Computer Technology-Based MBKM to Develop Mathematics Education Students' Metacognition and Metaskill Perspective

Hamdan Sugilar[*1]
UIN Sunan Gunung Djati Bandung, Indonesia
E-Mail : hamdansugilar@uinsgd.ac.id

Hilman Mangkuwibawa[2]
UIN Sunan Gunung Djati Bandung, Indonesia
E-Mail : hilmanmangkuwibawa@uinsgd.ac.id

Rully Agung Yudhiantara[3]
UIN Sunan Gunung Djati Bandung, Indonesia
E-Mail : rully.agung@uinsgd.ac.id

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Abstract

This research endeavors to assess the allocation of mathematics education courses concerning mathematics computer technology, metacognition, and meta-skills in mathematics learning. It also aims to gauge the outcomes of mathematical metacognition abilities through the utilization of mathematical computer applications. Employing a mixed-method approach, the study simultaneously gathered and analyzed qualitative and quantitative data. Quantitative data were derived from the outcomes of metacognition abilities, while qualitative information was obtained from curriculum documents and metacognition abilities. The metacognition thinking ability test comprised 10 short descriptions related to differential and integral calculus material. The participants were 45 seventh-semester students majoring in mathematics education during the 2021/2022 academic year at UIN Sunan Gunung Djati Bandung, all of whom undertook mathematics computer application courses. The findings indicate that the mathematics education study program has implemented a curriculum fostering the attainment of qualifications for graduates adept at applying mathematical computer technology, evidenced by the distribution of computer technology-based courses. Metacognition and meta-skills are deemed essential in preparing prospective teachers to engage in higher-level thinking and effectively apply new knowledge, particularly through the application of mathematical computer programs. Notably, students demonstrated good metacognition abilities based on the assessment results.

Keywords: Independent Learning-Independent Campus Curriculum, Computer Technology, Metacognition and Meta-skills.

Abstrak

Tujuan penelitian ini adalah untuk mengetahui sebaran mata kuliah pendidikan matematika berbasis teknologi komputer matematika, metakognitif dan meta skill pada pembelajaran matematika, dan hasil kemampuan metakognitif matematik dengan menggunakan aplikasi komputer matematika. Metode penelitian ini adalah mix method dengan pendekatan penelitian integrative, data kualitatif dan kuantitatif dikumpulkan *secara bersamaan dan dianalisis. Metode kuantitatif berupa hasil kemampuan metakognitif, data kualitatif berupa dokumen kurikulum dan kemampuan metakognitif. Analisis data berupa hasil tes kemampuan berpikir metakognitif terdiri dari 10 uraian singkat terdiri dari materi kalkulus diferensial dan integral. Subjek penelitian adalah 45 mahasiswa semester VII tahun akademik 2021/2022 pendidikan matematika UIN Sunan Gunung Djati Bandung yang menerima mata kuliah aplikasi komputer matematika. Hasil penelitian diperoleh bahwa program studi pendidikan matematika telah mengimplementasikan kurikulum yang mendorong capaian kualifikasi lulusan terampil mengaplikasikan dan memanfaatkan teknologi komputer matematika berupa sebaran mata kuliah berbasis teknologi komputer. Metakognitif dan meta skill dibutuhkan untuk menyiapkan mahasiswa calon guru untuk mampu berpikir tingkat tinggi dan terampil menggunakan pengetahuan baru berupa penerapan aplikasi komputer matematika. Hasil kemampuan metakognitif mahasiswa dalam kategori baik.*

Kata Kunci: *Kurikulum Merdeka Belajar-Kampus Merdeka, Teknologi Komputer, Metakognitif dan Meta-skill*

Introduction

Teachers are expected to maintain a harmonious balance between addressing global challenges in the digital era and employing technology judiciously in the learning process. To achieve this equilibrium, they are expected not only to be proficient in utilizing technology but also in developing and optimizing technological tools. In addition to technological proficiency, teachers should enhance their competencies in pedagogy, professionalism, personality, and social interactions. This holistic approach ensures that teachers are well-rounded professionals prepared to fulfill their duties effectively.

Teachers' competency can be pursued through various efforts, including training sessions, workshops, seminars, further academic studies, independent learning, and self-teaching. Specifically, their participation in training programs or seminars focused on digital technology in education contributes significantly to elevating their competence. Positive outcomes from such initiatives are evident in improving teachers' competence. For example, teachers' exclusive use of the Desmos web platform for learning and proficiently solving mathematical problems with the aid of computer applications have improved their competence. Assessments reveal that high school mathematics teacher exhibit a satisfactory level of proficiency in designing computer-based learning materials. Moreover, workshops conducted through In-House Training programs have been observed to enhance teachers' capacities for creating effective learning experience media [1][2].

