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MATHEMATICS EDUCATION LEARNING AND TEACHING

Development of Geometry Module Based on Computational Thinking Assisted by GeoGebra

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abstract

This study aims to produce valid and feasible geometry module development research integrated computational thinking assisted GeoGebra. This research uses a type of R&D research that contains three stages, namely (1) (define), (2) (design), and (3) (develop). The research subjects were students in Tadris Matematika FTIK IAIN Pekalongan. Data collection techniques were carried out by conducting observations, questionnaires, and learning outcomes tests. The data analysis techniques used were analysis of the validity of teaching materials, analysis of test items, analysis of feasibility of the module, and analysis of the effectiveness of the module. The results showed that the developed module: (1) valid, after going through the validation process, (2) feasible, because there is a good response about the mathematics teaching materials integrated computational thinking assisted by GeoGebra from students and teachers, and (3) effective, by considering because students' mathematical abilities increase through a geometry module integrated computational thinking assisted by GeoGebra.

Keywords:

Development, Geometry Module; Computational Thinking; GeoGebra



Open Access

INTRODUCTION

The optimization of the education system in Indonesia depends on several main aspects of learning, including input, teachers as intermediaries, and teaching materials as information that will be given to students (Anwar, 2014: 1). Based on the three pillars mentioned above, learning mathematics requires an important aspect that teachers need to optimize, namely teaching materials. Mathematics learning can achieve optimal if teaching materials are developed with existing principles and are needed in mathematics lessons. One of them is the ability of algorithms and structured thinking contained in computational thinking. In Indonesia, apart from formal education, computational thinking and programming is currently being introduced by several researchers. This is intended to increase the score (even increase the ranking). This increase can be obtained by working hard to equip Indonesian students with the abilities that will be measured at PISA 2021, especially mathematics and computational thinking (Zahid, 2020: 712). In the last decade, several studies have also focused on computational thinking in mathematics learning (Fakhriyah, Masfuah, & Mardapi, 2019).

However, the reality shows that the development of computational thinking skills is not yet optimal. This is evident from the results of the PISA test in 2018 where Indonesia was ranked 71st out of a total of 79 PISA participants in mathematics. The problems expressed are also supported by the low ability of computational thinking in several schools and educational institutions. One of them is what the researchers did through observation of Tadris Matematika students at IAIN Pekalongan. The lack of computational thinking skills which was found through this observation, so that they can not think algorithmically, critically and structuredly. This must be overcome by maturing the learning process, both in terms of implementation and preparation of teaching materials (Yuntawati, Sanapia, & Aziz, 2021; Trisnawati, Purwanti, & Fahmy, 2022). In addition, Unfortunately, the textbooks used in learning still consist of only a lot of problems, without a more detailed discussion that facilitates students to be more critical and creative.

Teaching materials should be made in an innovative and interesting way in order to improve the quality of learning. Teaching materials that must be optimized in the era of the industrial revolution 4.0 include the main ones, namely teaching materials that are integrated with technology. Students' interest in learning will increase if a teacher has creativity and innovation in processing learning in ICT-assisted classes or technology in compiling and making learning materials/media (Rahadyan, Hartuti, & Awaludin, 2018: 12). One form of technology and mathematical applications that can be used is to use GeoGebra. This application allows one to learn with the interrelationships between analytic, visual, and numerical representations. According to Japa, Suarjana, & Widian (2017: 44), through GeoGebra, students' spatial abilities can increase and students become more trained in developing their mindset in working on mathematical problems.

Observations have been carried out at IAIN Pekalongan, it can be seen that the learning materials developed have not been optimal, both printed and online. In fact, in the modern era of the industrial revolution 4.0 everyone is required to be able to compete by having innovation, critical and creative abilities and utilizing technology for learning. This condition can affect the decline in the quality of teaching materials developed by

when one becomes a teacher. This is in line with findings (Arif & Iskandar, 2018) which reveal that teachers' abilities and skills in compiling teaching materials are still not optimal, so teachers do not yet have sufficient provisions in developing and compiling the 2013 curriculum teaching materials currently used.

