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RESEARCH ARTICLE

Advocating Mathematics Teacher Research Prowess for Improved Professionalism

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ABSTRACT

While serving in the field of practice, teachers have continued to hold to the view that research is an activity carried out by professional researchers based outside the basic schools. This is because traditionally, class teachers have never been expected to comment on the theory and practice of their work. However, recent push by the Teacher Research movement across the globe has emphasized teacher research as a process in which educators note problems in the context of their own schools and classrooms and propose investigative methods appropriate to address the problems. On this premise, this review first considers the ramification of mathematics teacher research in improving professionalism in the teaching and learning of mathematics. Secondly, teacher professionalism in mathematics education was given a detailed coverage. Thirdly, the task of mathematics teachers as researchers was considered. The role of higher education in nurturing fruitful collaborations with basic schools was discussed along with the implications of mathematics teacher research for classroom practice in Nigeria.

1. INTRODUCTION

Research is the bedrock of progress in any vocation or discipline. The activities involved in the practice of research dissect the problems and prospects of a field of study into manageable bits that are capable of being comprehended. The outcome of research charts the pathways to development, evaluation, discovery, and refinement of methods of inquiry.

Research, by definition, is a logical way of finding solutions to an identified problem. It is an investigation for the determination of facts in order to know whether the facts should be retained as a satisfactory status quo or needed some amendments (Emaikwu, 2015). Based on this definition, six characteristics of research can be identified, that is (1) Research aims at solving problems, (2) Research is conducted in a systematic and objective manner, (3) Research is based upon accurate observable experience and descriptions, (4) Research emphasizes the development of generalizations, principles or theories that will be helpful in predicting future occurrence, (5) It demands patience on the part of the researcher, (6) It involves gathering and analysis of data.

In view of the significance of research, particularly in the field of mathematics education, graduating students are required to present and defend a written project work in partial fulfillment of the requirements for the award of their first degree, be it a Bachelor of Education (B. Ed) or a Bachelor of Science Education (B. Sc. Ed). This research work, which usually falls into the course listing of the final year of study, is a culmination of the students' learning experiences as undergraduates (Abah, 2017a). The research project, as the course is often titled, carries the highest credit load in the entire Mathematics Education Programme as specified by the Benchmark Minimum Academic Standards (BMAS) of the National Universities Commission (NUC) (National Universities Commission, 2017). EDU 499 or EDU 599, as the course is often coded by different universities, is so important that there exist several preparatory courses targeted at making undergraduates good at research report writing. One of the most vital pre-requisites for Research Project in Educational Research Methodology, a course taken in the third year of the Mathematics Education Programme.

Marshall (2009) postulates three key reasons why the use of research projects and dissertations in undergraduate curricula has been seen as increasingly important. First, projects and dissertations have been seen as a means of encouraging more students to think about "staying on" as research students and thus contributing to the research productivity of departments and schools. By extension, after graduation, such practicing mathematics teachers can continue as teacher researchers. Second, projects and dissertations are deemed to be an important means of bringing about an effective research culture to underpin all undergraduate curricula. Third, projects and dissertations have come to be seen as an important component of degree programmes across the disciplines, because of the clear emphasis they place on learners taking responsibility for their own learning and engaging with the production of knowledge.

For the graduates of mathematics education in the field of practice, the research project is a vital journey into mastering research skills and techniques that are appropriate to the discipline and a wider set of employment-related skills or high-level transferable skills. Ketteridge and Shiach (2009) identify this common skill set as the Joint Skills Statement (JSS) and list them as including research skills and techniques, research environment, research management, personal effectiveness, communication skills, networking and team working, and career management. The characterization of these skills by the mathematics teacher obviously depends on his or her conceptualizations of research and student identity claims while still an undergraduate.

In an elaborate study to show that conceptualizations of research and student identity claims differ widely, Ross, Dennis, Zhao, and Li (2017) explore the emergence of four ideal types of understanding of research. The first type of students views research as a means of problem-solving. In this perspective, research is deemed as an act of intervention carried out by a researcher, a means to solve problems through discovering, accumulating and evaluating knowledge. Research perceived in this way is also linked by students to a process involving structured steps or procedures and in which they see themselves as component part (Ross et al., 2017). The second type of research students considers the exercise of research as a form of expertise requiring specialized knowledge and skills. Students who conceptualize research in this way tended to position themselves as outsiders in relation to their profession, or at least novices standing at the edge of the professional boundary (Ross et al., 2017). Such teachers-in-training perceived researchers to be experts who receive specific training in reading literature, writing academic papers and developing knowledge in statistics.

