


Development of Mathematics Teaching Materials with Integration of 4C Skills for College Students

Mayang Gadih Ranti*¹, Rinda Azmi Saputri²

Universitas Islam Negeri Antasari Banjarmasin, Indonesia

mayanggadiah@uin-antasari.ac.id*¹, rindaazmi@uin-antasari.ac.id²

 <http://dx.doi.org/10.30595/alphamath.v11i1.26212>

ABSTRACT

The development of 4C skills—critical thinking, creativity, collaboration, and communication—is essential for preparing college students to meet the demands of the 21st century. Despite this urgency, there remains a significant gap in the availability of mathematics teaching materials that explicitly integrate these skills. This study addresses that gap by developing a novel teaching module that embeds 4C skill development within mathematics instruction, specifically in a basic statistics course for college students. Employing a Research and Development (R&D) methodology, the module was designed, tested, revised, and finalized through five systematic stages. Product trials were conducted with third-semester students in the Mathematics Education Program at UIN Antasari Banjarmasin. Data were collected through tests, questionnaires, and interviews, and analyzed using both quantitative and qualitative methods. Results indicate that the developed module is highly valid, practical, and effective. The key contribution of this research lies in offering an innovative educational resource that not only enhances mathematical understanding but also actively cultivates students' 4C skills. This integrated approach represents a novel contribution to mathematics education and provides a model for future curriculum development aimed at fostering essential 21st-century competencies.

Keywords: Critical Thinking, Creative Thinking, Collaboration, Communication.

ABSTRAK

Pengembangan keterampilan 4C (berpikir kritis, kreativitas, kolaborasi, dan komunikasi) merupakan hal yang sangat penting untuk mempersiapkan mahasiswa menghadapi tantangan abad ke-21. Namun, hingga saat ini masih terdapat kekurangan bahan ajar matematika yang secara eksplisit mengintegrasikan keterampilan tersebut. Penelitian ini bertujuan untuk mengisi kesenjangan tersebut dengan mengembangkan modul pembelajaran matematika yang secara inovatif mengintegrasikan keterampilan 4C, khususnya pada mata kuliah Statistika Dasar bagi mahasiswa. Penelitian ini menggunakan metode Research and Development (R&D) yang dilaksanakan dalam lima tahap, yaitu analisis kebutuhan dan perumusan tujuan, perancangan produk, uji coba produk, revisi produk, dan produk akhir. Uji coba dilakukan pada mahasiswa semester 3 Program Studi Pendidikan Matematika UIN Antasari Banjarmasin. Teknik pengumpulan data meliputi tes, angket, dan wawancara, dengan analisis data secara kuantitatif dan kualitatif. Hasil penelitian menunjukkan bahwa modul yang dikembangkan sangat valid, sangat praktis, dan efektif digunakan. Kontribusi utama dari penelitian ini adalah tersedianya bahan ajar inovatif yang tidak hanya memperkuat pemahaman matematika, tetapi juga secara aktif melatih dan mengembangkan keterampilan 4C mahasiswa sebagai bekal menghadapi tantangan masa depan.

Kata kunci: berpikir kritis, berpikir kreatif, kolaborasi, komunikasi.

Received : March 22, 2025

Accepted : May 22, 2025

Published : May 23, 2025

Introduction

Currently, the teaching materials needed by students are teaching materials that are able to facilitate the acquisition of skills in facing various challenges in the era of globalization. In the industrial era 4.0, every individual is required to be competitive and adaptive in facing every change. There are four skills that must be mastered to be able to face the challenges of the 21st century, namely critical thinking, creative thinking, communication and collaboration or abbreviated as 4C (Partnership for 21st Century learning, 2019).

The four skills above are very important for an individual to have in facing an increasingly advanced era. According to (Nurhikmayat & Jatisunda, 2019), with the ability to think critically one can analyze the truth of a problem solving so as to find the right solution, while (Abidin et al., 2018) stated that creative thinking is an important skill to have to become a superior person. Critical thinking skills are also very important for students to have in order to prepare a 21st century generation that is able to answer future challenges (Nurhidayati & Khasanah, 2021). Meanwhile, good communication and collaboration skills allow a person to interact competently in various communities in the global and digital era (Sahril et al., 2022).