In educational context, technology serves as a tool for solving life problems, both simple and complex. Furthermore, multimedia or software can help solve math problems at a higher level of difficulty [3][4]. When it comes to mathematics teachers' ability to use computer, smartphones and internet, there is no significant difference between mathematics teachers in junior high school and senior high school[5]. What should be taken into consideration is their ICT competence. Teachers who are well-equipped with ICT tools and facilities to prepare for teaching is one the main factors in success of technology-based teaching and learning[6].

A key goal of the *Merdeka Belajar Kampus Merdeka* (MBKM) curriculum in PTKI (*Perguruan Tinggi Keagamaan Islam*/ Islamic Higher Education Colleges) is to enhance the quality of graduates, equipping them with the essential skills for the 21st century and the era of Industry 4.0. It is imperative for this policy to be promptly embraced and put into action, particularly through the integration of courses that foster information and technology-based skills. Students have expressed their agreement with the concept of MBKM policy[7].

Initiatives aimed at making technology more accessible to students require a thorough understanding and optimal utilization of technology-based tools. Students should

[1] Muhammad Win Afgani and Retni Paradesa, 'Kemampuan Guru Matematika SMA Dalam Merancang Media Pembelajaran Berbasis Komputer', *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, 6.10 (2021), 1558–62.

[2] Naufal Ishartono, Yosep Dwi Kristanto, and Fariz Setyawan, 'Upaya Peningkatan Kemampuan Guru Matematika SMA Dalam Memvisualisasikan Materi Ajar Dengan Menggunakan Website DESMOS', in *Prosiding University Research Colloquium*, 2019, 78–86.

[3] M Salehudin and H J Sada, 'Use of Technology-Based Multimedia for Teacher Professional Education (PPG): User Experience (UX) Analysis', *Al-Tadzkiyyah: Jurnal Pendidikan Islam*, 11.1 (2020) <https://doi.org/10.24042/atjpi.v11i1.5857>.

[4] Hamdan Sugilar, 'Multimedia Matematika Di Era Digital', in *Prosiding-Seminar Nasional Teknik Elektro UIN Sunan Gunung Djati Bandung*, 2020, pp. 442–51.

[5] In In Supianti, Acep Saeful Malik, and Anggit Sagita, 'Kemampuan Guru Matematika Dalam Menggunakan Komputer, Smartphone, Dan Internet', *Symmetry: Pasundan Journal of Research in Mathematics Learning and Education*, 6.1 (2021), 19–32.

[6] Simin Ghavifekr and Wan Athirah Wan Rosdy, 'Teaching and Learning with Technology: Effectiveness of ICT Integration in Schools.', *International Journal of Research in Education and Science*, 1.2 (2015), 175–91.

[7] Yuni Wulandari and others, 'Orientasi Pengembangan Dan Penerapan Kurikulum Merdeka Belajar Pada Program Studi Pendidikan Matematika', *Jurnal Review Pendidikan Dan Pengajaran (JRPP)*, 4.2 (2021), 317–21; Yasmansyah Yasmansyah, 'Konsep Merdeka Belajar Kurikulum Merdeka', *Jurnal Penelitian Ilmu Pendidikan Indonesia*, 1.1 (2022), 29–34.

consistently employ computer applications for proficient and effective resolution of mathematical problems. This approach is crucial in constructing their comprehension of mathematical concepts during classroom learning, as their understanding is derived from a combination of critical thinking and the supportive aid of computer applications. It ensures that students not only grasp the subject matter of mathematics well but also acquire proficiency in utilizing computer applications [8].

Therefore, teachers or mathematics education students aspiring to enter the teaching profession must enhance their readiness to proficiently master and promptly apply mathematical computer applications in the learning process. It is equally vital to cultivate their critical thinking skills while utilizing these tools. This is done to support students' optimal cognitive engagement. Consequently, prospective teacher candidates should be equipped with courses centered on computer-based or digital learning. This holds significance in the current digital era where technology has become an integral part of daily life. Notably, the teacher plays a pivotal role as the primary influence on students. Their quality of teaching significantly impacts students' rapid development. In light of this data, students tend to progress more swiftly when guided by teachers of above-average quality [9].

Another essential competency that individuals should possess and be ready to develop is High-Order Thinking Skills (HOTS). These advanced cognitive abilities encompass problem-solving, critical thinking, creative thinking, reasoning, and decision-making skills [10]. HOTS are integral competencies in the contemporary world, making it imperative for every student to acquire them. The pursuit of HOTS involves utilizing computer applications as instrumental tools to facilitate their development.[11].

