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Trends in Mathematics Education Research in Indonesia

Nurwati Djam'an, Neni Mariana, and Mangaratua M. Simanjorang

Abstract Various efforts have been made in Indonesia to improve the quality of education, including improving the quality and productivity of educational research. Integrating research results into classroom learning is expected to enhance the quality of education. The government's commitment to research can be seen in increased research funding through several existing research schemes and mandatory output demands from funded research. This chapter reviews research in mathematics education funded by National Competitive Research in Indonesia according to research types, topics dealt with, research focus, research outputs, and target audiences. This review provides an overview of the dominant research trends and absences toward more diverse and effective education research to improve mathematics education in Indonesia. We hope that this chapter will stimulate discussions among researcher administrators, educators, and all who are concerned about quality education in Indonesia.

Keywords Mathematics education research · Trends research in Indonesia · Quality education

1 Introduction

Numerous calls and proposals have been made and many projects have been implemented by the government to improve the quality of mathematics education in Indonesia. Particularly, one of the efforts to improve mathematics education quality

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is through research activities. Improving the quality of research increases competitiveness and strengthens the Indonesian National Qualifications Framework (KKNI), which focuses on the outcomes of the national educational system in the country. Mathematics education research could enrich content, teaching strategies, media, and evaluation techniques for learning mathematics. Moreover, the implementation of research results in the classroom could improve the quality of school mathematics education.

In addition, many Indonesian scholars have obtained research degrees overseas and expectedly must have gained insights from international research in mathematics education. National and international conferences, seminars, and workshops provide a key role in disseminating research findings of mathematics education researchers on the current trends, issues, and innovations in mathematics education and research. However, Atweh (2007) argues that "there still remains the concern about whose knowledge is bring represented and who is benefiting from such [international contacts]."

2 Research Grants to Improve Research Productivity

The efforts to improve the quality and quantity of research and community service in higher education in Indonesia are continuously carried out by the Directorate General of Research and Development Strengthening at the Ministry of Research, Technology, and Higher Education (Ristekdikti). The significant increase in Indonesian researchers' publications related to mathematics education in various international journals may indicate Indonesia's effort and achievement in improving the mathematics research quality. In the Indonesian context, the focus on increasing research productivity and quality in the country requires the research to produce innovative products and respond to local educational needs. Likewise, the Indonesian government also aims that research results also need to be directed toward obtaining protection of Intellectual Property Rights (IPR), both in Copyright and Industrial Property Rights. In short, the number of publications and IPR are two directions taken by Indonesian authorities as mandatory research outcomes that guide the attempts to improve research quality in Indonesia.

The Indonesian government is committed to improving the quality and quantity of academic publications. Funding support for research is expressly stated in Law Number 12 of 2012 concerning Higher Education Article 89. Universities that receive State Higher Education Operational Assistance (BOPTN) are expected to allocate at least 30% of their funding for research activities. BOPTN is a cost aid provided by the government to finance deficiencies in operational costs, for example, in dealing with the high cost of education. In addition to funding for research through BOPTN, the Indonesia Directorate General of Higher Education (DGHE) provides broader authority in research management to universities through decentralized research and community service programs. Universities are expected to manage their research agendas in line with the increasing funding support from the government.

There are two main funding research schemes for lecturers. The first is directly managed by universities. The second scheme is at a national level called the National Competitive Research Grant, with the aim to improve national excellence in research, including National Strategic Superior Research, University and Industry Priority Research, Foreign Cooperation Research and International Publication, Competency Research, National Strategic Research, Acceleration of Master Plan Research, and the Expanding of Indonesia's Economic Development (Direktorat Riset dan Pengabdian Masyarakat, 2018). The national scheme is more competitive than the decentralized scheme. However, several lecturers have applied for university funded research grants, while many lecturers do not attempt to apply for the National Competitive Research grants. One of the reasons might be the general perception among such lecturers that the application process is too bureaucratic. The funds are sourced from the annual state budget, disbursed, and audited by the Ministry of Finance.

