Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 5, 2379 – 2386

DEVELOPMENT OF LEARNING DEVICES BASED ON INFERENTIALISM TO IMPROVE STUDENT'S MATHEMATICAL REASONING ABILITY

[1]Rick Hunter Simanungkalit, [2]Hardi Suyitno, [3]Isnarto, [4]Dwijanto

[1]PPS, Semarang State University, Central Java, Indonesia, ricksimanungkalit@uhn.ac.id
[234]PPS, Semarang State University, Central Java, Indonesia

Abstract

The purpose of this study is to find out: (1) how the quality of learning devices based on inferentialism is developed, and (2) the application of learning devices developed on the basis of inferentialism can improve the mathematical reasoning abilities of students. the students?. This research is development research using Thiagarajan's development model, that is, a modified 4D model (Define, Design, Develop and Disseminate). The learning devices developed were lesson plans, student activity sheets, student books, and instruments to test students' mathematical reasoning ability. The research instruments were: (a) learning device validation sheets including: lesson plans, student activity sheets, student books, and tests of mathematical reasoning skills; (b) observation sheets to see the teacher's ability to manage student learning and activities; (c) research questionnaires to see students' responses to learning. The results of the data analysis show that the learning devices developed based on inferentialism meet the valid, practical and effective criteria. There is an increase in the mathematical reasoning abilities of the students using the developed learning devices.

Keywords: Development, Learning Devices, Mathematical Reasoning, Inferentialism.

1. INTRODUCTION

The National Council of Teachers of Mathematics (NCTM, 2000) says that when implementing mathematics learning, teachers must pay attention to five mathematical skills, namely: connections, reasoning, communication, problem solving, and representation. . One of the skills that teachers should pay attention to in learning mathematics is the ability to reason mathematically (reasoning) because it is one of the skills that students must possess (Permendiknas No. 22 of 2006 regarding the Standards of Content), Rosnawati (2011). This is in line with Turmudi (2008), Ball, Lewis & Thamel (Riyanto, 2011), Sumarmo (2013) who affirm that mathematical reasoning is the basis for the construction of mathematical knowledge.

Wahyudin (2008) that mathematical reasoning is very important in the learning process of mathematics, because mathematics is a science that is obtained through reasoning. Therefore, it can be concluded that one of the basic elements to improve mathematical performance is to improve reasoning skills that connect their knowledge with the subject matter in solving mathematical problems (Adegoke, 2013; Sajadi, Amiripour et.al. 2013).

Given the importance of mathematical reasoning, various efforts have been made by teachers, education professionals and also experts to improve students' mathematical reasoning skills. In fact, students' mathematical reasoning abilities are still in the low category compared to other mathematical abilities. Rosnawati (2011) suggests that the lowest average percentage achieved by Indonesian students is in the cognitive domain at the reasoning level, which is 17%. This is also expressed by Suryadi (Minarti, 2012) that one of the mathematical activities that are considered difficult by students is mathematical reasoning.

One of the efforts that can be made to improve students' mathematical reasoning skills is to innovate mathematics learning and develop learning devices. Teachers play an important role in designing innovative learning to support students' ability to reason mathematically. Teachers must organize and plan good and complete preparations to improve students' mathematical reasoning. One form of preparation to be prepared by the teacher is a learning device. Learning devices play an important role, because learning devices are a form of preparation that teachers carry out before carrying out the learning process (Brata in Komalasari, 2011; Suparno, 2002; Suhadi, 2007). Considering that learning devices are very important, the government has made several efforts, starting with workshops, tutorials, trainings, and also establishing experimental schools in the preparation and development of learning devices, but the reality on the ground is that there are still there are many teachers who do not have learning devices when they teach and often find learning devices are only limited to 'original creation' for sheer administrative completeness.