The third type of student-teachers conceptualizes research as science and presents it as a process of testing hypotheses or acquiring evidence to prove or disapprove certain beliefs (Ross et al., 2017). Such a conception of research work is based solely on a scientific worldview and rationality, with emphasis on the notions of objectivity, scientific methods, numbers, experimentations, quantitative methods, and statistics. The fourth type of students conceptualizes research as situated practice in a community of researchers, within the process of peer review and critique in the public domain (Ross et al., 2017). For these students and would-be teachers, research entails a communicative action that involves more than one actor and is examined based on certain norms and standards created by a community of researchers. In contrast with the other conceptualizations, this perspective places less focus on outcomes or technical knowledge, but rather brings the researcher towards the center of the research practice and requires an ability to reflect on the practice itself. Ross et al. (2017) added that students, and eventually teachers, who conceptualize research in this way, did not position themselves as outsiders but rather as part of a community, even if they see themselves at its periphery in this stage of their lives.

In essence, practicing mathematics teachers must see themselves as indispensable partners in research, actively leveraging on their on-the-field experience to turn out research outcomes that are novel, versatile and reproducible. They must first consider themselves as trustworthy stakeholders in mathematics education who are needed to assess the prevailing situation, plan instruction, access materials, communicate research outcomes and direct interactions in the classroom for the optimum growth and development of the learner. Other players in the educational system have often erroneously pursued educational policies that attempt to control teachers through conceptualizing them as mere technicians who require taming and have resulted in the restructuring that was done to teachers rather than with teachers (Lingard, Hayes & Mills, 2003). This misconception has continued to belittle the prospects of mathematics teachers as active researchers and has created a wide chasm between outcomes of research and implementation at the classroom level. An obvious outcome of this existing gap is the looming obstinacy and eventual relegation of research outcomes to the dusty shelves of their authors (Abakpa, Agbo-Egwu & Abah, 2017).

Misconceptions about the multifaceted roles of the mathematics teacher, especially with respect to research, can be addressed through efforts aimed at bringing researchers, practitioners, and policymakers together in order to influence practice and install respect for their differences. In this sense, understanding what teachers do, how they do it, and why they do it is central to any effort at reshaping education policy around teacher education, teacher professional development and school reform (Rust, 2009). As a contribution to such ongoing efforts, this present exposition seeks to bring to the front burner the ramifications of teacher research in mathematics education. The discourse that follows intends to raise awareness on the need to train mathematics teachers as self-reliant investigators, research partners and important contributors to knowledge generation in mathematics education. This present study is premised on the observed absence of a research culture among mathematics teachers, particularly in Nigeria. It intends to serve as a clarion call to stakeholders within the mathematics education sub-sector to reorient the general mentality around mathematics teacher research.

2. LITERATURE REVIEW

2.1 Teacher Professionalism in Mathematics Education

Mathematics education is a field of study concerned with the tools, methods, and approaches that facilitate the practice of teaching and learning mathematics (Abah 2017; Winarso, 2018). Mathematics educators take a comprehensive view of how mathematics as a subject of study is learned, understood and used. Mathematics education looks beyond mere applications to ways in which people think about mathematics, how they use it in their daily lives, and how learners can be brought to connect the mathematics they see in school with the mathematics in the world around them (Abah & Anyor, 2018). As a field of practice, mathematics education is an ecosystem comprising the learners, mathematics teachers across all levels, mathematics educators in teacher-training institutions, school administrators, mathematics education policymakers and regulating agencies of government, all interacting together for the efficient transmission of mathematical knowledge. The target of these stakeholders, most of the time is the attainment improved achievement of pupils and students at the basic and secondary education level.

It is common knowledge that the success of basic education, to a large extent, rest on the shoulders of the teachers. The mathematics teacher is a key stakeholder in the implementation of the mathematics curriculum and is at the center of the running of the school plant, building real-life relationships with students, and coordinating students' learning experience in mathematics (Abah, 2016, Fonna, 2018a; Mursalin et al, 2018). In enviable educational climes like Finland, teaching is viewed as a very honorable profession and is held in very high regard, with teachers granted a great deal of autonomy in the education system (Mendaglio, 2014). However, in Nigeria, the professionalization of teaching is still beclouded by several challenges with enforcement of regulations a huge uphill task.