Based on R&D Magazine Survey data, funding for research in Indonesia in 2018 was estimated at around USD 10.23 billion or 0.91% of GDP. This figure puts Indonesia at 28th out of 116 countries in terms of numbers, yet when viewed from the ratio to GDP, this portion still looks relatively small. However, in 2019, the budget for the research fund increased dramatically to approximately USD 69.4 million.

3 Mathematics Education System in Indonesia

According to Law No. 2/1989 on the National Education System, the objectives of the National Education System are two-fold. First, to develop a high-quality and self-reliant human being whose values are based on Pancasila, i.e., State ideology, spelled out in the five basic principles of the Republic of Indonesia: belief in one God; just and civilized humanity, including tolerance to all people; unity of Indonesia; democracy led by the wisdom of deliberation among representatives of the people; and social justice for all. Second, education plays a significant role in supporting Indonesian society, people, and the state. In the broader context of social and national development, the aim of education is, on the one hand, to keep and maintain Indonesia's cultural background and, on the other, to generate the knowledge, skills, and scientific progress that will keep the nation abreast of developments in the twenty-first century.

However, there is ample evidence that Indonesia still needs to improve the quality of its education. PISA tests conducted by the OECD in 2015 showed that Indonesian students were performing at lower levels than the OECD average in all areas of science, mathematics, and reading. Further, in PISA 2018, Indonesia ranked 74th out of 79 countries. Its PISA average for mathematical literacy was 379. The ability of Indonesian children's students is below the average OECD country participant (489). In addition, the OECD demonstrated that there is a significant disparity between regions in Indonesia. PISA's focus on mathematical literacy reflects increasing concern about how well students can apply mathematics to solve a real-life problem (OECD, 2009). In response to this case, more emphasis and policy on

mathematics literacy are needed. Moreover, the PISA results highlight mathematical literacy issues, the difficulties students face in solving PISA test items, teachers' quality, and equity.

In this chapter, the researchers analyzed the mathematics education research articles, which were funded by National Competitive Research. This chapter also attempts to relate to the type of research, research topics, focus, type of schools, and research outputs in Indonesia.

4 Research Procedure

To investigate the data regarding trends in mathematics education research, the data used in this study were drawn from 295 articles in 2019, and 381 articles in 2020 were published in national and international indexed journals and international conference proceedings, which are the output of funded research in those two years. This study used a random sampling technique to target 40 full papers included in international journals out of those 676 articles. The final sample consisted of 20 articles each year. The authors obtained the list of mathematics education lecturer's research that has been funded by the grants of Ristekdikti and has been published in international research journals. Furthermore, the authors analyzed the full text of sample articles published related to the funded research.

This study reviews the type of research, the topic of research, the focus of research, the targeted educational level of the study, and the outputs of research commonly adopted in the publication. The type of study refers to methods that are employed in the study. The research topic provides an overview of variables in the study (independent, dependent, and control variables). This study also identifies the educational level of the participants or the site of data collection was studied. In addition, reflect upon the outputs of research obtained over the sample articles.

5 Type of Research

The different research types gathered from the sample are the following: (1) research and development (R&D), a type of research in which a certain product is developed and later tested to determine its effectiveness; (2) survey, consisting of predetermined sets of questions for collecting data using a representative sample by interview, phone, or face to face; (3) experiment, wherein the treatment is administered to the subjects and the outcomes measured and analyzed; (4) literature reviews, which are conducted to provide or evaluate an overview of knowledge on a particular topic; (5) case study, which is an intensive study in which researchers focus on a unit of study, for instance, individual teachers, a classroom, etc.

