Development of The Learning Model Group Investigations Based Academic Culture (GIBAC)

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Abstract

This study introduces and evaluates the GIBAC Learning Model, aimed at enhancing students' mathematical communication skills in Indonesian secondary schools, achieving an impressive 30% increase in students' mathematical communication skills as evidenced by the n-gain method and dependent t-test analysis. Grounded in cooperative learning theory and motivation, the model integrates local academic culture and promotes student independence, offering a promising avenue for educational advancement in Indonesia. Employing a Mixed Methods approach, data from three secondary schools were collected via cluster random sampling, encompassing interviews, observations, expert assessments, and questionnaires. Analysis reveals the model's effectiveness in improving mathematical communication skills, underscoring its relevance to Indonesian educational practices. Practical implications for teachers emphasize the integration of cultural aspects and student autonomy in mathematics education, thereby contributing to the advancement of educational literature through Indonesian innovation and cultural adaptation in pedagogical frameworks.

Keywords: Development; Learning Model; GIBAC; Mathematical Communication.

Academic Culture for students in this study is classified into 3 types where the variations are students who are activists at school (meeting school), only school and do not participate in organisations and always go straight home (school go home), and school but like to hang out with their friends but do not participate in organisations (school hang out) where these types are also classifications of activist students, study oriented students, and mediocre students (Aktaş, 2023; Coulange et al., 2021; Masruroh & Mudzakkir, 2013; Sezer & Namukasa, 2021; Vela et al., 2020). And the close relationship between mathematical communication that must be built with good learning innovations (Bertrand & Namukasa, 2023; Coskun, 2024; Jumaisyaroh & Hasratuddin, 2016), the school environment also has diverse characteristics, so there is a need for an integrated academic culture (Masruroh & Mudzakkir, 2013).

This school academic culture respects the character of each student who has different uniqueness, but there is actually potential intelligence that is very likely to be identified and developed (Astuti et al., 2024; Nurfadilah & Hakim, 2019). And in the 21st century skills became known as the

6C, namely: character, citizenship, critical thinking, creativity, collaboration, and communication. One of the characteristics of the implementation of 6C skills in language teaching in the 21st century is the emergence of humanist aspects in education, such as education and curriculum centred on values and character, no longer focusing only on mastering subject matter (Seaqil, 2022). This requires good mathematical communication skills and a learning model that emphasises aspects of character values (Çelik Demirci & Baki, 2023; Hinton, 2005; Jones et al., 2023; Kihwele & Mkomwa, 2023; MacLeod, 2015; Warner, 2023). So it is expected that teachers must recognise and understand student intelligence because each student has different abilities by using the Group Investigation learning model as an effort to improve mathematics communication in accordance with the characteristics or academic culture of students with their respective uniqueness (Boondao, 2008; Causapin & Groombridge, 2017; Clavel & Mediavilla, 2020; Dreisiebner & Schlögl, 2019; Ng et al., 2009; Onoshakpokaiye, 2024). Seeing the formula and the connection, in this research, a GIBAC (Group Investigation Based Academic Culture) learning innovation will be built that focuses on mathematics communication skills.

The theoretical framework of this study is built upon several key components aimed at enhancing mathematics education in Indonesia (Faradiba et al., 2018; Yavich & Rotnitsky, 2020). Firstly, the study considers the specific context of mathematics learning within the Indonesian educational landscape (Adler et al., 2023; Alhashem et al., 2022; Alvarenga & Braga, 2024; Sjunnesson, 2020; Wortham, 2005). This involves understanding the unique challenges, cultural nuances, and educational practices prevalent in Indonesian schools. Secondly, the framework incorporates principles of cooperative learning theory, which emphasize collaboration, active participation, and mutual support among students to achieve common learning goals (Inprasitha, 2022).

Motivation plays a crucial role in the theoretical underpinnings of this study. Recognizing the importance of intrinsic and extrinsic motivation in driving student engagement and learning outcomes, the framework integrates motivational theories to inform instructional design and implementation strategies (Ead, 2023; Madden et al., 2018; Metelko & Maver, 2023; Shawky et al., 2021; Yamaguchi & Suzuki, 2019). Additionally, the theoretical framework encompasses other supportive theories that align with the characteristics of Indonesian students, such as socio-cultural theories of learning, cognitive theories, and constructivist perspectives Mathematical Communication Indicator Framework.