Some data show that the 4C skills of students in Indonesia are still relatively low. The results of the PISA (Program for International Student Assessment) survey in 2022 showed that Indonesia was in 69th position out of 80 countries (OECD, 2023). There was a decrease in the reading, mathematics and science scores of Indonesian students compared to the previous PISA results. Likewise, the results of TIMSS (Trends in International Mathematics and Science Study) in 2015 also showed that Indonesia was in 44th position out of 49 countries. These data show that the ability of students in terms of literacy and higher order thinking such as critical thinking, creative thinking and problem solving is still low.

At the university level, the urgency of mastering 4C skills for students is inevitable. Every university must be able to facilitate students with learning that encourages the development of IT-based communication and problem-solving skills (Makiyah et al., 2021). In addition, (Saragih et al., 2021) stated that academic activities for students must be able to facilitate students to be able to think critically, creatively and communicatively. This is also emphasized in (Rahmawati et al., 2021) that 21st century education leads to significant changes in teaching materials, learning media, or facilities as provisions in facing increasing global competition. The need for the availability of teaching materials that can encourage the development of students' 4C skills is very real. Students need to get learning facilities, including teaching materials

that can foster the ability to think critically, creatively, communicate, and work together effectively.

Study results (Harahap, 2019) show that the industrial revolution 4.0 has a significant impact on students. Students are required to have IT, communication, and collaboration skills to be more adaptive to the environment. However, the current problem is that in college-level learning, the integration of 4C skills has not been widely seen and has not been done optimally. Teaching materials that integrate 4C skills in lectures are not yet available. As a result, students often have difficulty adapting to challenges in the world of work due to the lack of 4C skills. Currently, there are often complaints from stakeholders or service users of graduates, namely the unsynchronization between the knowledge gained by students and the needs of the industrial world. (Saragih et al., 2021).

UIN Antasari Banjarmasin is a university that has a mission to become a center for the integration of knowledge based on local wisdom and global insight (Mujiburrahman et al., 2018). Students who are alumni of UIN Antasari Banjarmasin are expected to be able to contribute to global civilization while upholding local wisdom values. One of the four pillars of UIN Antasari's scientific philosophy is global insight. To realize this, students must be supported with 4C skills in facing global challenges. Based on observations at UIN Antasari Banjarmasin, currently the integration of 4C skills in learning is not optimal. Not many studies have raised the issue of 4C skills. In addition, the availability of 4C-based teaching materials in lectures is still very rare, especially for prospective mathematics teacher students.

Mathematics itself is a science that plays a strategic role in the formation of a person's critical and creative thinking skills. The purpose of learning mathematics is to form the ability to think reasonably, logically, systematically and critically (Depdiknas, 2016). Prospective mathematics teacher students are important agents in the acquisition of 4C skills for students. The solution offered to overcome the above problems is to design learning that integrates 4C skills in it. Therefore, development research will be conducted to produce teaching materials for prospective mathematics teachers based on 4C skills.

The novelty of this research is the development of mathematics teaching materials based on 4C skills for students that have never existed before and are expected to contribute to supporting the achievement of students' critical thinking, creative, communication and collaboration skills. The difference between teaching materials with the integration of 4C skills developed in this study is that the developed mathematics teaching materials for students display each 4C component explicitly in

the teaching material components, so that they really facilitate the development of students' 4C skills. The purpose of this research is to develop mathematics teaching materials with the integration of 4C skills that can be used by students and then determine the quality of the teaching materials produced.

Research Methods

The research method used in this study is development research (Research & Development/ R & D). OECD in (Jain et al., 2010) defines R & D as a creative effort to find new applications. The priority of R & D is to produce a product, either a new product or an improvement of an existing product. In this research, what will be done is the development of mathematics teaching materials that integrate 4C skills in it, namely elements of critical thinking, creative thinking, communication and collaboration.

The development model to be used in this research is adapted from the Dick & Carey Model. The Dick & Carey model is a learning design model that provides learning experiences to be able to make learning appropriate (Fauziah & Rohmah, 2024). The adaptation of the steps of the Dick & Carey development model used in this study was carried out in five development steps, namely (1) needs analysis and goal formulation, (2) product design, (3) product trial, (4) product revision, and (5) final product. The development steps can be seen in the following Figure 1 presentation.