Simply put, professionalism is the quality of practice in any particular discipline. Professionalism refers to the manner of conduct within an occupation, the integration and the contracted and ethical relations with clients (Hoyle, 1980 in Chow, Chu, Tavares & Lee, 2015). Teacher professionalism is the commitment that pushes teacher to go beyond minimum expectations to meet the needs of students. Morrow and Goetz (1988) identify 13 key areas of teacher professionalism namely, independent practice, code of ethics, licensing, single major professional association, exclusive practice rights, body of specialized knowledge, application of knowledge in professional practice, collaboration among members, candidate selection, rigorous and protracted training period, high status, high compensation and lifelong commitment.

Teacher professionalism is about teacher's knowledge, their autonomy and their membership of peer networks (Kubacka, 2016). In this sense, different educational systems focus on different aspects of teacher professionalism. Some systems put more emphasis on supporting the teacher knowledge base through activities such as incentivizing teacher professional development, some focus on autonomy through giving more decision making over curricular and teaching contents to teachers, and some focus on peer networks through cultivating strong networks of teachers. With these components of professionalism in place, teachers are more satisfied and confident and have a higher perception of the value of the teaching profession in society. The outcomes of improving support to teachers in these key areas definitely impact the quality of teaching and learning, particularly in mathematics.

Mathematics teachers focused on professionalism are concerned with the school community and how they can work with their colleagues to create an environment that maximizes learning and bolsters achievement in mathematics (Masitoh, 2018). Many developed and developing educational systems require mathematics teachers to participate in ongoing professional development programmes to maintain certification (Zeigner, 2018; Setiawaty et al, 2018). Teachers committed to professionalism enthusiastically participate in training to stay abreast of advances in technology and emerging trends in education. They seek information on best practices and teaching strategies for all categories of learners. Considering the fact that teacher professionalism hinges on knowledge enrichment, the ability to reflect upon and improve one's own teaching practice, strengthened confidence in one's ability to initiate changes in school culture, and school curriculum design (Chow et al., 2015), some teachers conduct research to continually improve their teaching methods and support the performance of their students (Zeigner 2018). Additionally, many mathematics teachers attend educational conferences and belong to professional organizations (such as the Mathematical Association of Nigeria) to connect with others in the field. Engaging in these personal development endeavors implies teacher professionalism in mathematics education communicates confidence, competence, and dedication to helping all students fulfill their potential.

Mathematics teachers need to innovate, to be able to support children and young people's learning through an ever-changing society. According to the Association of Teachers and Lecturers (ATL) (2012), this innovation is driven by a professionalism based on critical and effective self-reflection, professional autonomy and respect for the role. Specifically, in line with the ATL (2012), teacher professionalism is based on the following principles:

1. The teaching profession is a learning profession, continually developing deep knowledge of learning; how the brain works; subjects and the relationship between them; pupils as individuals, and their interests; and the broader context (political, economic, technological, social, cultural and environmental).
2. Teachers' professional role is based on care for pupils and responsibility for their learning. As part of that, teachers need to build relationships with pupils, families, communities and other professionals.
3. The teaching profession draws on theoretical understanding and knowledge in order to adapt teaching practices and methods to pupil need.
4. Teacher professionalism is about exercising judgment on curriculum, assessment, and pedagogy
5. Teachers have to balance their own professional values against their responsibilities to the organizations in which they work. Further, there has to be a balance between teacher autonomy and appropriate accountability measures prescribed by the government.
6. Teachers have a responsibility to debate education practice.

Eyeballing the practice of the teaching profession in Nigeria through the lens of existing paradigms of teacher professionalism unveils several discrepancies and shortfalls. For instance, the issuance of teaching license by the Teachers Registration Council of Nigeria (TRCN) has not been comprehensively co-ordinated to regulate teaching practice in Nigeria. Teaching has become the profession for every job seeker in the country, irrespective of qualification. With the changing tides in employment and the education sector (private sector-driven) rapidly becoming a major employer of labor in the country, most graduates of hitherto "marketable" disciplines are now ending up as classroom teachers (Abah, 2017). According to Abah (2017), this class of graduates resorting to teaching for a living often rush into further Post Graduate studies in education, just to secure their jobs and obtain the teaching license. These irregularities have continued to deflate the prestige of the teaching profession in the country and denying duly trained teachers exclusive practice rights.