One of HOTS components is metacognition. Through metacognitive awareness, students are coached to consistently formulate optimal strategies for selecting, remembering, recognizing, organizing the information at their disposal, and effectively solving the challenges they encounter[12]. Metacognition plays a crucial and beneficial role in both resolving mathematical problems and the overall process of learning mathematics. All the steps involved in the problem-solving process exhibit qualities that are characteristic of metacognitive abilities.[13].

A meta-skill is the capacity to rapidly acquire and apply new knowledge. Referred to as meta-abilities, these encompass the comprehensive set of skills essential for accelerating the learning of new skills or fostering proficiency in other existing skills. [14]. In the mathematics computer application course, students engage with computer applications to tackle both straightforward and intricate mathematical problems. The multitude of available mathematical computer applications necessitates that students develop the ability to select the most suitable application for a given problem—a skill integral to meta-skills. This research aims to explore the curriculum and dispersion of computer-based courses, metacognition, and

[8] Wati Susilawati and Hamdan Sugilar, 'Technological Pedagogical Content Knowledge Analysis', *Numerical: Jurnal Matematika Dan Pendidikan Matematika*, 2021, 1–8.

[9] Thomas F. Luschei, *Equitable Access to High Quality Teachers: Bridging the Gap for Inclusive Education* (California, 2023).

[10] Dkk Widana, Wayan I, *Modul Penyusunan Soal Keterampilan Berpikir Tingkat Tinggi Matematika* (Jakarta: Direktorat Pembinaan Sekolah Menengah Atas, 2019).

[11] Susilawati and Sugilar.

[12] Agusmanto J B Hutauruk, 'Pendekatan Metakognitif Dalam Pembelajaran Matematika', *Repository FKIP Unswagati*, 2017.

[13] Meryance V Siagan, Sahat Saragih, and Bornok Sinaga, 'Development of Learning Materials Oriented on Problem-Based Learning Model to Improve Students' Mathematical Problem Solving Ability and Metacognition Ability.', *International Electronic Journal of Mathematics Education*, 14.2 (2019), 331–40; Jeni Wilson and David Clarke, 'Towards the Modelling of Mathematical Metacognition', *Mathematics Education Research Journal*, 16.2 (2004), 25–48.

[14] Rhiân Davies, '10 Meta Skills You Need to Achieve Career Success', *Web Online*, 2023 <https://www.testgorilla.com/blog/meta-skills/>; Juste Semetaite, '6 Meta-Skills Candidates Need in 2023 to Work Well with AI', *Web Online*, 2023.

meta-skills within mathematics education. Additionally, it seeks to assess mathematical metacognition abilities concerning the utilization of mathematical computer applications.

Research Method

The research employs a mixed-methods approach with an integrative research methodology, where qualitative and quantitative data are concurrently collected and analyzed. The quantitative aspect involves assessing metacognition abilities, while qualitative data include the analysis of curriculum documents, the metacognition abilities study program at PTKIN, and the exploration of metacognition abilities and meta-skills. The research instruments encompass a test evaluating metacognitive thinking abilities using a computer application and an interview form.

The analysis of data includes the results of a metacognition thinking ability test comprising ten questions related to differential and integral calculus material. The research focused on 45 students in the seventh semester of the 2021/2022 academic year, Class A, in the mathematics education program at UIN Sunan Gunung Djati Bandung, who were enrolled in a mathematics computer application course. Curriculum documents were gathered from various curricula accessible on the website of PTKIN in Indonesia. The data analysis technique involves evaluating computer-based course curricula concerning the learning outcomes of mathematics education study programs, specifically in terms of applying technology to learning. The results of metacognition abilities and meta-skills are analyzed using SPSS version 23.

Finding and Discussion

Finding

A. Mathematics Education Curriculum

In accordance with the Director General of Islamic Education's Decree Number 1591 of 2022, outlining the Technical Guidelines for the Implementation of MBKM at PTKIN (Pendis Kemenag RI, 2022), the objectives of the MBKM policy are delineated. These objectives include enhancing graduate quality to equip them with essential capabilities for the 21st century and the industrial era 4.0. The policy also aims to facilitate students' learning rights based on their interests and potential, fostering competitive graduates with distinct personalities. Additionally, it seeks to provide students with insights and experiences aligned with the graduate profile. Recognizing the significance of student readiness amidst social, cultural, scientific, technological, and industrial changes, it becomes crucial in formulating activities at PTKI. These activities are designed to support the attainment of superior and dynamic graduate competencies. The policy MBKM outlines nine distinct forms of activities aimed at achieving these objectives.