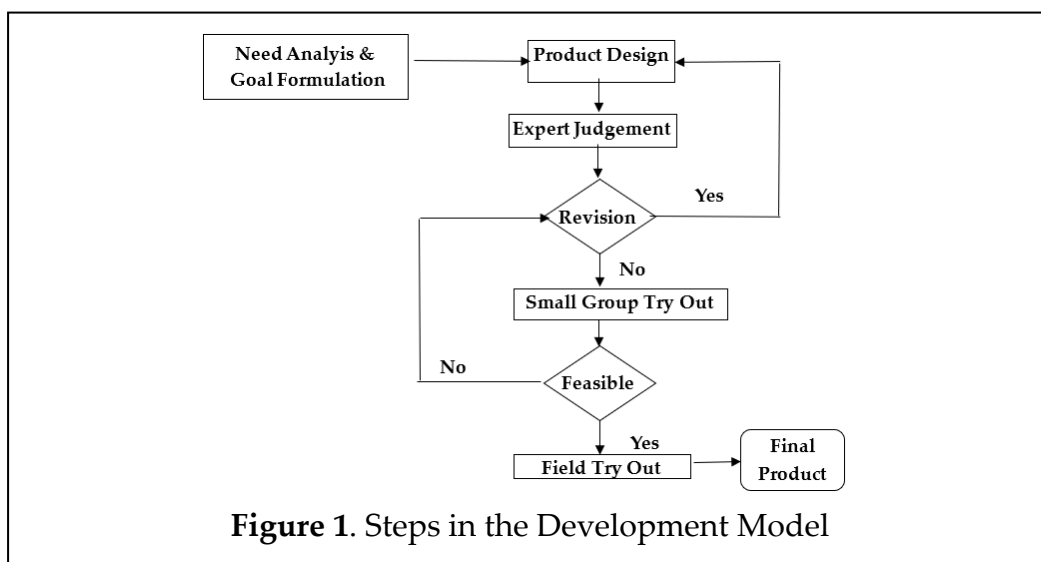


Figure 1. Steps in the Development Model

In the initial stage, a needs analysis was conducted. This analysis was carried out to determine the type of learning products in the form of teaching materials based on 4C skills needed. Information collection was carried out through interviews with the manager and students of the mathematics education study program at UIN Antasari

Banjarmasin. In addition, at this stage a literature study and formulation of objectives were also carried out. The results of the analysis are in the form of learning objectives to be achieved and what courses will be developed teaching materials with the integration of 4C skills. Next, after obtaining the product needs that need to be developed, the product design stage is carried out.

At the product design stage, product design is carried out in accordance with the competencies to be achieved according to the results of the needs analysis and the formulation of objectives obtained previously. This stage produces a product design in the form of an initial design of mathematics teaching materials with 4C skills integration, namely in the form of material coverage, product objectives and assessment. This initial product includes cover, content, and evaluation questions. The product display is complete and ready to be tested.

Next, the product was tested through three types of expert judgment, small group try out and field try out. Expert trials were conducted to obtain assessment results and input from experts on the teaching materials that had been produced, while small group trials were conducted to see the readability level of the products produced. Finally, the field trial was conducted in one class to determine the practicality and effectiveness of the teaching materials produced.

The results of the input from the expert trial were used as material for product revision of prototype 1. The revised product based on the results of the expert trial is called prototype 2. The results of this prototype 2 product were used in small group trials. The small group trial involved 3 - 6 student representatives from students with high, medium and low academic ability levels. The results of the limited trial were used as material for revision to be used in the field trial stage. The revised product based on the results of the field trial becomes the final product, namely quality 4C skills-based mathematics teaching materials.

The trial subjects in this study were students of the mathematics education study program at the Faculty of Tarbiyah and Keguruan UIN Antasari Banjarmasin class of 2023, totaling 23 students, of which 5 were male and 18 were female. Students conducted learning for 4 meetings using teaching materials that had been produced by focusing on the implementation of 4C skills in learning. Based on the results of this field trial, information is collected regarding the quality of teaching materials that have been produced. The quality of teaching materials is determined by referring to the criteria developed by Nieveen, namely validity, practicality and effectiveness (effectiveness) (Istiqomah, 2020).

Data collection techniques used in research are used to obtain information on the validity, practicality and effectiveness of the products produced. The data collection techniques used in this study were tests, questionnaires and interviews. The research instruments used in this study were expert validation sheets, student assessment questionnaires, and learning outcomes tests.

Then the data is analyzed to determine the level of validity, practicality and effectiveness of the teaching materials produced. Quantitative data from validation and questionnaire filling will be converted using a five scale into qualitative data. The validity obtained are in accordance with the predetermined criteria. The criteria for validity refer to [Table 1](#). The product is feasible and can be used if its validity are at least in the valid category.

