ICT. The use of learning management systems in learning activities has been widely used, one of which is as a forum for student portfolios, for example the use of *Ms.Teams* as a place where assignments are collected or as a platform for student evaluation such as exams. The learning stages can also be arranged systematically in the learning management system so as to make it easier for students in learning activities because in challenge-based learning students actively and independently develop their knowledge while the teacher only serves as a facilitator and student companion. The steps for ICT integrated Challenge Based Learning are described in table 2.

Integrating the ICT integrated Challenge Based Learning model in mathematics learning is able to improve statistical ability because it will facilitate students to carry out activities in a series of inter-continuous processes, ranging from identification, characterization, measurement, control and reducing variation activities providing opportunities for improvement in the process to be able to solve problems related to data in life as characteristic Statistical thinking.

Challenge Based Learning according to Nichols, et al. (2016) is divided into three stages, namely the engage, investigate and act phases. In this case, the student learning series is carried out in a structured and continuous manner. The syntax in Challenge Based Learning is in line with statistical thinking ability which requires a continuous thinking process starting from understanding problems, looking for data, data processing, to the evaluation process in an effort to solve problems.


Susilawati, et al. (2019) stated that challenge-based learning can improve statistical thinking ability. Widi (2016) and Ramadhani & Narpila (2018) examined the use of problem-based learning in improving statistical thinking ability. Widakdo (2017) stated that the use of project-based learning on the topic of statistics can improve mathematical representation skills where this ability is related to statistical thinking ability. Siswono, et al (2018) stated that project-based learning is effectively used in statistical learning where in learning statistics includes the ability to think statistically. It is known that challenge-based learning and problem-based learning have the same focus, namely on solving problems and challenges by requiring students to be active and independent in developing knowledge to produce the solutions needed. Challenge based learning has many similarities with project based learning where the challenge based learning framework is based on project-based learning activities. Therefore, it is suspected that challenge-based learning can improve statistical thinking ability.

Hidayati, et al. (2018) and Lukman & Sutisnawati (2016) examined the development of an ICT-based statistics module which concluded that it could be effectively used in learning activities, this gave rise to the suspicion that ICT is suitable for use in statistical topics where statistical thinking ability are covered. Lukman & Setiani (2018) examined the development of project-integrated ICT-based applied statistics

teaching materials which concluded that the teaching materials obtained eligibility criteria with excellent categories and were valid and suitable for use in learning, this resulted in the conjecture that ICT integrated with projects or learning based on masala completion was a good combination.

Challenge Based Learning packaged in the form of a project can improve statistical skills. Another study conducted by La Nani & Alhaddad (2020) showed that ICT-assisted project-based learning is considered effective in improving students' statistical communication skills. La Nani (2015) explains that statistical communication skills are an important requirement to assist students in statistical thinking, connecting a statistical idea with another, expressing the results of their thoughts, both verbally and in writing. Thus, ICT-assisted project-based learning is able to improve statistical thinking ability. Other studies have shown that the application of ICT-assisted project-based learning can significantly improve students' statistical ability on data location size materials (Yoisangaji, et al., 2019). The use of ICT in learning can improve statistical abilities. The increase in statistical ability in experimental classes that use ICT assistance, namely hippo animation, has a significantly higher value compared to control classes that do not use ICT assistance (Hidayat & Perdana, 2021).

Table 2. ICT integrated Challenge Based Learning Innovation in mathematics lessons data analysis elements

Phase	Syntax	Realization
Engage	Big Idea	<p>At the beginning of the learning of the material, several images containing public data were presented as an introduction to big ideas. In this section, a foreword is given regarding the material to be studied, namely data analysis.</p> <p>Example:</p>  <p>Source: freepick.com</p> <p>Humans are social beings who coexist with each other. There is a lot of information to be given as general knowledge. Such information is often conveyed in the form of data in a visual form.</p>
	Essential Question	<p>Students are asked to compile some important questions related to the big idea at hand.</p> <p>Example:</p> <ol style="list-style-type: none"> 1. What is data? 2. How do I obtain data? 3. How do I present data so that it can be useful to others?
Investigate	The challenge	<p>Students are given challenges that must be completed in groups with 2 to 3 members.</p> <p>The challenges given are:</p> <p>Make observations on your environment, it can be in the form of a community environment or a school environment. Look for a condition that can be represented into a data. Look for data related to these conditions and make a presentation of data from the conditions obtained by creating information boards (in the form of digital posters and physical media) that are useful for others.</p> <p>Information boards are in the form of data that has been processed, both in the form of tables and diagrams.</p> <p>In this case the student can make observations on various conditions in his environment, for example:</p> <ol style="list-style-type: none"> 1) Students can observe the school environment and take conditions related to the number of male and female students in each class. As a solution to the challenge, students can create student distribution information boards that can be displayed on the school wall and digital posters that can be uploaded on the school's website. 2) Students can observe the community environment and take conditions related to the number of inhabitants. Students search

		for data on the number of births and the number of deaths of residents in each neighboring neighborhood in a certain period of time. As a solution to the challenge, students can create an information board on the death and birth rate of residents that can be displayed in the village hall and digital posters that can be uploaded on the website.
	Guiding Question, Guiding Activities, and Guiding Resources	<ul style="list-style-type: none"> • To help the process of solving challenges, students will be faced with several questions that help to build understanding related to data analysis. • Then students will be given several activities to solve problems related to challenges and understanding related to data analysis. • As a form of confirmation of understanding the analysis of data that has been formed, students will be given several sources of auxiliary information. • In this stage, students are allowed to use tools either using a calculator, mobile phone, tablet, or computer.
Act	Solution	Students complete challenges after having knowledge related to data analysis.
	Assessment	In the process of completing the challenge, students will be directed to access the platform (it can be <i>Ms. Teams</i>) to collect work results from each of the existing stages. Student assessment can be done with performance assessment.
	Publication	The result of completing the challenge is in the form of physical objects and digital posters that can be used for the public.

Based on the discussion above, it was obtained that the implementation of the ICT integrated Challenge Based Learning model has a close relationship with statistical thinking ability. The syntax in the Challenge Based Learning model can be implemented with the help of ICT in the implementation process. The series of problem solving required in Challenge Based Learning is carried out in a structured manner, starting from the engage stage, investigate to the act stage. Through the implementation of the ICT integrated Challenge Based Learning model, it is hoped that it will be able to improve students' mathematical statistical thinking ability so that they are able to equip students with knowledge in facing problems in the 21st century.

3. Conclusion

Based on the discussion, it was obtained that the ICT integrated Challenge Based Learning model is an innovative solution to improve students' statistical thinking ability. The ICT-based Challenge Based Learning model can provide a meaningful learning experience by facilitating students to carry out activities in a series of mutually continuous processes, ranging from identification, characterization, measurement, control and reducing variation activities providing opportunities for improvement in the process to be able to solve data-related problems in life as characteristic of statistical thinking. The suggestion proposed is that further research is needed on the development of learning instruments and media with an ICT integrated challenge based learning model that contains indicators of statistical thinking ability and the implementation of these models in mathematics learning.

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