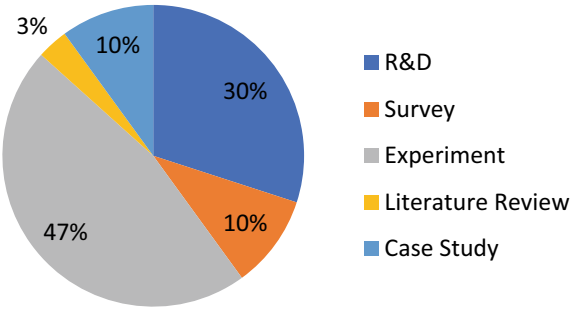

Fig. 1 Type of research

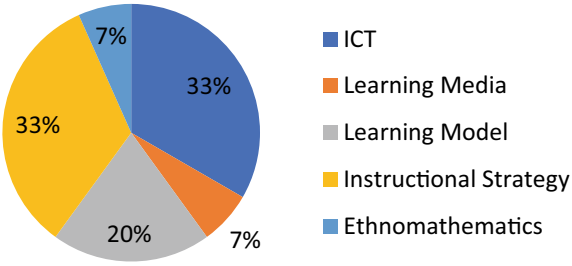

Fig. 2 Topics of research

From the overall data collected, 46.7% of the sample were experiments and then followed by Research and Development (R&D) 26.67%, survey and case study as many as 10%. The rest, 3.3%, are literature review and instructional design (Fig. 1).

Most researchers used the experimental design or mixed methods in this study. Experiment research is the most familiar type of research design for mathematics education researchers in Indonesia. In this research design, the treatment to be implemented is a model of teaching and learning, and one or more dependent variables are examined to measure the impact of the model. On the other hand, R&D, which follows after experimental design, serves to refine the practices and examine their impact (Fig. 2).

6 Topics of Research

Some research topics identified in this study include ICT, learning media, learning model, instructional strategy, and ethnomathematics. Learning media refer to equipment that can be a component for implementing active learning. Media could be manipulative and virtual media.

The learning model is designed to develop curricula, materials, and guidelines in class and outside the classroom, which consists of four things, namely: (a) syntax, which contains a teacher's steps in carrying out learning activities; (b) social system, which describes the role and relationship between students and teachers while the

learning process is ongoing; (c) the principle of reaction is a picture of the teacher's role during the learning process; and (d) support system, which consists of all the means that support the implementation of learning (Joyce & Weil, 2009), while an instructional strategy is a technique used by teachers to deliver the materials and assist in the comprehension of the subject.

The percentage distribution of the use of both learning models is about 20%, and instructional strategy is around 33%. The trend of research topics in mathematics education in Indonesia is increasing in information communication technology (ICT) in mathematics education, such as e-learning and mobile technology by around 33%. In addition, increasing attention is being paid to ethnomathematics in mathematics education research in Indonesia (about 7%). Ethnomathematical approaches to mathematics education research seek to understand the roles of mathematics in different ethnic groups and nations. It presents mathematical concepts of the school curriculum in a way that relates these concepts to the students' cultural and daily experiences, thereby enhancing their abilities to elaborate meaningful connections and deepening their understanding of mathematics. For example, one article titled "The Development of Geometrical Learning Devices Based on Rumah Gadang Ethnomathematics for Grade VII Junior High School." In this study, the researcher developed the Rumah Gadang ethnomathematics-based geometrical learning devices in the form of the lesson plan and student activities.

An important change in mathematics learning needs to be realized to accommodate the ongoing and current changes in the demographics of learners in mathematics classrooms. Several scholars have developed a culturally relevant pedagogical theory that examines the teaching and learning process in a critical paradigm and through explicit connections between the culture of learners and their school subjects (Rosa & Orey, 2011). From an ethnomathematics perspective, it is necessary to integrate a culturally relevant curriculum into the existing mathematics curriculum. Based on the views of Torres-Velasquez and Lobo (2004), this perspective is an essential component of culturally relevant education because this perspective proposes teachers' contextualize mathematics learning by linking mathematical contents to the culture and real-life experiences of students.