As a result of the above conditions, the learning devices produced by teachers fall far short of the demands. Many teachers rule out that teaching is a series of systems based on planning, execution, evaluation and reflection. In addition to that, it is often found that the learning devices used are still focused on the material contained in the curriculum, thus students tend to memorize without understanding the concepts and meanings. As a result, when students are faced with non-routine problems, such as mathematical reasoning problems, they will have difficulty solving them.

The development of learning devices must be adjusted to the level of knowledge and experience of the students (Simanungkalit, 2016). Learning devices must also be oriented to the correct learning model. Teachers need to be able to choose learning models that can improve students' mathematical reasoning skills. The selection and use of the correct learning will produce maximum results. The use of learning models that are not in accordance with the development of students will have an impact on the developmental stage of student learning. In this study, the learning devices to be developed are based on inferentialism. Inferentialism is a theory that explains the formation of concepts and the determination of knowledge claims in terms of conclusions made by individuals (students). The process of conceptualizing and establishing knowledge claims (conclusions) takes place in a context of intersubjective practice, where there are activities of giving and asking for reasons to recognize, relate to, and challenge each other's commitments (Brandom: 1994; Taylor et al. al: 2017) . In simple terms, it can be said that inferentialism is a new theory in mathematics education that emphasizes the way in which individuals construct their knowledge while participating in social practice.

There are three main concepts of inferentialism, namely (1) Sensitive to reasoning (giving and asking for reasons), (2) Scoring (recording numbers or scoring/giving evaluations), and (3) Reasoning space (reason space). It is simply explained that inferentialism characterizes learning with socio-cognitive activities simultaneously. Learning with the inferentialism model provides a perspective that students acquire knowledge (cognitive) and participate (socially) simultaneously and cannot be separated from each other in the learning process.

Based on the above explanation, the author wishes to develop a mathematical learning device based on inferentialism to improve students' mathematical reasoning skills. The formulation of the problem in this research are: (1) How is the quality of learning devices based on inferentialism developed?, and (2) Can the application of learning devices developed based on inferentialism improve learning skills? students' mathematical reasoning?

The objectives of this study are: (1) to determine the quality of learning devices developed based on inferentialism, and (2) to determine the improvement of mathematical reasoning skills with learning devices developed based on inferentialism.

2. Method

2.1. types of research

This type of research is Research and Development (R&D). This research was carried out at BintangTimur Junior High School Pematangsiantar. The population of this study was the students of class VII-1. The design of this research uses a modified Thiagarajan model known as the 4-D model (Define, Design, Develop and Disseminate). The learning devices developed are lesson plans, student activity sheets (SAS), student books, and instruments for testing students' mathematical reasoning ability.

The quality of the learning devices developed based on inferentialism is evaluated based on the criteria of Nieven (2007). These criteria assess the quality of learning devices based on three aspects, namely: (1) Validity; (2) Practicality; and (3) Efficacy.

2.2 Data collector

The data collection techniques and devices in this study were carried out using:

(1) Checklist Sheet

The checklist sheet is used to obtain data in the form of validation statements regarding aspects of the developed device. The technique used consists of providing learning devices that have been prepared along with a validation sheet to the validator to be evaluated by placing a check mark (√) in the available column. The validated instruments are: lesson plans, SAS, student books and mathematical reasoning ability test.

(2) Observation Sheet

Observation sheets are used to collect data on the implementation of learning with inferentially based learning devices. The technique used to collect this data is to provide a Learning Implementation Observation Sheet to Associate Teachers to complete during the learning process. The instrument that was observed was the teacher's ability to manage learning and student activities during the learning process.

(3) Learning questionnaire

The questionnaire in this study was used to measure student responses related to learning and the devices used. After the lesson is over, each student will be asked to complete a questionnaire about learning and devices used.

(4) Mathematical Reasoning Ability Test

The Mathematical Reasoning Ability Test was compiled and developed by adopting the Singapore Mathematical Reasoning Test and used to determine the increase in mathematical reasoning ability.