Based on these recommendations, research findings, and field studies, the researcher concluded that it is necessary to develop a geometry module that integrates computational thinking assisted by GeoGebra. The application of GeoGebra in mathematics has been widely used in schools and universities, but it still rarely integrated with computational thinking. Therefore, this study aim to develop a geometry module that integrates computational thinking assisted by GeoGebra.

LITERATURE REVIEW/ THEORETICAL FRAMEWORKS

Computational Thinking

Computational Thinking (CT) is not only used in informatics subjects, but also in other fields of science that integrate CT into learning, including in mathematics. Several countries in Asia such as Japan, Hong Kong, China and Taiwan and even Malaysia have also implemented the concept of computational thinking in teaching (Morris, Jong, & Liu, 2020; Ung, Saibin, Naharu, Labadin, & Aziz, 2018).

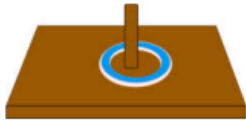
Computational Thinking was first introduced by Papert (1980) and further popularized by Wing (2006). Wing (2016) reveals that computational thinking is a way of thinking which involves the formulation of problems and solutions so that the solutions can be represented in a form that can be executed by information processing agents. Computational thinking skills in the 21st century need to be continuously explored and trained as the main way of solving HOTS (Higher Order Thinking Skill) problems.

Sentance & Csizmadia (2017: 469) mentions the cognitive processes that work in computational thinking, namely: (1) the ability to think algorithmically, (2) the ability to think about decomposing, (3) the ability to think to generalize, identify and make patterns, (4) the ability to thinking about abstraction, choosing a good/right representation, and (5) the ability to think about evaluation. The concept of thinking in CT is the main ability needed by students in learning mathematics. These abilities are developed in several forms of CT activity. Another opinion was expressed by Gadanidis, et al (2017: 458) that computational thinking can be scenariod in various forms, namely on computer screens, circuit and robot controls, bias in algorithms designed to solve problems. In learning mathematics, CT can be seen from the process of compiling algorithms conceptualized by students to solve problems.

Several recent studies have shown that computational thinking plays a role and has a major contribution in mathematics. computational thinking processes human information and knowledge to be completed through solutions that are arranged algorithmically and systematically so that they are effective and efficient (Sa'diyyah, Mania, & Suharti, 2021: 19; Maharani, 2020: 86; Rahmadhani & Mariani, 2021: 289; Rahmania, Sulisworo, &vRahma, 2023, 45).

The following is an example of computational thinking activities in learning mathematics in Indonesian.

Sarah si berang-berang bermain karet gelang dengan teman-temannya. Setiap berang-berang harus memasukkan 5 karet gelang ke sebuah batang kayu.



Setiap lemparan karet yang masuk ke batang kayu akan mendapat poin sebagai berikut:

Lemparan	Poin
Pertama	5
Kedua	4
Ketiga	3
Keempat	2
Kelima	1

Tantangan:
Sarah melempar dengan hasil sebagai berikut, berapa poin yang diperolehnya?



Figure 1

Computational thinking's problem

Source: Bebras Book accessed at <https://bebras.or.id/>

The problems above can encourage students' curiosity, analytical skills, creative and critical thinking. The main principle in computational thinking is not only solving mathematical problems, but logical and reasoning skills as well as thinking algorithmically which explores the ability to think in a structured way to reach the desired problem solution.

GeoGebra

GeoGebra is one of the right choices to represent mathematical objects. According to Hohenwater, GeoGebra is a computer software compiled and designed for mathematics lessons, and is usually used in the fields of geometry, algebra, and calculus (Japa et al., 2017: 41). GeoGebra can be used to overcome teachers' difficulties in integrating knowledge that will be conveyed to students but with an attractive packaging because GeoGebra accommodates three approaches, namely analytic, visual, and numerical (Rahadyan et al., 2018: 13). So, it can be concluded that GeoGebra is software created to accommodate the preparation of media and teaching materials for mathematics and is enriched with analytic, visual, and numerical approaches. GeoGebra will be very helpful in visualizing problems that require algorithmic and clear paths, such as computational thinking skills.