7 Focus of Research

The data show that about 29.4% of the mathematics education research variable were related to learning achievement. While 11.8% focus on problem-solving, 5.9% is a type of higher-order thinking and creativity, and the rest is a type on mathematical communication, confidence, mathematics abstraction, and emotional intelligence. More details about these percentages are presented in Fig. 3. As some researchers perceive, the aims of education are that mathematics education needs to build students' capacity for problem-solving, reasoning, communicating, and intelligence. The data are consistent with Kilpatrick and Findel (2001), who argued that

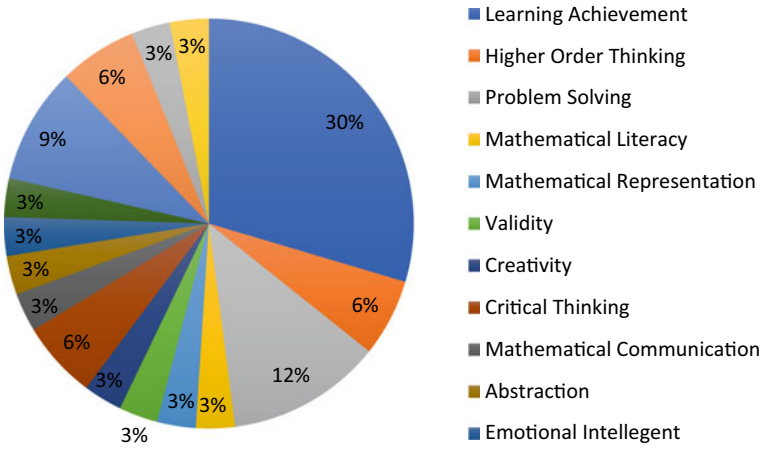

Fig. 3 Focus of research

mathematics education is the means to instruct the students in understanding mathematical concepts, operations, and relations, formulizing problems mathematically, and devising strategies for solving it, seeing mathematics as useful.

One parameter of the success of an education system is to look at the results of learning achievements. As mentioned before, the type of research that was mostly used in mathematics education research in Indonesia is experimental research designs, including evaluation of the implementation teaching approach. More focus is on classroom pedagogy. The aims of mathematics education research in this study are mostly to promote creativity, critical thinking, problem-solving, mathematical literacy, communication, mathematical representation, and confidence. Soedjadi (2000) states that teaching mathematics needs to promote mathematics values. This is in accordance with competencies demanded in school mathematics learning from elementary to high school (Midgett & Eddins, 2001). Particularly, mathematics learning activities are oriented not only to mastery of mathematical material alone but also to mathematics as a tool and means for students to achieve other competencies.

8 Type of Schools

This research indicates that different types of schools are targeted by mathematics education researchers in Indonesia, including primary school, junior high school, senior high school, university, and special school. These classes include junior high school, about 36.67%, senior high school around 30%, university about 23.33%, and primary school about 6.67%. However, the data analysis returned very little research on mathematics education in a special school for learning disabilities, only

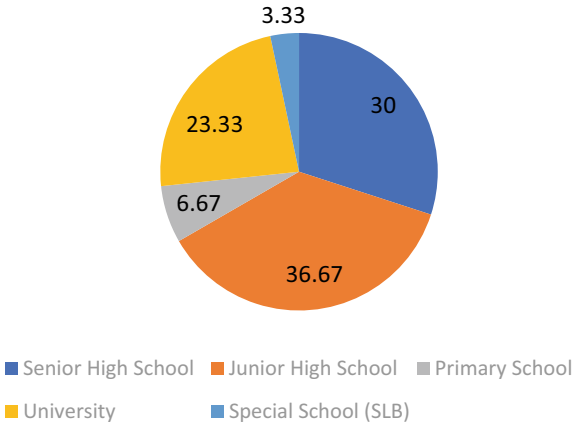

Fig. 4 Type of schools

about 3.33%. The distribution of this data shows the tendency of researchers' interest in finding an alternative solution to improve the quality of mathematics education, mainly at the secondary school level (junior and senior high school), then followed by tertiary level (university) with less concern so far to a primary and special school for learning disability.

Research that focuses on inclusive mathematics education is still low, especially the study to examine disability issues in mathematics education. Further investigation shows that the tertiary level is most likely related to teacher training universities (Fig. 4).