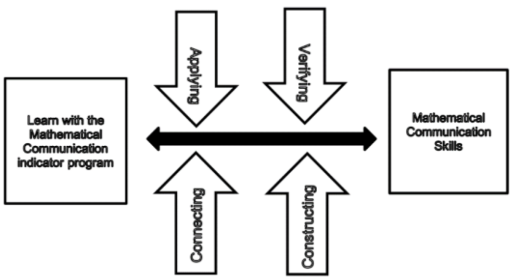

Figure 1: Mathematical Communication Indicator Framework

Furthermore, the framework acknowledges the diverse learning styles, backgrounds, and abilities of Indonesian students. By embracing inclusive pedagogical approaches, the study aims to cater to the diverse needs of learners and promote equitable access to quality mathematics education. Central to the theoretical framework is the recognition of student autonomy and empowerment in the learning process (Liu, 2020). By promoting autonomy-supportive teaching practices, the study seeks to cultivate students' intrinsic motivation, self-regulation skills, and sense of ownership over their learning (Çelik Demirci & Baki, 2023; Lutfauziah et al., 2024; Yazlık & Çetin, 2023). Additionally, the framework emphasizes the importance of culturally responsive teaching practices that honor and incorporate students' cultural backgrounds, identities, and experiences into the learning process.

Furthermore, the theoretical framework highlights the importance of leveraging educational technology to enhance teaching and learning experiences. Integrating technology into instruction can facilitate access to resources, promote interactive and multimedia learning experiences, and foster digital literacy skills among students. Additionally, the framework emphasizes the need for ongoing assessment and evaluation to monitor student progress, inform instructional decision-making, and continuously improve the effectiveness of the GIBAC learning model.

Table 1. GIBAC learning stages

No	Stage	Learning implementation
1	Group division	Group Division Based on Mathematical Communication.
2	Discovery	Discussion Based on Mathematical Questions with reference to Bruner's theory of Learning by Discovery.
3	Presentation	Teachers provide guidance and support according to Vygotsky's theory of Social Support.
4	Evaluation	Mathematical Communication Oriented Evaluation

In summary, the theoretical framework of this study provides a comprehensive and integrated approach to enhancing mathematics education in Indonesia. By drawing on relevant theories and principles, the study aims to promote collaborative, engaging, culturally responsive, and student-centered learning experiences that empower students to develop their mathematical communication skills and achieve academic success.

Method

Research Design and Participants

This research adopts the research and development (R&D) model approach with the R&D concept, according to Ploom with the following research design:

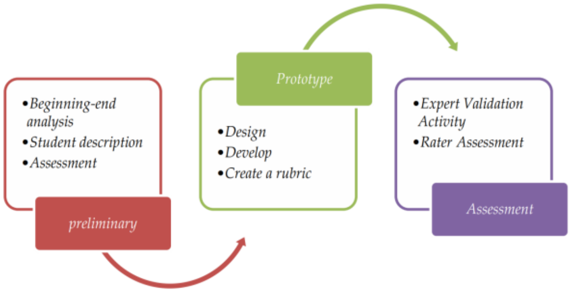

Figure 2. Ploom Research Design (Cahyadi et al., 2023)

This research was conducted in 3 schools. The subjects involved in the research and development trials were Class XI high school students. So in determining the research sample using purposive sampling, the sample used was 160 students. In the initial research to find out the problems, potential and needs of teachers using a questionnaire of 35 students, interviews 6 students and involving 3 schools. While the process in research and development trials is as follows:

a. Instrument validator 3 Validator

b. Initial field trial

c. Main field trial

d. Operational trial

e. Implemantation

Data Collection Technique

In this research, there are several data collection techniques applied, namely interviews, observations, the use of questionnaires, and rating scales. Through interviews, the researcher aims to gain an in-depth understanding of the situation and problems that arise, through direct interaction with relevant sources. On the other hand, observations were made to directly witness the learning process, which then became the basis for analysing the research needs. The use of questionnaires, which were designed in a closed-ended manner, aimed to explore further information about the existing needs. In addition, a rating scale was also included in this study, involving evaluation by experts and direct assessment by students and teachers.