The features possessed by GeoGebra attract attention which raises students' curiosity and their interest in learning and exploring. This opinion is reinforced by the research results of Wondo, Mei, & Seto, (2020: 163) which says that the existence of GeoGebra can

bridge students in increasing their active interest and learning achievement. Activities in GeoGebra can also train students in thinking algorithmically and structuredly.

METHODS

Research Design

This research method is research and development (R&D) using a 4-D development model which includes define, design, develop, and disseminate stages (Thiagarajan, Semmel & Semmel, 1974). However, in this study, it was modified into a 3-D development model considering that the disseminate stage was not carried out due to time, energy, and cost limitations in completing the four stages.

The define stage aims to determine and define everything that is needed in learning, by analyzing the objectives and limitations of the subject matter. This stage consists of five activity steps, namely: (a) student analysis, (b) material analysis, (c) task analysis and (d) specification of learning objectives. The design stage aims to design teaching materials and research instruments in order to obtain prototypes (examples of learning devices and research instruments). The activities carried out at this stage consisted of four activities, namely: (a) preparation of test criteria, (b) selection of media, (c) selection of formats and (d) initial design. The development stage aims to produce a final draft for the development of learning tools. This stage consists of two activities carried out successively, namely: (a) expert assessment, and (b) module trials.

Subject, Data Collection, and Analysis

The subjects of this study were students majoring in Tadris Matematika at IAIN Pekalongan. Data collection techniques carried out were observation, interviews, documentation, and tests. Validation is carried out by competent experts and practitioners. Modules with a valid category are if the results of the module assessment by expert validators are at least good. While the module with the feasible category is if the module is used efficiently and there is a difference in mathematics learning achievement between before and after using the module.

Following are the criteria for assessing the validity module (Widyoko, 2010).

Table 1
Module Validity Score

Interval	Category
3,25 – 4,00	Very Good
2,50 – 3,25	Good
1,75 – 2,50	Poor
1,00 – 1,75	Very Poor

The expert's assessment aims to obtain suggestions, criticisms which are used as input for revising the learning tools (initial draft/draft I) so that draft II is produced which can be categorized as good and suitable for field trials. The stages in this validation generally include 1) validation of the content of the geometry module which is integrated with computational thinking, whether it is in accordance with the material and objectives to be measured, 2) validation in terms of language, whether the learning device uses good

and correct Indonesian or whether the sentence in learning tools do not cause double understanding. The geometry feasibility module trial was carried out with a paired-samples test.

The collected data will be analyzed both qualitatively and quantitatively as needed. According to Moleong (2002) qualitative analysis techniques are carried out by reducing data, presenting data, concluding, and verifying data. Quantitative techniques are implemented to measure the effectiveness of the geometry module integrated with computational thinking assisted by GeoGebra in learning mathematics. The test that was carried out was the *paired sample t test* by comparing the pretest and posttest values.

Frame Work Flow

The stages of development are shown in Figure 2.