Creating courses as a practical implementation of MBKM policy involves acquiring semester credit units from other study programs within the same curriculum. For instance, if a study program aims to enhance CPL (*Capaian Pembelajaran Lulusan*/ graduate learning outcome) in technology, it can incorporate courses from informatics study programs with the desired number of credits. The primary objective of the Mathematics Education/Tadris Study Program is to produce graduates with expertise as teachers, researchers, and developers of mathematics teaching materials. These graduates are expected to be knowledgeable, well-versed, and continuously updated in their field, possessing a commendable personality. Furthermore, they should be capable of executing their responsibilities in line with Islamic ethics, knowledge, and expertise.

Table 1. Indicators and Descriptions of Learning Outcomes in the Mathematics Education Study Program in Technology Aspects

No.	Indicators	Description
1.	Profile of Mathematics Education Graduates	The main profile of graduates of the Mathematics Education/Tadris Study Program is as teachers, researchers and

		developers of mathematics teaching materials who are knowledgeable, in-depth and up-to-date; good personality, knowledgeable and up-to-date in their field and capable of carrying out duties and being responsible based on Islamic ethics, knowledge and expertise.
2.	Description of Qualification Level 6 for Undergraduate Level in the IQF of Employability and Generic Description	Able to apply their field of expertise and utilize science, technology, and or art in their field in solving problems and being able to adapt to the situation at hand.
3.	Description of Learning Outcomes in the Field of Attitudes and Values	12. Able to adapt, work together, create, contribute, and innovate in applying science to social life and have global insight in their role as citizens of the world; 14. Present oneself as a stable, mature, wise and authoritative person as well as having adaptability, flexibility, self-direction, well and full of initiative in the workplace; 18.Internalizing the spirit of independence/entrepreneurship and innovation in learning Mathematics in school/madrasah education units (SMP/MTs/SMA/MA/MK/MAK).
3.	Description of Knowledge Field Learning Outcomes	15. Applying information and communication technology in planning lessons, implementing learning, evaluating learning and managing learning mathematics; 19. Mastering the integration of technology, pedagogy, scientific content and/or expertise, as well as communication in learning mathematics;
4.	Description of General Skills Learning Outcomes	1. Be able to apply logical, critical, systematic, and innovative thinking in the context of the development or implementation of science and technology that pays attention to and applies humanities values according to their field of expertise 3. Be able to examine the implications of the development or implementation of science and technology that pays attention to and applies the values of the humanities in accordance with their expertise based on scientific principles, procedures and ethics in order to produce solutions, ideas, designs or art criticism 10. Demonstrate information literacy skills, media and utilize information and communication technology for scientific development and work ability; 12. Able to collaborate in a team, demonstrate creative abilities (creativity skills), innovative (innovation skills), critical thinking (critical thinking) and problem solving (problem solving skills) in scientific development and implementation of tasks in the world of work

Source: [15]

Based on table 1, indicators and descriptions of learning outcomes in mathematics education study programs on technological aspects. explained in detail so that graduates of mathematics education are able to adapt, be creative, use technology in their teaching. In the profile of graduates, it is explained that teachers are knowledgeable and up to date in their fields, meaning that they not only understand scientific material in mathematics but more than that, are knowledgeable and up-to-date in accordance with the times and are able to utilize, apply, and develop technology.

At the qualification description level 6 for the undergraduate level in the IQF workability and generic description, graduates are expected to proficiently apply science, technology, and/or art in addressing challenges. This proficiency includes the ability to adapt to various situations. This implies that when confronted with complex

[15] Dirjen Pendis, *Standar Kompetensi Lulusan (SKL) Dan Capaian Pembelajaran Lulusan (CPL) Program Studi Jenjang Sarjana Pada Perguruan Tinggi Keagamaan Islam Dan Fakultas Agama Islam (FAI) Pada Perguruan Tinggi* (Jakarta: Direktorat Pendidikan Tinggi Keagamaan Islam Direktorat Jenderal Pendidikan Islam Kementerian Agama Republik Indonesia, 2018).

mathematical problems, graduates can seek assistance from technology, particularly through the use of computer applications capable of resolving intricate or challenging problems.