Data Analysis Technique

The data analysis technique used in evaluating the quality of the developed GIBAC Learning Model considers two main aspects: sustainability and effectiveness. Evaluation of product sustainability involves expert judgement and user (teacher) response. Meanwhile, the effectiveness of the product is observed through the results of the operational field trials that have been conducted.

Results And Discussion

Initial Product Development Results

The preliminary study was conducted in order to gather information about the problems that occur in the field, then analyse the problems and needs for assessment. Interviews were conducted involving 6 students. Product validation of the GIBAC Learning Model was conducted after the initial design of GIBAC. The percentage results of the scores given by Validator 1 were 4, Validator 2 was 3.5 and Validator 2 was 3.6. The score has passed the "Eligible" criteria score range, which is between 2.8 to 3.4. In fact, the score obtained from the material expert if converted into the "Very Feasible" category. The provision of suggestions and input from material experts and media experts is used as a basis for improving the application before being used in the field.

Product Trial Results

The operational trial stage is carried out when the GIBAC Learning Model has gone through several stages of improvement. This improvement is intended to correct the shortcomings of GIBAC so that it can be used properly and practically in learning activities. Normality test of pre and post test of students' mathematics communication skills.

The results of the calculation of the normality of student ability scale data are presented in the following table:

Table 2. Results of the normality test of students' abilities in the operational field trial

No.	Data	Shapiro Wilk			Description
		Statistic	df	Sig	
1	Pre Test	0,952	40	0,092	Normal
2	Post Test	0,946	40	0,054	Normal

The pre test and post test are normally distributed. Furthermore, the ordinary dependent t-test or paired sample t-test commonly referred to as the paired t-test is a type of hypothesis test that aims to compare or determine the average difference between two groups that are paired with each other. The data on the scale of the teacher's ability to conduct assessments includes paired data because the respondents used in the pre-test and post-test data are the same.

Table 3. Results of paired t-test of teacher ability in the operational field trial

No.	Data	Paired Samples Test			Description
		t	df	sig	
1	Pre Test - Post Test	7,470	39	0,000	Ho is rejected

Based on the data above, it is known that the t_hitung negative with a value of - 7.470 and a value of t_tabel 2,086. Because t_hitung < t_tabel then it can be concluded that Ho is rejected, meaning that there is a significant average difference in the ability of students who use the GIBAC model and do not use the model. The next step after the prerequisite test and hypothesis test are carried out is to find the n-gain value. The purpose of finding the n-gain value is to measure the improvement of students' mathematics communication skills.

Table 4. Students' pretest and posttest results

Average Value		Gain	Criteria
Pre Test (Control Class)	Post Test (Experiment Class)		
69	91	0,71	High

Based on the table above, the average value in the control class (pre test) is 69 and the average value in the experimental class (post test) is 91 so that it can be seen that there is an increase aimed at a gain value of 0.71 and the increase is included in the high criteria.

Feasibility of the GIBAC Learning Method

There is an Academic Culture in this study classified into 3 types where the variations are turtles (meeting lectures), butterflies (going home lectures), and fireflies (hanging out lectures) where these types are also a classification of activist students, study oriented students, and mediocre students (Masruroh & Mudzakkir, 2013). Strengthening communication skills is needed in preparing experienced students. (Kaya & Aydin, 2016; Pourdavood et al., 2020). So that students need to get a reinforcing learning process in early investigation (Mitchell et al., 2008). Then openness to new ideas and the desire to apply them. In addition to co-operating with each other, teachers also need to be motivated to try new things related to their duties. Developing mathematical concepts is inseparable from habituation and involvement in the learning process which can be obtained through active experience.