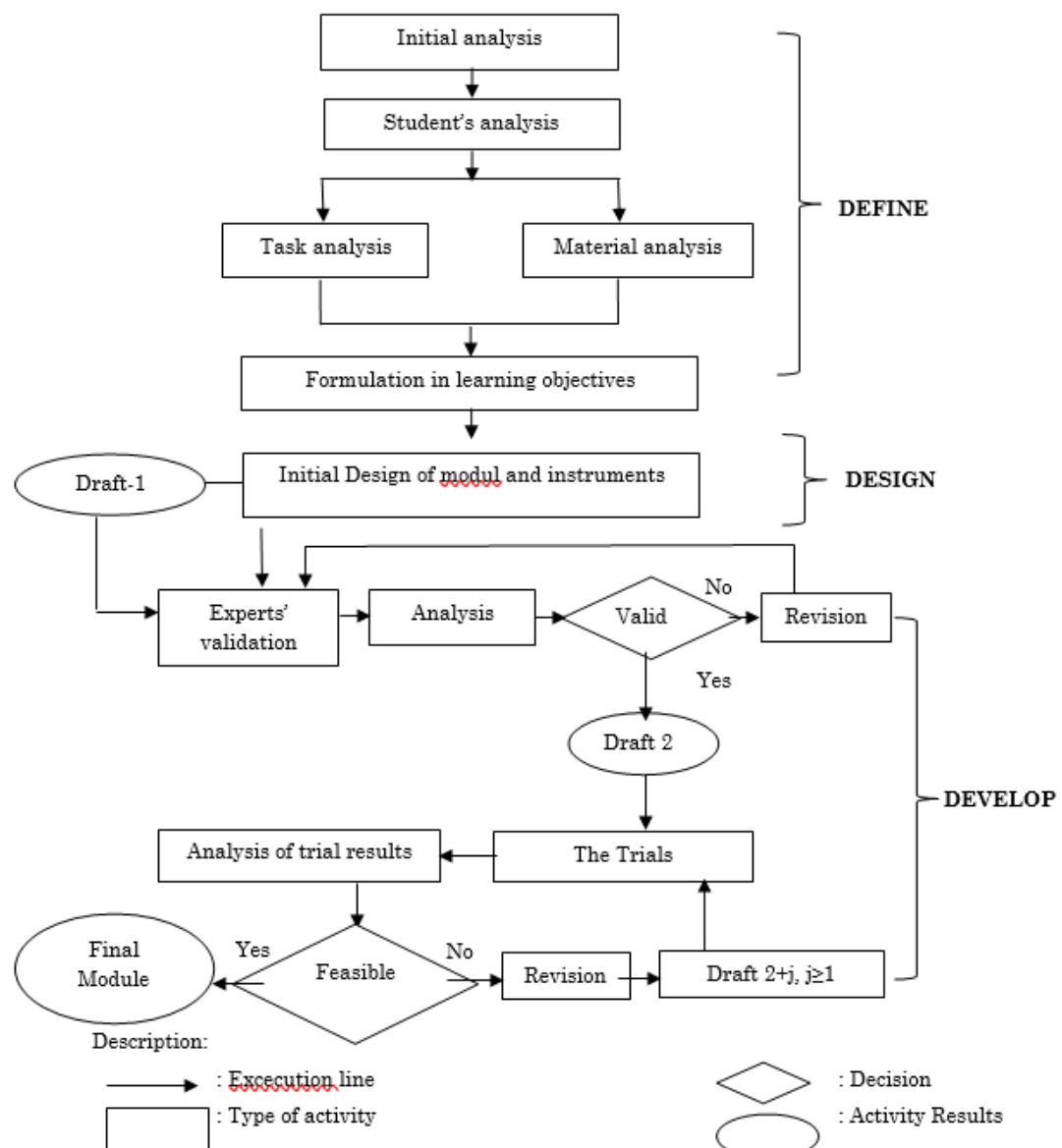


Figure 2
3-D Development Model

RESULT AND DISCUSSION

Define

Task analysis on geometry gets the following results: (1) State the elements of geometric shapes; (2) Finding and calculating the area of a geometric shape; (3) Finding and calculating the volume of a three-dimensional shape. In the material analysis, the main material that will be learned by students has been identified and arranged in the form of a concept map. It is important to do the preparation of a geometry module integrated computational thinking assisted by GeoGebra, so that the material presented in the research is systematic and nothing is missed.

Design

The geometry module which is integrated with computational thinking assisted by Geogebra which is being developed consists of material and sample questions, interactive problem exercises, and student worksheets. The results of the design of integrated computational thinking geometry modules assisted by the Geogebra application produced at this stage are called draft 1. Next, draft 1 will be validated by validators. Before validation is carried out, research instruments are first made. The designed validation instruments include module validation sheets and math ability test validation sheets. Other research instruments created were student response questionnaire sheets and teacher response questionnaire sheets

Develop

Module and Test Validity Analysis

Module validation includes 3 aspects, namely (1) Writing format, (2) Content Eligibility, and (3) Language. The results of the validation by 3 experts and practitioners of the developed modules and tests are shown in Table 1.