Table 2. Distribution of Computer Technology-Based Courses in Mathematics Education

No.	Courses	Credit	Semester
1.	Basic programming algorithms	2	2
2.	ICT Literacy	2	2
3.	Computer Programs	3	4
4.	Mathematics Learning Multimedia	3	4
5.	Mathematical Computing	3	5
6.	Web Design Programming	3	5
7.	Applications Computer Mathematics	2	7
8.	Visual Communication Design	2	7

Source: [16]

According to Table 2 detailing the allocation of computer technology-based courses in mathematics education study programs, various PTKIN institutions structure their programs to produce undergraduate mathematics education students proficient in applying and developing technology. Students undergo a series of computer technology-based courses throughout several semesters, with some being mandatory and others optional. These courses include subjects like computer programming, web design, visual communication design, and the implementation of mathematical computer applications. The objective of offering such courses is to ensure that undergraduate mathematics education students acquire skills beyond mathematics and develop a robust understanding of technology.

B. Metacognition and Meta-skills

From a knowledge perspective, HOTS questions primarily assess the metacognition dimension, encompassing more than just measuring factual, conceptual, or procedural aspects. The metacognition dimension signifies the ability to interconnect diverse concepts, interpret information, engage in problem-solving, select problem-solving strategies, explore new methods, engage in reasoning, and make sound decisions. The characteristics of HOTS questions, in general, align with the metacognition dimension. Students who exhibit high or moderate levels of metacognition in resolving HOTS questions are considered to possess good command in critical thinking skills[17].

Table 3. Characteristics of HOTS questions

No.	HOTS Question Characteristics
1.	Measuring Higher Order Thinking Skills
2.	Based on Contextual and Interesting Issues (Contextual and Trending Topic
3.	Not Routine and Carrying Novelty
4.	Cognitive Level (Analyze, Evaluate, and Create)

Based on table 3 detailing the attributes of HOTS questions, it comprises four distinct features: assessing HOTS; rooted in contextual and engaging subjects (contextual and trending topics); non-routine and introducing novelty; and involving cognitive levels such as analyze, evaluate, and create. These traits serve as a valuable reference in mathematics learning, guiding various stages including modeling, methodology, and evaluation, as delineated in the format of HOTS assessment questions. Puspendik (2015) [18] classifies HOT questions into 3 cognitive levels: level 1, knowledge and

[16] Prodi Pendidikan Matematika UIN SGD Bandung, 'Kurikulum Akademik', *Prodi Pendidikan Matematika UIN SGD Bandung*, 2023 <https://mathedu.uinsgd.ac.id/kurikulum.php> [accessed 12 September 2023].

[17] Nuqthy Faiziyah and Bagas Legowo Priyambodho, 'Analisis Kemampuan Berpikir Kritis Dalam Menyelesaikan Soal Hots Ditinjau Dari Metakognisi Siswa', *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, 11.4 (2022), 2823–35.

[18] Widana, Wayan I.

understanding; level 2 application, and level 3 reasoning. Specifically speaking, the level of reasoning includes the dimensions of the thinking process: to analyze (C4), evaluate (C5), and create (C6). Not all questions at the reasoning level are inherently challenging. Questions at level 3 possess characteristics that necessitate the application of reasoning and logic in decision-making (evaluation), forecasting, reflection, and the capability to formulate innovative strategies for solving non-routine contextual problems. The subsequent segment provides an illustration of HOTS questions in this particular study.

Meta-skills refer to the capacity to swiftly acquire and apply new knowledge, commonly known as meta-abilities. They constitute a comprehensive range of abilities crucial for expediting the learning of new skills or fostering proficiency in existing ones. These high-level skills significantly augment an individual's capability to rapidly grasp and implement new knowledge. Research underscores three key meta-skills: self-awareness, creativity, and resilience, identified as having the most substantial impact in the contemporary workplace.

C. Metacognition Ability Value of Solving High-Level Mathematics Problems using a Mathematical Computer Application

To find out the metacognition value of solving math problems with the help of computer mathematics applications, students are given 10 descriptive questions of various mathematical materials. Students are free to choose the right application to solve the problem. Based on calculations with the help of SPSS version 23 presented in table 4.

Table 4. Metacognition Value Data

N	**Valid**	**45**
	Missing	0
Mean		77.9556
Std. Deviation		4.85216
Variance		23.543
Minimum		65.00
Maximum		88.00

Referring to Table 4, the mean score for metacognition abilities supported by mathematical computer applications is 77.95, with a standard deviation of 4.84. The scores range from a minimum of 65 to a maximum of 88. These data indicate that student performance falls within the good interval category, as scores surpass 50. Assessing the average, it is evident that it falls within the good category. This implies that students exhibit a proficient level of skills or meta-skills in addressing metacognition questions aided by mathematical computer applications. Subsequently, an examination of the percentage distribution is presented in Table 5.