A plethora of challenges in compensation for teachers has depreciated the status of the teaching profession in Nigeria. With the lackadaisical attitude of the government and even private school proprietors, there has been a continuous downward trend in the level of commitment of teachers in general. This has transform teaching into a "transiting profession", a temporal position and awaiting ground for "greener pastures". The ramifications of the rampant inadequacies of the teaching profession in the country are truly beyond the scope of this present piece of work. Despite the obvious difficulty in staying committed to the profession, mathematics teachers who intend to distinguish themselves are indeed standing out in their field of practice.

Beginning from the apprenticeship exercise embarked upon by undergraduates of mathematics education within the teaching practice course framework, mathematics teachers can build the right mentality of research to reflect on their personal practice (Abah 2016). A good teaching practice exercise is supposed to highlight the school as the appropriate environment for translating educational methodologies and theories into real-life success stories. As the pre-service teacher becomes a full-time teacher, the mathematics classroom can then be seen as an active hub where the mathematics teacher engages himself or herself in a theory-building process through teacher research. Engagement in teacher research raises the sense of self-worth for the mathematics teacher and ultimately redefines teacher professionalism for the school, the community, and the nation.

2.2 Mathematics Teachers as Researchers

The mathematics teacher is an individual trained to deliver instruction in mathematics with the aim of bringing about learning and acquisition of skills in mathematics. The trained mathematics teacher is that individual entrusted with the all-important job of curating rich learning experience for pupils/students in mathematics. This individual continually leverages his or her training to deploy instruction techniques that are expected to raise and sustain students' perception of their abilities to attain good results in mathematics. Effective mathematics teaching involves active engagement, ongoing discourse, and reflection in all actions within the context of mathematics. The job of the mathematics teacher is to sequence curricular content to bring about improvement in learners' conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition.

While immersed in the task of organizing knowledge delivery, the teacher often finds himself or herself in need of systematic inquiries with outcomes that may better enhance key decision making in the teaching-learning process. Following such needs broadly lead to teacher research. Cochran-Smith and Lytle (1999) define teacher research in the broadest possible sense to encompass all forms of practitioner inquiry that involve systematic, intentional and self-critical inquiry about one's work in basic education, secondary education or continuing education classrooms, schools, programmes, and other formal educational settings. Rust (2009) observes that because it is intimately embedded in practice and in the time frames of teachers' lives in classrooms, teacher research describes a form of qualitative inquiry that draws on techniques that are generally already part of the instructional toolkit of most practitioners. Teacher research includes inquiries that others may refer to as action research, practitioner inquiry, teacher inquiry, and teacher or teacher educator self-study. Through teacher research, mathematics teachers with the research skills to share and critique their practice become key collaborative professionals in the change processes within school communities (Gray & Campbell-Evans 2002).

In the view of Chow et al. (2015), teacher research is a process in which educators note "problems" in the context of their own schools and classrooms and proposes investigative methods appropriate to address the problems. Educators also systematically observe and analyze results in the light of their professional knowledge and share the results with others, while enacting change in their own classrooms. Teacher research is thus a means to facilitate the professional growth of both pre-service and in-service teachers, while promoting critical reflection, change, and reform in basic education. It makes use of qualitative data, including journals, oral inquiries, and observational data and is often reported in narrative forms of representation (see Abah, 2017b for example). Teacher research enables mathematics teachers to carry out research projects and reflect on their own practice during and after the projects, aside just acquiring knowledge from university experts outside their basic school. This has positive effects on the professional competence of mathematics teachers since action research is a necessary and integral part of the process of developing teaching as an evidence-based process.