9 Outputs of the Research

According to the data obtained in this study, the product of research identified in the sample is categorized such as instructional material, learning models, and media. Instructional material mentioned here is about the research on the use of instructional materials for effective teaching and learning, which also discovered the reluctance and perceived effects of it. On the other hand, the research-based learning model is one of the researches that is expected to improve students' ability, including learning outcomes. The research aims to develop a learning model by combining two or three teaching approaches or strategies. In the end, the research examines the effectiveness of the model. Moreover, media in this study are related to the design of mathematics learning media using such as Research and Development (R&D); the Analysis, Design, Development, Implementation, and Evaluations (ADDIE) development model; and the effects of using media in mathematics learning.

Furthermore, handouts as part of media that arise from the research conducted define as mathematics learning material in the form of a book or module, for example, the article with the title: Development of reflective module based on child-friendly

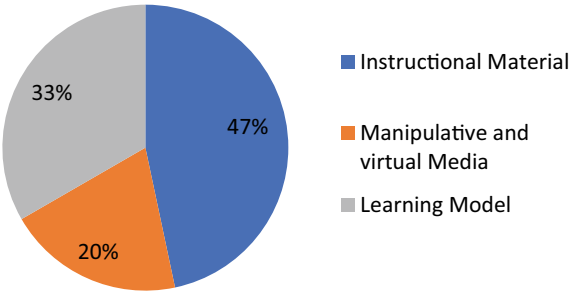

Fig. 5 Outputs of the research

school to improve numeracy and confidence. This study aims to: (1) determine the process of developing a reflective module based on child-friendly schools, (2) produce a child-friendly school-based reflective module that meets the eligibility criteria, and (3) reveal the effectiveness of the resulting reflective module to improve students' numeracy literacy skills and self-confidence of fifth-grade elementary school (Fig. 5).

The output of the research of the articles, namely: instructional material, manipulative and virtual media, and learning model. As concerned with experimental research design, some articles contain learning models about 33%. The experiment research aims to establish the cause-and-effect relationship between the implementation of the learning model and the dependent variable. With increasing interest by mathematics education researchers in Indonesia in the implementation of ICT, the research product identified was media, including manipulative and virtual, which is about 20%.

The fact that most of the research products (47%) are related to instructional material shows that there is a significant concern among Indonesian researchers to approach alternative solutions for improving mathematics education quality from theoretical aspects, which later may be used as the foundation of teaching and learning practice in the mathematics classroom. In addition to theoretical concern, there is also another concern about media used in teaching and learning, which is not far less than an instructional material. This data exposure may express that most researchers in Indonesia tend to seek the way to improve mathematics education from instructional material aspect and classroom implementation aspects, especially in learning media. These two concerns cover most of the research outputs.

10 Discussion

2 Educators and researchers in mathematics education in Indonesia have adopted a variety of perspectives to understand and study mathematics education issues. Mathematics education research in Indonesia by conducting R&D, experiment, case study, survey, and literature review tried to provide innovative mathematics learning, study

the development of cognitive levels such as higher-order thinking and critical thinking skills, students' creativity in solving a mathematics problem.

Based on the data of the most trending types of research, experimental studies are on the top of the list. It indicates that most mathematics educational research in Indonesia tends to try out a certain learning model, media, and strategies used in mathematics learning. The second place was the R&D research type. This type of study is also another layer of research that also includes experimental study. Moreover, this demonstrates how mathematics education researchers in Indonesia primarily work with statistical data. In other words, the hegemony of positivism and post-positivism research paradigms is going on in Indonesia. Why do these two types of research dominantly funded in Indonesia?

Research for Indonesians might be a means to prove the hypotheses of the researchers, and thus, the researchers need to do it objectively supported by statistics. The objectivity plays most important role in such worldviews. Even if we do mixed methods such as R&D, we keep going by proving the product of the developmental process using experimental studies. At this point, we at last do the "real" research. Furthermore, most research funding goes to these types of research. Mostly, the funders reckon that research should have a clear outcome. Therefore, R&D has become the second most adopted research type.