Tabel 5. Frequency of Metacognition Values

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	65.00	1	2.2	2.2	2.2
	69.00	1	2.2	2.2	4.4
	71.00	3	6.7	6.7	11.1
	75.00	3	6.7	6.7	17.8
	77.00	23	51.1	51.1	68.9
	79.00	5	11.1	11.1	80.0
	82.00	3	6.7	6.7	86.7
	84.00	1	2.2	2.2	88.9
	88.00	5	11.1	11.1	100.0
	Total	45	100.0	100.0	

Examining Table 5 reveals that over half, specifically 51.1%, of the most frequently appearing values within the range of 65 to 88 fall within the value of 77, indicating a good category. To gain insights into students' approaches in addressing metacognition questions with computer applications, interviews were conducted. Students were asked two questions, focusing on their problem-solving experiences

with and without applications, particularly gauging the level of usefulness for mastering conceptual understanding.

Table 6. Results of Student Interviews on Computer Assisted Metacognition Questions

No	Question	Response/Answer
1.	Give your opinion about solving mathematics with mathematical computer applications	- Speed and efficiency: Mathematical computer applications can quickly perform complex calculations or involve large numbers. - Accuracy: If calculations involve complex or complicated operations, using a mathematical computer application can reduce the risk of human error. - Visualization: Some math apps can provide graphical or result visualizations that aid in better understanding of concepts. - Calculation complexity: If we perform calculations using a mathematical computer application, no matter how complex it is, the application can certainly help with its special abilities, whereas manual calculations will take a long time and be prone to errors. - Answering questions using a computer application makes the process of calculating numbers faster and more effective and has a higher level of accuracy compared to the manual method - With computer applications it can also be made to check the correctness of manual calculations that have been done previously. - Can get answers to math problems in a short time and some detail the steps for the process so that they can equate computer work with manual work
2.	Give your opinion about solving mathematics without mathematical computer applications	- Manual Calculation: - Understanding of concepts: Performing calculations manually can help with a better understanding of the mathematical concepts involved. - Practice and skills: Manual calculations help hone math skills and increase the speed and accuracy of calculations - Unassisted exams: In some situations, such as exams where the use of computer applications or calculators is not permitted, the ability to answer questions manually is important. By getting used to answering questions manually, a person will be better prepared to deal with such exam situations. - Certain contexts: In some situations, manual calculations may be more practical or sufficient, especially when only a few simple operations are involved.

Table 6 presents the outcomes of interviews conducted with 10 students, delving into their perspectives on completing mathematics tasks with and without the use of mathematical computer applications. In general, the following observations can be made: Utilizing mathematical computer applications accelerates and streamlines calculations, enabling swift resolution of complex mathematical problems. In contrast, manual methods require more time and a profound understanding. Nevertheless, it is acknowledged that using mathematical computer applications may encounter occasional errors or face other challenges, such as issues that are not easily detected.

The decision to employ a mathematical computer application or tackle questions manually hinges on the user's context and objectives. At times, a blend of both approaches can be adopted to leverage the advantages of each method. This perspective suggests that when presented with the choice between using an application or solving

problems manually, students tend to favor applications due to their speed, ease of use, and guided step-by-step processes, which aid in material comprehension. On the other hand, the manual method demands more optimal thinking, emphasizing a deeper understanding of mathematical concepts as the essence of effective problem-solving.

Discussion

When articulating learning outcomes pertaining to attitudes and values, scholars should demonstrate innovation in applying knowledge to social contexts and exhibit a global perspective. Universities must focus on critical aspects such as assessing outcomes, course evaluations, and acknowledging academic credit for affective results. This emphasis is warranted due to the significant impact of personality on learning outcomes [19] [20].

Innovation and a global perspective can be understood as the ability to creatively address challenges and devise ideas or solutions for encountered problems. A global outlook involves cultivating a mindset that embraces broad knowledge and expansive viewpoints, avoiding narrow perspectives. When describing learning outcomes in the realm of applying information technology and mastering technology integration, it implies that undergraduate mathematics education should adeptly apply information technology and master technology integration in an effective and optimal manner, ensuring a close relationship between mathematics and technology.

The proficiency in technology involves not only utilization but also the capability to innovate and address various challenges. Learning outcomes in the domain of general skills are elaborated in a detailed and lucid manner, encompassing competencies such as information literacy and the adept use of information and communication technology to enhance knowledge and employability. MBKM curriculum is an embodiment of the policy set forth by the Minister of Education and Culture of the Republic of Indonesia, Nadiem Makarim. This policy grants students the autonomy to pursue studies for three semesters outside their designated study program, as stipulated in Permendikbud No. 3 of 2020.