Students' experiences in physical, emotional, and cognitive interactions will make it easier for students to learn mathematics (Akkan & Horzum, 2024; Stohlmann & Yang, 2024; Suhendri, 2015; Wardah & Das, 2018). The activities designed in the experience stage are facilitating students to experience the reasoning process individually by identifying similarities in problems and strategies in learning (Mitchell et al., 2008). (Mitchell et al., 2008; Oppong-Gyebi et al., 2023; Sojayapan & Khlaisang, 2020). Mastery of mathematical concepts leads to developing the ability to predict, analyse, prove, and think logically. The formation of these processes well, underlies the ability to solve mathematical problems. Learning strategies that emphasise prediction activities can help uncover misconceptions (Oppong-Gyebi et al., 2023; Viseu & Oliveira, 2012). In the process, the task sheet is designed to be used for scaffolding, which contains instructions for finding the relationship between the source and target solution strategies. Consistent learning of new learning strategies. As a learning organisation, schools should provide opportunities for teachers to improve their knowledge in learning, research and innovations related to learning and teaching. Communication is the main means to convey and exchange ideas, including in the learning process. However, for prospective mathematics teachers, this skill is not limited to conversations in general. Rather, it involves presenting and interpreting symbols, data and images (Ambarwati & Kurniasih, 2021; Hendriana & Kadarisma, 2019; Rachmawati & Listiani, 2022). This is related to the role of lecturers in achieving both professional and pedagogical goals. Strengthening communication skills is needed in preparing experienced students (Moralı & Filiz, 2023; Umar, 2012).

Learning mathematics helps students in developing writing and verbal skills, especially those related to visual and verbal representations in problem solving (Kaup et al., 2023; Moralı & Filiz, 2023; Mumcu et al., 2023).The design of the communicating stage includes activities to motivate students to generate and share ideas by communicating in various forms. Consideration of the use of various forms of communication with the aim of helping to analyse students' ability to convey ideas so as to obtain a comprehensive conceptual understanding. The activity of experiencing and presenting knowledge supported by interaction with various parties and types of content is expected to facilitate students in communicating mathematics. And by looking at evaluation in learning is indicated by one's ability to review and measure the knowledge gained to assess the level of understanding. Where at this stage provides an understanding that . This stage is at the end of the learning process and is utilised as a strategy to get new ideas. (Setiyani et al., 2020). This is a critical stage because the evaluation stage reflects on learning activities so that it helps students where there are 4 things, namely learning, achievement, resistance (effort), and in the next stage is the success of efforts to create a culture of academic success in science and mathematics (Buxton, 2005; Eshaq, 2024; Møller & Kaup, 2023). Evaluation activities are carried out individually and in groups, and delivered in class by comparing different strategies or ideas so that action or change can be taken (Kurniawan et al., 2024; Ramirez, 2024; Saefudin et al., 2023).

Theories by Piaget, Bruner, Gagne, and Vygotsky inform academic culture across developmental stages. Piaget's stages highlight the progression of cognitive abilities from sensory exploration in infancy to abstract thinking in adolescence, shaping educational approaches accordingly. Bruner's constructivism emphasizes active learning and scaffolding, while Gagne's instructional theory advocates for systematic instruction to optimize learning outcomes. Vygotsky underscores the role of social interaction in cognitive development, promoting collaborative learning environments. Together, these theories guide educators in fostering dynamic and tailored learning environments that facilitate cognitive growth and academic achievement across diverse developmental stages.

Table 5. GIBAC learning model based on theory

Stage	Implementation	Based on theory
1	Group division	Group Division Based on Mathematical Communication: Applying Vygotsky's theory of the Proximal Zone of Learning, group division is based on students' abilities and needs to facilitate productive interactions in understanding mathematical material, in line with an academic culture that encourages collaboration and mutual help, followed by the introduction of Mathematics Communication Focused Materials (This approach reflects Piaget's theory of the Stages of Learning, by introducing derived concepts through an approach that promotes discussion and dialogue between students, creating a culture where learning is seen as a Shared endeavour).
2	Discovery	Discussion Based on Mathematical Questions with reference to Bruner's theory of Learning by Discovery, students are encouraged to actively participate in discussions to explore and understand the concept of derivatives, in accordance with an academic culture that encourages exploration and creativity, then students are directed to discovery with relevant Mathematical Cases (Linking Vygotsky's theory of Context Based Learning, students are given real cases or situations involving the concept of derivatives to apply their understanding in relevant contexts, fostering a culture of deeper understanding).
3	Presentation	Guidance in Maths Communication: Teachers provide guidance and support according to Vygotsky's theory of Social Support, to improve students' ability to use appropriate and effective mathematical language, in accordance with an academic culture that encourages peer support. Group-Based Presentations with a Focus on Mathematical Communication (According to Gagne's theory of Social Learning, group presentations