2.3 Data analysis technique

The analytical techniques in this study are grouped into 4 groups, namely:

(1) Analysis of the validity of the learning devices developed

The compiled learning devices are validated by validators or experts to see the level of agreement between the validators. Based on the opinion of the experts, the level of agreement between the observers (experts) will be determined, with the following validity value criteria:

$\leq Va < 2$: invalid

$2 \leq Va < 3$: less valid

$3 \leq Va < 4$: quite valid

$4 \leq Va < 5$: valid

$Va = 5$: very valid

(2) Analysis of the practicality of the learning devices developed

The practicality of learning devices is seen from (a) the ability of teachers to manage learning and (b) the responses of students to learning.

a) The capacity of teachers to manage learning

The teacher's ability to manage learning is the ability to develop a friendly and positive learning atmosphere, including the ability to open learning, organize learning, close learning, time management, and climate management or learning atmosphere. Based on the observations made by the observer in the implementation of learning, the teacher's ability to manage the learning process is determined by the average score given by the observer using the rating scale as follows:

$$AT = \frac{\bar{A} + \bar{B} + \bar{C} + \bar{D} + \bar{E}}{5}$$

With : AT = capacity of teachers

$\bar{A}$=average ability to open learning

$\bar{B}$=average ability to organize learning

$\bar{C}$=average ability to close learning

$\bar{D}$=average time management skills

$\bar{E}$=average ability to manage the learning climate

Based on the average value, the teacher's skills are ranked as follows:

The critery:

$1.00 \leq AT < 1.50$ = Very Bad

$1.50 \leq AT < 2.50$ = Bad

$2.50 \leq AT < 3.50$ = Good enough

$3.50 \leq AT < 4.50$ = Good

$4.50 \leq AT \leq 5.00$ = Very Good

The teacher is said to be able to manage learning if the average value is in the "Minimum" "Good enough" category.

(b) Student response to learning

The data from the student response questionnaires were analyzed using a qualitative description by presenting the percentage of positive and negative responses of the students when completing the student response questionnaire sheet, which was calculated by the formula:

$$\%\ \text{response to each aspect} = \frac{Number\ of\ Students\ gives\ certain\ aspects}{Total\ number\ of\ students}$$

To determine the achievement of learning objectives in terms of student responses, if the number of students who gave a positive response is greater than or equal to 80% of the many subjects studied for each essay.

(3) Analysis of the effectiveness of the learning devices developed

The effectiveness of learning devices can be seen from (a) the completeness of student learning and (b) the activities of students during learning.

(a) Integrity of student learning

The criterion states that students are said to have mathematical reasoning skills if 80% of the students taking the test have at least moderate mathematical reasoning skills (scoring greater than or equal to 2.66 or a minimum of B-). The score range to determine the student's proficiency level is classified in Table 1 below :

Table 1. *Student mastery level*

The value of the predicate r	*Predicate*
0.00 ≤ Value ≤ 1.00	*D*
1.00 < Value ≤ 1.33	*D +*
1.33< Value ≤ 1.66	*C-*
1.66< Value ≤ 2.00	*C*
2.00 < Value ≤ 2.33	*c +*
2.33< Value ≤ 2.66	*B-*
2.66< Value ≤ 3.00	*B.*
3.00 < Value ≤ 3.33	*b +*
3.33< Value ≤ 3.66	*A-*
3.66< Value ≤ 4.00	*A*

The student's level of success is determined by the percentage of completion of the student's learning.

(b) Student activities

Active Learner Activity Level is the percentage of time that learners are active in the learning process and meet their target time. The level of active activity of the students can be seen from the percentage of students absorbing information and the percentage of interference from other students during the learning process. Student activity level is also determined by comparing the allocation of learning time used to the percentage of ideal time used for each student activity shown in Table 2.