Table 1. Criteria for Validity

Percentage	Criteria
$85,01 \% < X \leq 100 \%$	Very Valid
$70,01 \% < X \leq 85 \%$	Valid
$50,01 \% < X \leq 70 \%$	Less Valid
$1,01 \% < X \leq 50 \%$	Not Valid

Then to determine the practicality of the product, the practicality criteria are used as in [Table 2](#). The product is feasible and can be used if its validity are at least in the practical category.

Table 2. Criteria for Practicality

Percentage	Criteria
0 % – 20 %	Not Very Practical
21 % – 40 %	Not Practical
41 % – 60 %	Quite Practical
61 % – 80 %	Practical
81 % – 100 %	Very Practical

Meanwhile effectiveness is seen from the results of student evaluation tests. Evaluation tests to measure effectiveness are conducted at the end of learning after all learning using the teaching materials produced is completed. The effectiveness analysis conducted through the completeness of student learning test results. Assessment of student test results in the form of essay questions is carried out using the formula: $\text{Test Value} = \frac{\text{Total Score Obtained}}{\text{Total Maximum Score}} \times 100$. Teaching materials are said to be effective if based on the results of the evaluation test more than or equal to 75% of students reach a score of 70.

Result and Discussions

The results of this study are in the form of teaching materials in the form of basic statistics course module products used in mathematics teacher candidate lectures. The teaching materials developed integrate 4C skills, namely critical thinking, creativity, collaboration and communication. The results of this study are in line with (Ardiansyah et al., 2022) who states that to prepare graduates who are adaptive to the times, especially the era of disruption, a teacher must design learning that facilitates the development of 4C skills in students. In this research, the preparation of teaching materials is carried out following the rules for preparing teaching materials, and the achievement of each of the 4C skills.

The activities and materials in the module are designed in such a way as to facilitate the achievement of 4C skills. The integration of 4C skills is done through the presentation of problems that can encourage critical and creative thinking skills, and group work or discussion instructions that can develop students' collaboration and communication skills. The research steps taken in this study are in accordance with the stages of the development model used, namely the Dick & Carey development model, namely (1) Needs Analysis and Goal Formulation, (2) Product Design, (3) Product Trial, (4) Product Revision, and (5) Final Product.

Needs Analysis and Goal Formulation

The initial stage was needs analysis and goal formulation. The needs analysis and goal formulation resulted in the finding that currently there are no modules or mathematics teaching materials that explicitly integrate 4C skills. The available modules or teaching materials still mostly contain material and practice problems that do not facilitate the achievement of 4C skills. Only 60% of Mathematics Education study program students have previously heard of 4C skills, the remaining 40% do not know what 4C skills are at all. Teaching materials available in current lectures, both in the form of modules, handouts, student worksheets, and books do not fully facilitate the achievement of 4C skills. According to students, only 20% of students stated the availability of teaching materials that integrate 4C skills, and the other 80% stated that there were no teaching materials that integrated 4C skills in it. The formulation of objectives was carried out through material analysis as well as the SLOs of the Mathematics Education Study Program and CPMK in basic statistics courses.

Product Design

The next stage is product design which results in the design of teaching materials with the integration of 4C skills in it. The integration of 4C skills is done by providing module sections that display or facilitate 4C skills in it. The problems and instructions presented in the module encourage students to develop 4C skills, namely critical

thinking, creativity, collaboration, and communication. Explicitly written parts of learning activities in the module that write critical thinking, creativity, collaboration and communication activities.

The content of the module is adjusted to the steps of the 4C activities, namely critical thinking, creativity, collaboration and communication. Each step of the 4C activities is outlined in each learning meeting. The table of contents of module shows that each meeting in the learning activities consists of a series of activities that invite students to do 4C activities such as “let's think critically”, “let's think creatively”, “let's collaborate”, and “let's communicate”. The explicit appearance of the name of the activity aims to invite students to really get involved in doing 4C activities.