Teacher research as a research paradigm diffuses the gap between research outcomes and classroom implementation. In this perspective Griffiths (2004) developed a typology of teaching research links around four key categories:

1. Teaching can be research-led in the sense that the curriculum is structured around subject content, and the content selected is directly based on the specialist research interests of the teaching staff. Along with this axis the emphasis tends to be on understanding research findings rather than the research process.
2. Teaching can be research-oriented in the sense that the curriculum places emphasis as much on understanding the processes by which knowledge is produced as on learning the certified knowledge that has been achieved. The research experiences of teaching staff in this sense are brought to bear a more diffuse way.
3. Teaching can be research-based in the sense that the curriculum is largely designed around inquiry-based activities, rather than the acquisition of subject content. In this mode, the experiences of staff in processes of inquiry are highly integrated into the student learning activities. Here, the division of roles between teacher and student is minimized and the scope for two-way interactions between research and teaching is deliberately exploited.
4. Teaching can be research-informed in the sense that it draws consciously on the systematic inquiry into the teaching and learning process itself.

Drawing on Griffiths' first three categories, Healey (2005) adds a further one and expresses their relationship diagrammatically along two axes, one from an emphasis on research content to an emphasis on research processes and problems, and the other from a student-focused approach to a teacher-focused approach (Fig. 1).

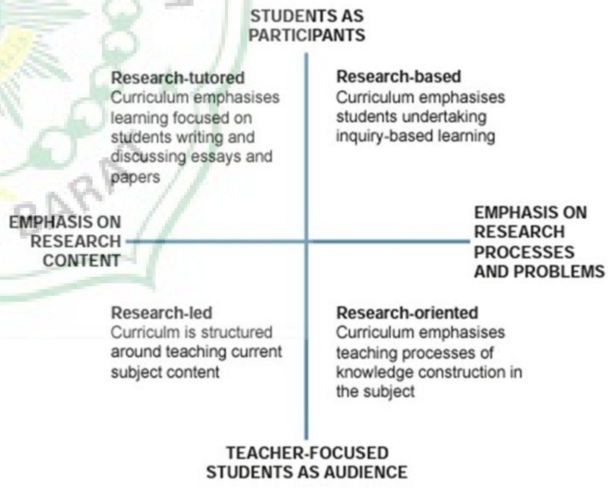

Figure 1. Curriculum Design and the Research –Teaching Nexus (Healey, 2005)

Teacher-researcher originates in the disposition of the teacher towards inquiry. The inquiry is a relational stance of outward motion, a seeking of understandings, both of the world and of other people (Lysaker & Thompson, 2013). For pre-service teachers, this means actively reaching out, adopting a stance of curiosity, and questioning their assumptions about teaching and learning. On this basis, Lysaker and Thompson (2013) suggest a non-linear and recursive inquiry cycle, to support the relational stance:

1. *Provocations:* This is a term used to describe something in the environment that arouses interest or curiosity, and which may create a sense of discomfort. Provocation is a moment of not knowing, a feeling of uncertainty that is embraced and explored

as a point of departure for learning. In teacher research these provocations often come from children and lead to classroom investigations.
2. *Personal and Social engagement in pursuing questions that arise from provocations:* Pre-service teachers learn to view their own interests, questions and discomforts in and around teaching as provocations for their learning.
3. *A process of revisiting, reflecting and revisiting both thinking and practice.*
4. *Assessment and reporting:* Through the personal and social engagements of teacher research, teachers work at pursuing the provocations, continually revisit and reflect on their experience through discussion and writing and finally assess and report on the outcome of their Inquiry.
5. *New inquiry.*

In teaching practice, a teaching notebook may be all that the mathematics teacher requires to begin teacher research. Teaching notebooks clearly benefit mathematics teachers as they collect and reflect on classroom experiences. Mathematics teachers can continue to improve with the holistic, reflective view of their teaching that the notebook offers. In choosing a process, some teachers may prefer to jot down, briefly, reflections at the end of every day. Others might find daily journals burdensome and would prefer a once-in-a-week journal. It is also important for the mathematics teacher to choose a focus. This focus could be on the teaching strategies and general outcomes, or on lesson plans, how students progress, and teaching effectiveness. The specific details of the focus are often described in the journal over a period of time and then later revisited. Reading the journal may help the mathematics teacher identify and emphasize strengths and recognize and improve weaknesses.