Table 2. *Percentage of ideal time for student activities*

Types of student activities	Effective percentage (P)	
	ideal time	**Tolerance (5%)**
Actively listen/pay attention to the explanations of the teacher/friend	14%	9% ≤ P ≤ 19%
Read and understand the problems given.	eleven%	6% ≤ P ≤ 16%
Solve problems according to the procedure.	38%	33% ≤ P ≤ 43%
Make discussions or ask questions.	24%	19% ≤ P ≤ 29%
Draw conclusions related to the material and the problems.	13%	8% ≤ P ≤ 18%
Irrelevant student behavior in teaching and learning activities (interference)	0%	0% ≤ P ≤ 5%

(4) Analysis of the increase in students' mathematical reasoning skills.

Calculate the increase in students' mathematical reasoning skills using learning devices developed based on inferentialism, determined by the Normality-Gain formula, namely:

$$N - gain = \frac{\text{Postest Value} - \text{Pretest Value}}{\text{Ideal Value} - \text{Pretest Valuet}}$$

With the following criteria:

gain<0,3 = low category

0,3 ≤gain≤0,7 =moderate category

gain>0,7 = high category

3. Results and discussion

Learning Device Validation Results

The results of the analysis of the validation of learning devices by experts are in the category of valid. Lesson Plans (LP) with an average total validity score of 4.13, Student Activity Sheets (SAS) with an average total validity score of 4.17, and Student Books with an average total validity score of 4.10.

The mathematical reasoning ability validity test instrument has selected 3 questions that meet the content criteria and valid constructs.

The results of the practicality of the learning device.

The ability of teachers to manage learning.

In this study, the teacher's ability to manage learning was included in the fairly good category with a teacher ability score of 3.68. So in this category it can be said that the teacher is capable of managing learning with the learning devices developed and it is concluded that these criteria have been met.

student response

The results of the analysis of the students' responses to the components of the learning devices and the learning process are said to be positive if more than 80% of the students' responses are in the positive category. In this study, an analysis of student responses found that more than 80% of students gave a positive response to each aspect of response to learning devices.

The positive response of the students cannot be separated from the conditioning of learning with a learning model based on inferentialism, among others: the activities of asking questions and asking for reasons become something new for students in learning mathematics. Students in this study will freely give opinions and rebuttals to the opinions or claims of other students. The activity of giving us an assessment of the opinions or statements of other students is also something new for students. And the response of the students to this activity was very good. This indicates that the learning devices developed based on inferentialism can foster students' motivation and interest in learning in performing learning.

The results of the effectiveness of learning devices.

Integrity of student learning

The results of the analysis of the domain of student learning on mathematical reasoning skills obtained 23 students who completed with a minimum score of B-) of 26 students or about 88.46%, so it was concluded that this criterion had been met. .

student activities

The results of the analysis of student activities during the learning activities have met the criteria for the specified ideal time tolerance. All student activities have been performed within the specified ideal time tolerance interval, so it can be concluded that this criterion has been achieved.

The activities of the students in learning using learning devices based on inferentialism are very good and positive. This is because with inferentialism-based learning devices, students will directly and simultaneously develop their individual and social knowledge simultaneously. The mathematical concepts that you have understood will be developed together with the presentation of your arguments when there is an activity of giving and asking for reasons.

Giving and asking for this reason is the hallmark of inferentialism. The teacher conditions students to make knowledge claims through the game of giving and asking for reasons. Knowledge claims will always be based on and lead to an ideology that is believed and hegemonizes the minds of the students themselves. In this stage, conclusions occur as students' new insights engage cognitively and socially simultaneously. In this activity, the activities of the students will be maximized and will have a more positive value.

Test results to improve mathematical reasoning ability

The results of the calculations with N-Gain obtained an increase in the mathematical reasoning ability of the students by 0.56 or in the middle category, which means that the mathematical reasoning ability in the experimental class increased with respect to the ability of earlier mathematical reasoning.