The MBKM curriculum implementation is delineated through the allocation of elective courses, allowing students to explore subjects within their own discipline or in diverse fields. Alternatively, students may engage in practical internship lectures within their chosen field. This approach affords students the freedom to select their preferred field of study. Furthermore, they have the flexibility to earn credits outside their designated study program, utilizing the three semesters for learning either in collaboration with corporations or independently outside corporate structures.

Regarding the intersection with technology and information, it is evident that KKNI (*Kerangka Kualifikasi Nasional Indonesia*/the Indonesian National Qualifications Framework) and the implementation of MBKM curriculum offer specific guidance and operational instructions pertaining to the preparedness expected from students in mastering and utilizing technology to confront contemporary global challenges. The arrangement of computer technology-based courses across semesters offers students valuable exposure to programming, design, and computer-assisted problem-solving, fostering proficiency among mathematics students in both implementing and advancing computer programs.

Metacognition knowledge encompasses the understanding or beliefs an individual holds about oneself and others as cognitive agents, tasks, actions or strategies, and how these elements

[19] Kerry Shephard, 'Higher Education for Sustainability: Seeking Affective Learning Outcomes', *International Journal of Sustainability in Higher Education*, 9.1 (2008), 87–98.

[20] Carmina Fandos-Herrera and others, 'The Influence of Personality on Learning Outcomes and Attitudes: The Case of Discussants in the Classroom', *The International Journal of Management Education*, 21.1 (2023), 100754.

interact to influence the outcomes of intellectual endeavors[21] .

Beyond the outcomes of thinking lies an understanding of the processes leading to these thoughts. Individuals possessing metacognition abilities are conscious of both the processes and outcomes they attain. Essential meta-skills that individuals, including candidates and employees, should cultivate and enhance encompass the rapid learning and application of information, possessing a heightened level of emotional intelligence, and adept problem-solving. Fundamentally, meta-skills serve as the foundation for developing, processing, and executing various other skills.[22].

Nonetheless, whereas soft skills typically involve interpersonal adaptability across diverse environments and individuals, meta-skills are enduring. Meta-skills cultivate a lasting enthusiasm and commitment to lifelong learning, establishing a foundation for acquiring new skills. The students' metacognition abilities fall within the "good" category, signifying their proficiency in addressing HOTS questions with the aid of mathematical computer applications. While utilizing the application is straightforward, grasping its precision requires a solid understanding. Students with robust meta-skills can effortlessly employ mathematical computer applications for both HOTS and LOTS (Lower Order Thinking Skills) questions.

Conclusion

Several PTKINs have adopted MBKM curriculum within their mathematics education study programs. This curriculum grants students the freedom to select courses based on their preferences from the available materials after completing five semesters. The study program integrates computer technology-based courses aimed at equipping undergraduate mathematics education students with skills and adaptability to technology. The cultivation of metacognition and meta-skills in learning mathematics becomes imperative for preparing graduates who possess the ability to contemplate processes or exhibit an awareness of how to think. In terms of meta-skills, students are provided with the proficiency to apply computer-based technology, encompassing programming, website or media development, and computer-assisted problem-solving in mathematics. The metacognition abilities of students in solving computer-assisted math problems or employing meta-skills are classified within the "good" category.

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References

Books

Dirjen Pendis, *Standar Kompetensi Lulusan (SKL) Dan Capaian Pembelajaran Lulusan (CPL) Program Studi Jenjang Sarjana Pada Perguruan Tinggi Keagamaan Islam Dan Fakultas Agama Islam (FAI) Pada Perguruan Tinggi* (Jakarta: Direktorat Pendidikan Tinggi Keagamaan Islam Direktorat Jenderal Pendidikan Islam Kementerian Agama Republik Indonesia, 2018)

Luschei, Thomas F., *Equitable Access to High Quality Teachers: Bridging the Gap for Inclusive Education* (California, 2023)

Journals

Afgani, Muhammad Win, and Retni Paradesa, 'Kemampuan Guru Matematika SMA Dalam Merancang Media Pembelajaran Berbasis Komputer', *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, 6.10 (2021), 1558–62

Faiziyah, Nuqthy, and Bagas Legowo Priyambodho, 'Analisis Kemampuan Berpikir Kritis Dalam Menyelesaikan Soal Hots Ditinjau Dari Metakognisi Siswa', *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, 11.4 (2022), 2823–35

[21] John H Flavell, 'Metacognition and Cognitive Monitoring: A New Area of Cognitive–Developmental Inquiry.', *American Psychologist*, 34.10 (1979), 906.