		allow students to share their understanding of mathematical concepts and enrich their learning experience, creating a culture of knowledge sharing).
4	Evaluation	Mathematical Communication Oriented Evaluation: Evaluation discussions focusing on mathematical communication reflect Gagne's theory of Formative Evaluation, where students give and receive feedback to improve their mathematical communication skills, in keeping with an academic culture that encourages continuous growth and learning. Then conduct Individual Reflection on Mathematical Communication (Students' individual reflection on their mathematical communication corresponds to Bruner's theory of Metacognition, helping them identify their strengths and weaknesses and plan steps for further growth, in line with an academic culture that encourages self-reflection and development).

Product Practicality

This assessment will pay attention to the criteria for developing digital media in the form of the GIBAC Model which is used to improve students' Mathematical Communication skills. (Slamdino et al., 2004) which determines how accurately the objectives are achieved. In the knowledge element, operationally effective, efficient and safe products can provide meaning and benefits from users of the GIBAC Model. Students gain an understanding of the importance of Maths communication. The GIBAC Learning Model is expected to improve Maths communication skills and independence and a high level of satisfaction.

The results obtained after the assessment activities using the GIBAC Model showed that students' abilities increased. This is seen from the average value of the post-scale assessment of student abilities also increased. In addition, hypothesis testing also shows that there is a significant difference and improvement in students' abilities before and after using the GIBAC Learning Model. So it is expected that the use of the GIBAC Model can provide an understanding of the development and have good implications for teacher practice in learning. Therefore, the use of the GIBAC Model can be used as a means to assist and improve Mathematics communication skills. Thus, there was a variation in the mean of students' ability as well as a significant increase in students' ability with significance classified as a high category.

Limitations and Challenges

Despite its promising results, this study faces several limitations and challenges. Firstly, the implementation of the GIBAC Learning Model was limited to three secondary schools in Indonesia, potentially limiting the generalizability of the findings. Additionally, the duration of the study may not have been sufficient to capture long-term impacts on students' mathematical communication skills. Moreover, while efforts were made to incorporate local academic culture, the model's adaptation to diverse regional contexts within Indonesia remains a challenge. Furthermore, logistical constraints, such as resource availability and scheduling conflicts, may have influenced data collection and implementation fidelity. Finally, the subjective nature of some data collection methods, such as interviews and observations, introduces the possibility of bias. Addressing these limitations and challenges will be crucial for future research to provide a more comprehensive understanding of the GIBAC Learning Model's effectiveness and applicability in diverse educational settings across Indonesia.

Conclusion

The findings of this study offer practical implications and recommendations for educators and policymakers in Indonesia. Firstly, integrating the GIBAC Learning Model into mathematics curricula across secondary schools can significantly enhance students' mathematical communication skills. Teachers should receive adequate training and support to effectively implement this model in their classrooms. Additionally, educational policymakers should consider incorporating elements of the GIBAC Learning Model into national education policies and frameworks, emphasizing the importance of cultural relevance and student autonomy in mathematics education. Furthermore, collaboration between schools, educational institutions, and communities can facilitate the adaptation of the model to diverse local contexts, ensuring its effectiveness across different regions of Indonesia. Moreover, ongoing research and evaluation efforts are necessary to continuously refine and improve the GIBAC Learning Model, addressing any emerging challenges and further enhancing its impact on students' mathematical communication skills. By prioritizing these recommendations, stakeholders can collectively contribute to the advancement of mathematics education in Indonesia, fostering a generation of confident and competent learners in the field of mathematics.

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