The module is designed in such a way as to encourage students to do activities that develop 4C skills at each meeting. Critical thinking activities are carried out by presenting complex problem solving problems that encourage students to reason or think at a high level, while creative thinking activities are carried out through open-ended problems. Likewise, collaboration activities are carried out through group discussion tasks, while communication activities are facilitated through presentation tasks and writing conclusions in their own words. Discussion activities are an effective step in improving students' communication skills because through discussion there will be a process of exchanging information or ideas (Husna et al., 2024). The product in the form of a draft basic statistics module by integrating 4C skills that has been produced is then called prototype 1 of the developed product. Furthermore, this prototype 1 will be validated by experts in product trial activities.

Product Trial

Products that have been produced at the design stage are tested through product trials with three stages, namely (1) Expert judgment, (2) Small group tryout, and (3) Field tryout. The expert judgment test was carried out by asking for expert assessments of the products produced. Experts who become validators are mathematics education lecturers who are competent in the fields of language, media and teaching material development. The results of the expert judgement showed that the average validation score obtained was 4.44 with an average percentage of 88.8%. This means that the module with the integration of 4C skills produced is in the very valid criteria. Furthermore, the validation results from each validator on each aspect of the assessment can be seen in [Figure 2](#).

Based on [Figure 2](#), it is obtained that the language suitability aspect has the highest percentage of 92.50%, followed by the media aspect of 88.75% and the material suitability aspect of 88.33%. The presentation suitability aspect has a presentation of

87.14% and the average percentage for all evaluation aspects is 89.18%. In addition to providing an evaluation, the validator also provided suggestions for improving the prototype 1 module before becoming prototype 2. Some suggestions for improvement include adding sources to the material and the 4C skill elements are more prominent in the module. Furthermore, the revised product based on input from experts is called prototype 2 and is used further in the small group tryout stage.

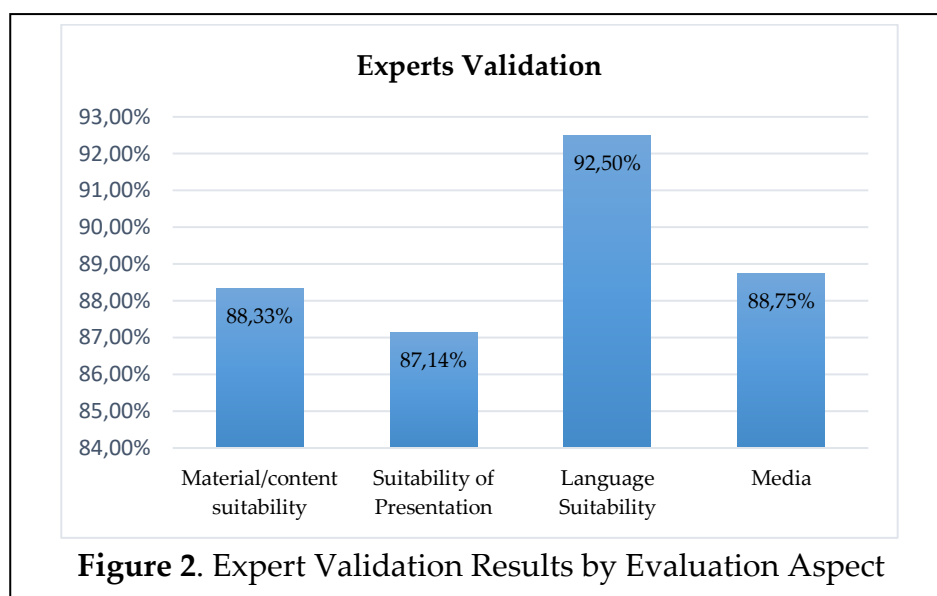


Figure 2. Expert Validation Results by Evaluation Aspect

The small group tryout was conducted to see the readability test of the product that had been produced. The small-group tryout was carried out by involving six students of the mathematics education study program who were selected based on the heterogeneity of academic abilities, namely high, medium and low abilities to read or observe the modules that had been produced. The six students were then asked for comments or input on the bilingual mathematics learning tools they read or observed. The comments or inputs were used as materials to revise the product before the field try-out. Some of the results of input or comments from the small group tryout are 1) some images such as infographics in the module are less clear, making it difficult to read and understand the data content in the images; 2) the color quality of the colored parts needs to be improved; and 3) over and layout need to be made more attractive and colourful.

Furthermore, a field tryout was carried out involving students of the mathematics education study program who conducted lectures in the odd semester of the 2024/2025 academic year, totaling 23 people. This field tryout was conducted to determine the practicality and effectiveness of the resulting module. The practicality test results showed that the student assessment score was 86.14% and included the Very Practical category. Likewise, the effectiveness test results through the learning outcomes

evaluation test showed 76.19% of students scored ≥ 70 with an average score of 73.48. These results lead to the conclusion that the module with the integration of 4C skills used is effective to use.