Evidently, mathematics teacher research starts with a commitment to examine an aspect of teaching and learning and is carried out through the intentional and systematic collection and analysis of classroom data. Mathematics teacher researchers choose research questions that matter to them. Because they determine their own questions and the course of their research journey based on their own learning needs, their research is responsive to those needs. Teacher research requires a description of the context for teaching and learning. Rather than attempt to control for variables, mathematics teacher researchers strive to identify, define, articulate and elucidate the context as a whole, to reveal the assumptions at work within the context, and to uncover the connections as well as tensions among elements of that context. By implication, mathematics teacher research both shapes and is shaped by its context. Their research questions reflect the mathematics teachers' current understanding of their topics, their students and their teaching context. In a sense, mathematics teacher research is contextual because it is context-dependent, context-relevant and context-responsive.

If the traditions of teacher research are examined, McLaughlin (2004) observes that the following purposes and conceptions can be seen:
1. For a practitioner to develop their own practice through understanding particular or general aspects of practice or solving pedagogical problems.
2. To address issues of power and injustice through critiquing policy, promoting equity and seeking to optimize the social conditions of practice for practitioners and learners.
3. Contributing to public knowledge about education, teaching, and learning.

Similarly, the effects and benefits of mathematics teacher research, according to McLaughlin (2004) are:
1. It resulted in a renewed feeling of pride and excitement about teaching and in a revitalized sense of oneself as a teacher.
2. The research experience reminded teachers of their intellectual capability and the importance of that capability to their professional lives.
3. The research experience allowed teachers to see that the work that they do in school matters.
4. The research experience reconnected many of the teachers to their colleagues and their initial commitments to teach
5. The research experience encouraged the teacher to develop an expanded sense of what teachers can and ought to do.
6. The research experience restored in teachers a sense of professionalism and power in the sense of having a voice.

The idea of mathematics teachers doing research will only be sustainable if teachers themselves want to embark on it. Here, Salleh (2014) observes, the school leadership plays a very important role in enabling them to do so, by building capacity through appropriate professional development.

2.3 The Role of Higher Educational Institutions

Whenever classroom teachers look to research as a guide to action, there is always a problem of coverage and content. Published educational research, emanating from higher educational institutions, simply does not provide comprehensive answers to many of the issue that teachers face on a daily basis (McAleary, 2016). Specific school teaching activity has never been subject to rigorous extensive research, raising questions relating to how teachers use evidence in the classroom and what they feel are the most effective approaches to engaging with research and using it to inform their practice (Judkins, Stacey, McCrone & Inniss, 2014). Outside the stand-alone and degree programmes offered by institutions of higher learning, there is the need for the intellectual citadels to take up more responsibility in mentoring, peer observation, conference organization and networking at the Basic Education Level (Roux & Valladares, 2014).

The gap in the translation of research findings into classroom practice is mainly due to the inadequacy of present provision for interpreting research findings to help inform decision making and action. If basic schools are to use academic research to improve their practice, it is clear that becoming informed about relevant research and interpreting it in relation to a basic school's needs has to be integrated into the processes of generating and implementing the school's development plans (McIntyre, 2004). Higher educational institutions leading research in basic schools will have to work hard to find evidence relevant and useful in their contexts and will need to exercise skill in judging the quality of the research that does exist (McAleary, 2016).

In implementing the teacher-as-researcher paradigm, educational reforms, especially those championed by higher educational institutions, must encourage grassroots practitioner research. Much has happened to make the teacher feel powerless and disinclined to take the initiative towards classroom research. There is now a need for creativity with regard to establishing promising "points of entry" for teacher research in a climate of imposition (Hancock 1997). Given that research is an extra layer of work for teachers, it is important to provide support that will enable lift off, if possible through hands-on help to be provided by academic researchers in higher educational institutions. With this form of support in place for many teachers, teacher research will offer the possibility of border crossing, of bridging the gap between academic research and knowledge derived from practice (Rust, 2009). Such a support system should be aimed at breaking down the discourse barriers in published research reports and increasing teacher's confidence and skills to critically review current policy (Gray & Campbell-Evans, 2002). In essence, teacher education programmes in higher education need to develop a framework for the collaborative reflective inquiry to assist a deep understanding of informed teaching in response to student learning.