[22] Rhiân Davies.

Fandos-Herrera, Carmina, Julio Jiménez-Martínez, Carlos Orús, Alfredo Pérez-Rueda, and José Miguel Pina, 'The Influence of Personality on Learning Outcomes and Attitudes: The Case of Discussants in the Classroom', *The International Journal of Management Education*, 21.1 (2023), 100754

Flavell, John H, 'Metacognition and Cognitive Monitoring: A New Area of Cognitive–Developmental Inquiry.', *American Psychologist*, 34.10 (1979), 906

Ghavifekr, Simin, and Wan Athirah Wan Rosdy, 'Teaching and Learning with Technology: Effectiveness of ICT Integration in Schools.', *International Journal of Research in Education and Science*, 1.2 (2015), 175–91

Hutauruk, Agusmanto J B, 'Pendekatan Metakognitif Dalam Pembelajaran Matematika', *Repository FKIP Unswagati*, 2017

Ishartono, Naufal, Yosep Dwi Kristanto, and Fariz Setyawan, 'Upaya Peningkatan Kemampuan Guru Matematika SMA Dalam Memvisualisasikan Materi Ajar Dengan Menggunakan Website DESMOS', in *Prosiding University Research Colloquium*, 2019, pp. 78–86

Prodi Pendidikan Matematika UIN SGD Bandung, 'Kurikulum Akademik', *Prodi Pendidikan Matematika UIN SGD Bandung*, 2023 <https://mathedu.uinsgd.ac.id/kurikulum.php> [accessed 12 September 2023]

Rhiân Davies, '10 Meta Skills You Need to Achieve Career Success', *Web Online*, 2023 <https://www.testgorilla.com/blog/meta-skills/>

Salehudin, M, and H J Sada, 'Use of Technology-Based Multimedia for Teacher Professional Education (PPG): User Experience (UX) Analysis', *Al-Tadzkiyyah: Jurnal Pendidikan Islam*, 11.1 (2020) <https://doi.org/10.24042/atjpi.v11i1.5857>

Shephard, Kerry, 'Higher Education for Sustainability: Seeking Affective Learning Outcomes', *International Journal of Sustainability in Higher Education*, 9.1 (2008), 87–98

Siagan, Meryance V, Sahat Saragih, and Bornok Sinaga, 'Development of Learning Materials Oriented on Problem-Based Learning Model to Improve Students' Mathematical Problem Solving Ability and Metacognition Ability.', *International Electronic Journal of Mathematics Education*, 14.2 (2019), 331–40

Sugilar, Hamdan, 'Multimedia Matematika Di Era Digital', in *Prosiding-Seminar Nasional Teknik Elektro UIN Sunan Gunung Djati Bandung*, 2020, pp. 442–51

Supianti, In In, Acep Saeful Malik, and Anggit Sagita, 'Kemampuan Guru Matematika Dalam Menggunakan Komputer, Smartphone, Dan Internet', *Symmetry: Pasundan Journal of Research in Mathematics Learning and Education*, 6.1 (2021), 19–32

Susilawati, Wati, and Hamdan Sugilar, 'Technological Pedagogical Content Knowledge Analysis', *Numerical: Jurnal Matematika Dan Pendidikan Matematika*, 2021, 1–8

Widana, Wayan I, Dkk, *Modul Penyusunan Soal Keterampilan Berpikir Tingkat Tinggi Matematika* (Jakarta: Direktorat Pembinaan Sekolah Menengah Atas, 2019)

Wilson, Jeni, and David Clarke, 'Towards the Modelling of Mathematical Metacognition', *Mathematics Education Research Journal*, 16.2 (2004), 25–48

Wulandari, Yuni, Adzra Afifah Mahmuda, Maylinda Dwi Astuti, Wikan Tiyasning Ariyanto, and Darmadi Darmadi, 'Orientasi Pengembangan Dan Penerapan Kurikulum Merdeka Belajar Pada Program Studi Pendidikan Matematika', *Jurnal Review Pendidikan Dan Pengajaran (JRPP)*, 4.2 (2021), 317–21

Yasmansyah, Yasmansyah, 'Konsep Merdeka Belajar Kurikulum Merdeka', *Jurnal Penelitian Ilmu Pendidikan Indonesia*, 1.1 (2022), 29–34

Online References

Semetaite, Juste, '6 Meta-Skills Candidates Need in 2023 to Work Well with AI', *Web Online*, 2023

Harahap, Nawi, 'Karakteristik Soal HOTS', *Web Online*, 2019 <http://majalah1000guru.net/2019/07/high-order-of-thinking-skill/>