Product Revision

Product revision is the most important stage in a development research. The test results of each trial become the basis for product improvement. Revision I was carried out based on the results of expert judgment, namely based on input or suggestions from validators. Revision II was carried out based on the results of the small group try-out, namely the results of the student readability test, and Revision III was carried out based on input from students related to the practicality of the module used in learning. Revision III is the last revision carried out until the final product is compiled.

Some of the product revisions made based on the trial results are 1) inclusion of reference sources in the introduction material. Before the revision, the definitions used in the introduction material did not include the source, then it was improved by adding a bibliography section to the module according to the source referred to in the introduction material; 2) adding a question mark to the "What is 4C" section. Before the revision there was no question mark in the title "What is 4C", then after the revision a question mark was added to the section; 3) before the revision, it was necessary to show more 4C activities in each subchapter. Then the module was revised by displaying each 4C activity in each subchapter; and 4) before the revision, there were some infographic images that were not clearly legible, then revised by making improvements to the infographic images to make them clearer.

Final Product

The final product is a basic statistics module with the integration of 4C skills (critical thinking, creativity, collaboration, communication) that can be used for mathematics teacher candidates. The activities in the module have been designed in such a way as to facilitate the use of 4C skills for students. This module is the result of revisions based on the results of trials. This 4C skills-based basic statistics module has proven its quality through its validity, practicality and effectiveness. This module can facilitate students to achieve 4C skills, namely critical thinking, creative thinking, collaboration and communication skills and can be used in lectures.

Teaching materials in the form of basic statistics modules with the integration of 4C skills received a good response from students. Students considered the teaching materials presented were very interesting and different from the teaching materials that had existed before. The integration of 4C skills in the module encourages students to be more active in learning. Learning activities in the module encourage students to

be involved in developing critical thinking, creative thinking, collaboration and communication skills. The development of teaching materials that develop students' 4C skills is very important because the success of universities in facing the industrial era 4.0 is one of the indicators that there are innovations made in creating quality human resources and being able to face the challenges of technological development and the world of work in the future (Widodo, 2021).

Students' 4C skills are developed through activities in the module. Students' critical thinking skills are developed through activities to solve problems based on problem solving or reasoning. This is in accordance with the indicators of critical thinking skills, namely (1) determining solutions to problems with specific objectives, (2) analyzing, generalizing, organizing ideas based on available information, and (3) drawing conclusions based on problem solving obtained based on appropriate arguments (Cahyono, 2016). Likewise, students' creative thinking skills also develop with open-ended problems. Open-ended problems can encourage students' creative thinking skills. This is in accordance with what Ristontowi & Riwayatati (2020) stated that one way to increase students' creativity is by presenting open-ended problems (Ristontowi & Riwayatati, 2020). The open nature of a story problem can also encourage student creativity (Ismara et al., 2017).

Collaboration and communication skills are achieved through group discussions and presentations. Students are enthusiastic about learning through group discussions because learning becomes more interactive and dynamic. This activity can make them work together so that they can more quickly find solutions to the problems given. Through this group discussion activity, students can also train their communication skills with other students in one group, in addition to presentations that train their public speaking skills. The importance of improving communication skills for students is in line with the opinion that good communication skills are very relevant to learning in higher education and are the main competencies needed by students in facing the challenges of the world of work in the era of globalization (Andika & Yuliana, 2023). Likewise, collaboration skills need more attention so that they not only become a habit in academic activities, but also in everyday life (Nurwahidah et al., 2021).

Overall, students responded positively to this module. This module is able to encourage students to develop critical and creative thinking skills, as well as the ability to collaborate or cooperate through group work. Likewise, students' mathematical communication is increasingly honed through the use of this module. Student learning outcomes also increased and students were more motivated in learning. This is in accordance with what is revealed (Saragih et al., 2021) that learning using 4C can increase the role or activity and learning outcomes of students. The development of

4C skills in students not only affects the cognitive aspects, but also the affective and psychomotor aspects of students (Nurhidayah et al., 2023).