Inferentialism is a new theory to improve mathematical reasoning. Simanungkalit, et al. (2021) stated that the inferentialism-based learning model achieves at least four goals, namely (1) improve students' mathematical reasoning, (2) generate student activity in learning through a scientific approach; (3) increase students' motivation in learning and (4) increase students' understanding of the relationship between mathematics and the surrounding environment. Inferentialism is a new theoretical framework in mathematics education (Ruben, N, Samuel D. Taylor, Arthur Bakker, and Jan Derry: 2017), as well as the research of Taylor, SD; Noorloos; R & Bakker, A (2017). Inferentialism provides an alternative constructivism characterization of individual-social interactions that focuses on the role of reasoning in learning (Bakker and Derry 2011; Hußmann and Schacht 2009; Schindler and Hußmann 2013).

4. Conclusions and Recommendations

Conclusions

From the results of the above research, it can be concluded that: (1) The learning devices developed based on inferentialism are of good quality or are suitable for use in terms of validity, practicality, and efficacy; (2) There is an increase in students' mathematical reasoning abilities when using learning devices developed based on inferentialism. The increase in students' mathematical reasoning ability is 0.56 or in the "Medium" category, which means that the mathematical reasoning ability in the experimental class increases with respect to the students' mathematical reasoning ability previous.

recommendations

More research is needed to develop a new learning model, namely an inferentialism-based mathematical learning model. The learning model that will be developed later will describe the standard learning syntax, the social systems, the reaction principles, the support systems and the instructional and accompanying impacts that have been analyzed and disseminated.

References

[1] Adegoke, Benson Adesina. (2013). Modeling the Relationship between Mathematical Reasoning Ability and Mathematics Attainment. Journal of education and Practice, 4(17): 54-61. https://www.iiste.org/Journals/index.php/JEP/article/view/7388

[2] Bakker, A. & Derry, J. (2011). Lessons from inferentialism for statistics education. Mathematical Thinking and Learning, 13, 5-26. https://www.tandfonline.com/doi/abs/10.1080/10986065.2011.538293

[3] Brandom, R. (1994). Making it explicit: Reasoning, representing, and discursive commitment. Cambridge, MA: Harvard University Press. https://altexploit.files.wordpress.com/2017/07/robert-brandom-making-it-explicit_-reasoning-representing-and-discursive-commitment-harvard-university-press-1994.pdf

[4] Hußmann, S., & Schacht, F. (2009). Toward an inferential approach analyzing concept formation and language processes. In V. Durand-Guerrier, S. Soury-Lavergne & F. Arzarello (eds.),Proceedings of the Sixth Congress of the European Society for Research in Mathematics Education (pp. 842–851). Lyon: Institut National de Recherche Pédagogique. https://pdfs.semanticscholar.org/3320/5b6705c524c17c18ef505d28457c6d735568.pdf#page=924

[5] Komalasari, K. (2011). Pembelajaran Kontekstual Konsep dan Aplikasi. Bandung: PT Refika Aditama. https://opac.perpusnas.go.id/DetailOpac.aspx?id=1223140

[6] Minarti, Eva Dwi. (2012). Penerapan Model Generatif Untuk Meningkatkan Kemampuan Penalaran dan Koneksi Matematika SMP. Tesis. Tidak Diterbitkan. Jakarta : Program Pascasarjana Universitas Pendidikan Jakarta. https://123dok.com/document/y96r11dy-penerapan-pembelajaran-generatif-generative-meningkatkan-kemampuan-penalaran-matematis.html

[7] NCTM. (2000). Principles and Standards for School Mathematics. Reston: NCTM. https://www.nctm.org/Standards-and-Positions/Principles-and-Standards/?gclid=EAIaIQobChMIyYz8gviH-AIVTTErCh2YQwkrEAAYAiAAEgI-DvD_BwE

[8] Nieveen, N. (2007). An Introdution To education Design Research. (Online). (http://www.slo.nl/organisatie/international/publications, diakses 15 oktober 2014).