Table 2
Recapitulation of Module and Test Validation Results

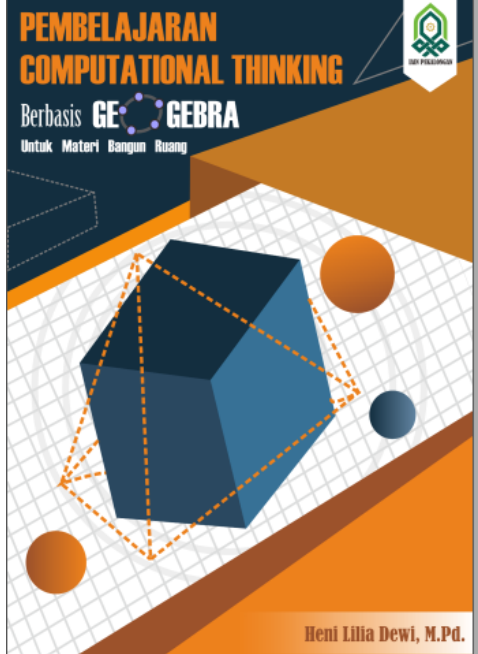
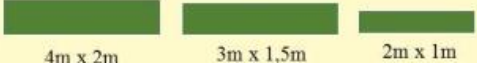
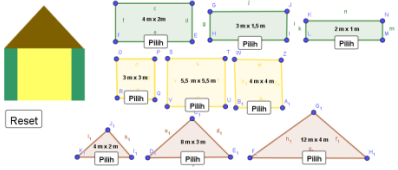
	Average Validation of Each Validator				Criteria
	E1	E2	E3	Average	
Module	3,28	3,4	3,28	3,35	Very Good
Test	Valid	Valid	Valid	Valid	Valid

Some of the comments and suggestions provided are as follows.

1. The color and contrast of the letters need to be adjusted.
2. The questions that will be developed in the module can be adopted from Bebras questions which can be accessed at <https://latihanbebras.ipb.ac.id/>
3. There needs to be a summary of the module, preface and other accessories so that an overview of the module can be seen before it is opened.
4. Focus on the content/substance, not only on the appearance, because the display of many pictures is suitable for elementary students.

Several module comparisons before and after the revision are illustrated in the following figure.

Table 3
Module comparisons before and after the revision

Bevore Revision	After Revision
 Module cover before revision	 Module cover after revision
Rumah impian Pak Nirwa tersusun dari 2 buah persegi panjang, 1 buah persegi dengan sisi yang sama panjang dengan sisi persegi panjang, dan 1 buah segitiga dengan panjang sisi alas berukuran penjumlahan dari 2 sisi lebar persegi panjang + 1 sisi kubus. Bangun mana yang harus Pak Nirwa pilih agar membentuk rumah impiannya?  (Rumah impian Pak Nirwa) Diantara bahan bangunan A, B, dan C, bangun mana yang harus Pak Nirwa pilih agar membentuk rumah impiannya? A  4m x 2m 3m x 1.5m 2m x 1m Before revision (not yet GeoGebra integrated)	Deskripsi Soal Rumah impian Pak Nirwa tersusun dari 2 buah persegi panjang, 1 buah persegi dengan sisi yang sama panjang dengan sisi persegi panjang, dan 1 buah segitiga dengan panjang sisi alas berukuran penjumlahan dari 2 sisi lebar persegi panjang + 1 sisi kubus.  Tantangan: Bangun mana yang harus Pak Nirwa pilih agar membentuk rumah impiannya? Pilihan: - Persegi panjang 4m x 2m – Persegi 4m x 4m – Segitiga 8m x 3m - Persegi panjang 3m x 1.5m – Persegi 3m x 3m – Segitiga 4m x 2m - Persegi panjang 2m x 1m – Persegi 3m x 3m – Segitiga 4m x 2m - Persegi panjang 4m x 2m – Persegi 5.5m x 5.5m – Segitiga 12m x 4m After revision (GeoGebra integrated)



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The bibliography is complete because it is accompanied by a description of the theory inside



There is no cover and module summary yet



Cover and module summary are complete

Based on the comments and suggestions from the validator, an evaluation is carried out and followed up by revising the parts that need improvement. The test items for the learning outcomes test were designed to consist of 10 questions on geometric material. The revision of the computational thinking ability test can be seen in Table 2.