Conclusion

This study has demonstrated that the integration of 4C skills—critical thinking, creativity, collaboration, and communication—into teaching materials for prospective mathematics teachers can be effectively achieved through a structured development process. The five stages—needs analysis and goal formulation, product design, product trial, product revision, and final product—resulted in a basic statistics module that was evaluated as highly valid, practical, and effective. This confirms that 4C skill integration can be systematically embedded within mathematics teaching materials to enhance both content mastery and essential 21st-century competencies. Given the critical role of 4C skills in higher education, the approach used in this study can serve as a model for developing similar teaching materials in other courses and disciplines. Future research is encouraged to expand the integration of 4C skills across different subject areas to ensure students are well-equipped for academic and professional success. Continuous efforts are necessary to sustain and evolve this integration in educational practice.

Acknowledgement

Thank you to LP2M UIN Antasari Banjarmasin who has supported the research and all students of the Mathematics Education study program at UIN Antasari Banjarmasin who have helped in this research.

References

- Abidin, J., Rohaeti, E. E., & Afrillianto, M. (2018). Analisis Kemampuan Berpikir Kreatif Matematis Siswa SMP Kelas VIII Pada Materi Bangun Ruang. *Nusantara of Research : Jurnal Hasil-Hasil Penelitian Universitas Nusantara PGRI Kediri*, 1(4), 38–43. <https://doi.org/10.29407/nor.v5i1.12096>.
- Andika, M. V., & Yuliana, N. (2023). Meningkatkan keterampilan komunikasi di kalangan mahasiswa. *Jurnal Ilmu Sosial*, 2(5), 64–74.
- Ardiansyah, A. S., Agung, G. H., Cahya, N. D., & Dinasari, A. (2022). Upaya Mengembangkan Keterampilan 4C melalui Challenge Based Learning. *PRISMA, Prosiding Seminar Nasional Matematika*, 5, 627–637. <https://journal.unnes.ac.id/sju/index.php/prisma/>.
- Cahyono, B. (2016). Korelasi Pemecahan Masalah dan Indikator Berfikir Kritis. *Phenomenon : Jurnal Pendidikan MIPA*, 5(1), 15–24. <https://doi.org/10.21580/phen.2015.5.1.87>.
- Depdiknas. (2016). *Permendiknas Nomor 22 Tahun 2016 tentang Standar Isi*. Depdiknas.

- <https://doi.org/10.1002/ejoc.201200111>.
- Fauziah, E., & Rohmah, U. S. (2024). Pengembangan Materi dan Bahan Ajar PAI Dengan Model Dick And Carey. *Social Science Academic*, 2(1), 67–78. <https://doi.org/10.37680/ssa.v2i1.4740>.
- Harahap, N. J. (2019). Mahasiswa Dan Revolusi Industri 4.0. *Ecobisma (Jurnal Ekonomi, Bisnis Dan Manajemen)*, 6(1), 70–78. <https://doi.org/10.36987/ecobi.v6i1.38>.
- Husna, N. S., Octaviani, R., Sahara, Z., & Usiono, U. (2024). Penerapan Metode Diskusi Untuk Meningkatkan Kemampuan Komunikasi Peserta Didik Kelas Iii Di Mis Al-Wardah. *Khazanah Pendidikan*, 18(1), 53. <https://doi.org/10.30595/jkp.v18i1.20311>.
- Ismara, L., Halini, & Suratman, D. (2017). Kemampuan Berpikir Kreatif Matematis Siswa Dalam Menyelesaikan Soal Open Ended Di Smp. *Jurnal Pendidikan Dan Pembelajaran Untan*, 6(9), 1–8.
- Istiqomah, N. S. (2020). Pengembangan Perangkat Pembelajaran Matematika Berbasis Pemecahan Masalah Pada Materi Pythagoras Kelas Viii Smp. *MATHEdunesa*, 9(1), 104–111. <https://doi.org/10.26740/mathedunesa.v9n1.p104-111>.
- Jain, R. K., Triandis, H. C., & Weick, C. W. W. (2010). Managing Research, Development and Innovation. In *Research Technology Management* (Vol. 51, Issue 4). John Wiley & Sons. <https://doi.org/10.1080/08956308.2008.11657513>.
- Makiyah, Y. S., Mahmudah, I. R., Sulistyaningsih, D., & Susanti, E. (2021). Hubungan Keterampilan Komunikasi Abad 21 Dan Keterampilan Pemecahan Masalah Mahasiswa Pendidikan Fisika. *Journal of Teaching and Learning Physics*, 6(1), 1–10. <https://doi.org/10.15575/jotalp.v6i1.9412>.
- Mujiburrahman, Rusydi, M., & Musyarrafah. (2018). Integrasi Ilmu: Kebijakan dan Penerapannya dalam Pembelajaran dan Penelitian di Beberapa Universitas Islam Negeri. In *Antasari Press*. <https://doi.org/10.15408/ref.v5i3.25904>.
- Nurhayati, N., & Rahardi, R. (2021). Kemampuan Berpikir Kreatif Mahasiswa Dalam Mengembangkan Media Pembelajaran Matematika Saat Pandemi Covid-19. *Pembelajaran Matematika Inovatif*, 4(2), 331–342. <https://doi.org/10.22460/jpmi.v4i2.331-342>.
- Nurhidayah, S., Handini, O., Restuningsih, A., Slamet Riyadi, U., Sumpah Pemuda No, J., Banjarsari, K., Surakarta, K., & Tengah, J. (2023). Pengaruh Penggunaan Media Mind Mapping Berbasis 4C Terhadap Hasil Belajar Peserta Didik pada Pembelajaran Bahasa Indonesia Kelas V SD Negeri Tugu Jebres No.120 Surakarta Tahun Pelajaran 2022/2023. *Journal on Education*, 06(01), 5928–5940.
- Nurhidayati, M., & Khasanah, N. (2021). Penggunaan Metode K-Means Cluster Untuk Mengklasifikasikan Kemampuan 4C Mahasiswa. *Jurnal Ilmiah Matematika Dan Terapan*, 18(2), 160–169. <https://doi.org/10.22487/2540766x.2021.v18.i2.15615>.
- Nurhikmayati, I., & Jatisunda, M. G. (2019). Pengembangan Bahan Ajar Matematika Berbasis Scientific yang Berorientasi pada Kemampuan Berpikir Kritis Matematis Siswa. *Mosharafa: Jurnal Pendidikan Matematika*, 8(1), 49–60.