[9] Riyanto, B & Siroj, R. (2011). Meningkatkan kemampuan penalaran dan prestasi matematika dengan pendekatan konstruktivisme pada siswa Sekolah Menengah Atas. Jurnal Pendidikan Matematika, 5 (2), hlm. 111-127. https://ejournal.unsri.ac.id/index.php/jpm/article/view/581/174

[10] Rosnawati, R. (2011). Kemampuan penalaran matematika siswa SMP Indonesia pada TIMSS 2011. Prosiding Seminar Nasional Penelitian, Pendidikan dan Penerapan MIPA. http://staff.uny.ac.id/sites/default/files/penelitian/R.%20Rosnawati,%20Dra.%20M.Si./Makalah%20Semnas%202013%20an%20R%20Rosnawati%20FMIPA%20UNY.pdf

[11] Ruben, N, Samuel D. Taylor, Arthur Bakker, & Jan Derry. (2017). Inferentialism as an alternative to socioconstructivism in mathematics education. Mathematics Education Research Journal, Vol: 29; Issue: 2, 03 Februari 2017. H-Index: 20, Q-1. https://link.springer.com/article/10.1007/s13394-017-0189-3

[12] Sajadi, M, Amiripour, P., Rostamy-Malkhalifeh, M. (2013). The Examining Mathematical Word Problems Solving Ability under Efficient Representation Aspect. Mathematics Education Trends and Research. 1- 11.

https://www.researchgate.net/publication/290634336_The_Examinig_Mathematical_Word_Problems_Solving_Ability_under_Efficient_Representation_Aspect

[13] Schindler, M., & Hußmann, S. (2013). About students'individual concepts of negative integer—in terms of the order relation. In B. Ubuz, C. Haser, & M. Mariotti (eds.), Proceedings of the Eighth Congress of European Research in Mathematics Education(pp. 373-382). Ankara: Middle East Technical University. http://cerme8.metu.edu.tr/wgpapers/WG2/WG2_Schindler.pdf.

[14] Simanungkalit, R. H. (2016). Pengembangan Perangkat Pembelajaran Untuk Meningkatkan Kemampuan pemecahan masalahMatematis Siswa SMP Negeri 12 Pematangsiantar. MUST: Journal of Mathematics Education, Science and Technology, 1(1), 39-56. http://journal.um-surabaya.ac.id/index.php/matematika/article/view/96

[15] Simanungkalit, R. H. Dkk. (2021). Design of Innovative Learning Models: Constructivism to Inferentialism. Design Engginering: Issue: 9, Pages: 4437-4445. ISSN: 0011-9342. http://www.thedesignengineering.com/index.php/DE/index

[16] Suhadi. (2007). Petunjuk Perangkat Pembelajaran. Surakarta: Universitas Muhammadiyah.

[17] Sumarmo, U. (2013). Kumpulan makalah berpikir dan disposisi matematika serta pembelajarannya. Bandung : Jurusan Pendidikan Matematika F-MIPA UPI. https://fmipa.unj.ac.id/lib/index.php?p=show_detail&id=101651

[18] Suparno, P. (2002). Teori Perkembangan Kognitif Jean Piaget. Kanisius: Yogyakarta. http://library.fip.uny.ac.id/opac/index.php?p=show_detail&id=1025

[19] Taylor, SD; Noorloos; R & Bakker, A. (2017). Mastering as an Inferentialist Alternative to the Acquisition and Participation Metaphors for Learning. Journal of Philosophy of Education : October 2017, DOI: 10.1111/1467-9752.12264. https://onlinelibrary.wiley.com/doi/10.1111/1467-9752.12264

[20] Turmudi. (2008). Landasan Filsafat dan Teori Pembelajaran Matematika (Berparadigma Eksploratif dan Investigatif). Jakarta: Leuser Cipta Pustaka. http://perpus.bandungkab.go.id/opac/detail-opac?id=3882

[21] Wahyudin. (2008). Pembelajaran dan Model-model Pembelajaran. Bandung: UPI.