Table 4
Test Revision

No	Comments/Suggestions	Revision
1.	Better to use contextual problems	Using contextual problems related to real life
2.	Clarify the picture	The picture has been clarified
3.	Use realistic numbers with real problems	The numbers in the questions have been adjusted to real problems

Data Analyze

Module Feasibility Data Analysis

Based on the results of filling out the student response questionnaire, it was analyzed and it was obtained that 81.58% of students gave a positive response. In other words, students gave a positive response because more than 75% of students gave a positive response to the Geometry module based on computational thinking assisted by GeoGebra.

The teacher's response to the feasibility of the Geometry module based on computational thinking assisted by GeoGebra is the average teacher response questionnaire result of 4.17. So the lecturer's response to the module is in the good category. Comments and suggestions given by the teacher are as follows.

1. There is a need to socialize or disseminate Geometry module based on computational thinking assisted by GeoGebra.
2. Students better interpret learning with Geometry module based on computational thinking assisted by GeoGebra.
3. Students learn more independently and interactively.

Module Effectiveness Analysis

The first assumption test performed was the SPSS normality test using the Kolmogorov-Smirnov test with a significance level of 5%. Based on the Normality Test, it is found that the Sig value is $0.200 > 0,05$ with the conclusion that the data is normally distributed.

Table 5
Test of Normality

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Hasil	.142	76	.200	.913	76	.015

a. Lilliefors Significance Correction

The second assumption test that was carried out was the SPSS homogeneity test of variances using the Lavene test with a significance level of 5%. Based on the Lavene Test, it was found that the Sig value was $0,126 > 0,05$ with the conclusion that the data was homogeneous.

Table 6
Test of Homogeneity of Variances

		Levene			Sig.
		Statistic	df1	df2	
Hasil	Based on Mean	2.392	1	74	.126
	Based on Median	2.966	1	74	.089
	Based on Median and with adjusted df	2.966	1	72.342	.089
	Based on trimmed mean	2.611	1	74	.110

Then a paired-sample test is carried out to measure whether the module is effective by comparing the pretest and posttest values.

Table 7
Paired Samples Test

		Paired Differences				t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower Upper			
Pair 1	Pretest - Posttest	-14.553	7.191	1.167	-16.916 -12.189	-12.475	37	.000

Based on the SPSS output above, the calculation uses a paired t-test using SPSS, a sig value of 0.000 is obtained. Because Sig (0.000) < α (0.01), it can be concluded that the Geometry module based on computational thinking assisted by GeoGebra is effective for mathematical abilities.

The results show an increase in mathematical ability compared to before using the module. Based on detailed discussion descriptions of the material presented in the module, students are motivated and interested in non-routine questions, such as computational thinking questions, which have the characteristics of decomposition, pattern recognition, pattern abstraction and algorithm design. The existence of algorithmic processes and patterns in the questions makes lectures centered on the learner. Students' problem-solving abilities can be improved through student-centered learning (Kim, 2012).

The Geometry module based on computational thinking assisted by GeoGebra has been validated, revised, and has been tested. Based on the above results, this research has produced a Geometry module based on computational thinking assisted by GeoGebra that is valid, feasible, and effective in teaching mathematics. This is realized because during learning using modules, students practice to decompose problems, understand patterns, abstract problems, and develop algorithms clearly. Therefore, students become focused and can improve their mathematics learning achievement.

CONCLUSION AND IMPLICATION

Conclusion

Based on the results of the development and testing of the Geometry module based on computational thinking assisted by GeoGebra, it can be concluded as follows.

1. This development research produced a valid and feasible Geometry module based on computational thinking assisted by GeoGebra for use in mathematics learning.
2. Module development has gone through the results of field trials to determine the level of validation, feasibility, and effectiveness of the module. To find out whether the module is valid or not, validation of the learning device is carried out by validators (experts and practitioners) consisting of 3 people including 2

experts from mathematics lecturers and 1 practitioner from computational thinking experts.

3. The effect of module development results on mathematical ability, especially computational thinking abilities based on field trials as measured using tests. The results of the analysis of the pre test and post test show that there is a significant difference between before and after using the module.

The produced module could facilitate learners to understand the materials and enrich their computational thinking ability. Teachers could use this module as a reference for their teaching especially in geometry. For further research, it is recommended to develop teaching materials based on computational thinking assisted by GeoGebra on other materials with open-ended problems.

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