<https://doi.org/10.31980/mosharafa.v8i1.385>.

- Nurwahidah, N., Samsuri, T., Mirawati, B., & Indriati, I. (2021). Meningkatkan Keterampilan Kolaborasi Siswa Menggunakan Lembar Kerja Siswa Berbasis Saintifik. *Reflection Journal*, 1(2), 70–76. <https://doi.org/10.36312/rj.v1i2.556>.
- OECD. (2023). PISA 2022 Results (Volume I): The State of Learning and Equity in Education. In *OECD Publishing* (Vol. 1, Issue 183). <https://doi.org/10.22201/IISUE.24486167E.2024.183.61714>.
- Partnership for 21st Century learning. (2019). *21st Century Student Outcomes*. 1–9.
- Rahmawati, N. D., Rodliyah, I., & Saraswati, S. (2021). Pembelajaran Berorientasi HOTS Sebagai Inovasi Pembelajaran Abad 21. *Sainsteknopak*, 5(1), 1–6.
- Ristontowi, R., & Riwayati, S. (2020). Pengembangan Soal Open Ended Untuk Meningkatkan Kemampuan Berpikir Kreatif Matematis Mahasiswa. *Indiktika : Jurnal Inovasi Pendidikan Matematika*, 3(1), 26–34. <https://doi.org/10.31851/indiktika.v3i1.4931>.
- Sahril, Sofyan, R. R., Najamudin, A. A., Wirawati, N., Anwar, nurul S., Bulkis, I., & Zalsabila, A. (2022). Penerapan 4c dalam Mengembangkan Higher Order Thinking Skill (HOTS) pada Siswa Kelas VII di SMPN 27 Makassar. *INSIGHT: Indonesian Journal of Social and Humanities*, 2(1), 85–93.
- Saragih, M., Nst, H. S., Harisma, R., & Hasibuan, M. F. (2021). Desain Model Pembelajaran 4Cs (Creativity, Critical Thinking, Collaboration, Communication) untuk Meningkatkan Keterampilan Berpikir Tingkat Tinggi (Hots) Mahasiswa. *Jurnal EduTech*, 7(2), 236–244.
- Widodo, B. (2021). Implementasi Education 4.0 dan Merdeka Belajar dalam Matematika di Perguruan Tinggi. *PRISMA, Prosiding Seminar Nasional Matematika*, 4, 910–916. <https://journal.unnes.ac.id/sju/index.php/prisma/article/view/45178>.