Regarding learning mathematics in the twenty-first century, the few promising developments in mathematics education research in Indonesia are increasingly concerned about technology. No doubt much more research and reflection are needed about competencies to evaluate mathematical applications and ICT and the possible usefulness or its problematic effects. This is in accordance with Taguma (p. 42) who points out that "ICT can foster many benefits, including helping children visualize abstract issues or learn how to read. Besides, it fosters children's technological skills. Since computers are increasingly being used in households and schools and are becoming a more important part of people's everyday lives." Particularly, mathematics education research which appears in this study also has a concern with learning achievement but has no concern to connect or speak about economic factors behind mathematics achievement. As OECD (2013) points out a sobering thought that economics, income inequality, or socioeconomic status (SES) is more significant in explaining differences in mathematics achievement than gender and race.

There are more non-PGSD (Primary School Teacher Education) mathematics education lecturers than PGSD applying for the national research grant specifically designed to prepare the graduate students for teaching in junior and senior high schools. On the other hand, thematic learning is being implemented at all grade levels in elementary schools in Indonesia. Thus, elementary school teachers generally teach all fields of study. Mathematics education researchers tend to focus on their own expertise. Therefore, it makes sense that the research setting for mathematics education in Primary School is less likely to disperse to other types of schools.

Moreover, there may be other reasons for this phenomenon than to uncover the reason that needs more study, which is not covered by the focus of this study. However, high qualifications and status of primary education and kindergarten or preschool should be increased attention. Early childhood and primary education are essential

to prepare pupils for the secondary level of their education. Another important thing, especially regarding mathematics education, is not to allow students to fall behind in mathematics in their mastery of the subject. Thus, Van de Walle (2007) suggests that when students who have not mastered facts are engaged in exciting and meaningful experiences, they are motivated to learn facts and real opportunities to develop relationships that can aid in that endeavor.

As mentioned in the type of school part, research attempting to study related students with special needs is still rarely the focus of mathematics education research in Indonesia. However, mathematics education research will need to focus on the conceptualization of equity and improving equity and related values such as inclusion. There is a need to promote equity, and quality issues in mathematics education arise when individual students engage in the collective activity of learning mathematics at the level of the classroom (Atweh, 2011). To deal with equitable access and distribution of quality issues in the mathematics classroom, the teacher has access to many possible practices, such as differentiation of instruction and developing high expectations of achievement from students. However, teachers' practices to promote equity and quality mathematics education are constrained, among other things, by school policies regarding reward structure, teacher professional development, improved technology, or attention to social circumstances. Thus, teachers' practices in this regard are shaped by school policies to a large extent.

Furthermore, Stephan et al. (2015) identified the three specific biggest challenges in mathematics education: changing perceptions about what it means to do mathematics, changing the public's perception about the role of mathematics in society, and achieving equity in mathematics education. In achieving equity in mathematics education, there are challenges in helping people see that doing mathematics is about problem-solving, reasoning, curiosity, and enjoyment and not about following procedures to get "the answer" or just about doing. Particularly, Bigelow (2001) suggests that teachers need to get students to begin to look critically at the many unequal power relations in our society. According to Osler (2007), mathematics teachers need to create lessons around issues and questions that students have raised and are interested in learning about; create projects that challenge students to suggest just and mathematically sound solutions to the problems that they identified; provide the opportunity to the students to present and share their work; scaffold students' understanding of both the mathematics concepts and the issues they are studying; and allow the assessment to determine what students have learned about the mathematics concepts that were in the lesson or the projects.

The new challenge of mathematics education research in Indonesia is determining social, cultural, and political views about mathematics and mathematics education: Is mathematics really for all? Social justice and mathematics education? In the increasing professionalization of mathematics researchers, the growth of collaborative research within the mathematics education community is needed. Challenges and perils of globalization in international collaboration. There is a need to further enrich the types of research to be implemented in mathematics education because other types of studies might be more useful.

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