A robust framework for institutional strategies to link teaching and research is provided by Jenkins and Healey (2005). The framework comprising seventeen strategies was structured around four (4) broad areas namely, developing institutional awareness and institutional mission, developing pedagogy and curricula to support the nexus, developing research policies and strategies to support the nexus and developing staff and university structures to support the nexus. Similarly, Chow et al. (2015) present a model of interaction between university experts and frontline teachers which suggest that the ideal collaboration between university and schools is one in which teachers work closely with university experts in discovering new knowledge instead of relying on them. In this mode, the frontline teachers partner with the university experts in generating mathematical knowledge and theorizing their practice via consistent renewal and revision

2.4 Implications for Classroom Practice in Nigeria

Very often action research is a collaborative activity where practitioners work together to help one another design and carry out investigations in their classroom. Mathematics teacher research is designed, conducted and implemented by the mathematics teachers themselves to improve teaching in their own classrooms, sometimes becoming a staff development project in which teachers establish expertise in curriculum development and reflective teaching. Thus, the research-engaged school is one manifestation of evidence-informed professionalism.

Mathematics teacher research is needed for Nigeria because it is probably both unrealistic and undesirable to think that mathematics teaching can be entirely based on findings from academic research. As McAleary (2016) observes this would marginalize insights from experience, craft knowledge and small scale practitioner research. It is surely better for schools in Nigeria to strive for evidence-informed professionalism, which values lessons from formal research alongside other guides to act on. Just as the research of individual teachers has been most commonly aimed at their own professional development, and thus the improvement of both their educational understanding and their professional practice, so the dominant concern of basic schools as research institutions is with their institutional learning and thus with the improvement of both their policies and their practice (McIntyre, 2004). As individual teachers aspire to go beyond development of their own thinking and practice via teacher research, to challenge and enhance existing understandings, settlements, policies and practices more widely, there should be some aspiration at the school level for schools not just to be concerned in their own improvement but also to become "knowledge creating" institutions.

Teachers have a duty to use research-derived evidence but it will not give a precise script for every situation, so mathematics teachers in particular also have to use experience-based judgment. Teachers and school leaders cannot be seen simply as technicians who must passively accept and act upon directives from academic researchers in institutions of higher learning. In the view of McAleary (2016), teachers are professionals who must adopt research-derived guidance to meet the particular circumstances they face, using judgment and lessons from experience. In addition to research findings, other sources of evidence such as student and parent voice must be taken into account. The research-engaged school uses formal research findings but also much more informal modes of inquiry and reflection along with outcomes of teacher-research. The Nigerian Basic School system must understand the importance of personal insight derived from experience and good analysis of other forms of management information such as test results and feedback from students and parents. McAleary (2016) observes that five activities characterize the research-engaged school in action, namely, the research-engaged school:

1. Promotes practitioner research among its staff,
2. Encourages its staff to read and be responsive to published research
3. Welcomes (as a learning opportunity as well as a responsibility to the wider educational community) being the subject of research by outside organizations.
4. Uses research to inform its decision making at every level
5. Has an outward-looking orientation including research-based links with other schools or universities.

Mathematics teachers who do research activities in a long lasting quest for updated information about the approaches and trends to deal responsibly with the issues raised as part of their practice, with permanent activities of reflection and assignment always framed by the policies stated by the government (Vasquez, 2017). Should they find inconsistencies between their practice and the applicable government regulation, they could propose changes with the appropriate authorities and by doing that, teachers will grow as professionals and as active and responsible members of one's practice in purposeful, collegial forums enables a refining of practice that strengths both the individual and the group (Rust, 2009). In such an environment, teacher research offers the possibility of translation between the academy of mathematics education and the world of practice and between research, policy, and practice.

Judkins *et al.* (2014) put forward key findings on the perceived benefits of engagement in research evidence, including:

1. Overall, engaging in research evidence encourage practitioner reflection and open-mindedness.
2. Teachers' openness to adopting different pedagogical approaches is considered to make lessons more engaging for earners and engaging with research is seen to encourage this.
3. Teachers benefit from research evidence through its use to inform professional development and through the confidence acquired from implementing new approaches.
4. Teacher research has the ability to drive school improvement initiatives, to substantiate the reasons behind the change and to underpin staff professional development.

The outcome expected from research should ideally be the solution to the problem initially observed or the improvement of the conditions which originally made teachers reflect on the problematic situation or at least the establishment of a path to perform a longer or deeper research attempt (Vasquez, 2017). This process, once started and sensibly and responsibly supervised, generates the need to engage the whole educational community in it. This situation makes members of staff committed to their duties by becoming reflective and critical on their performance, improving the basic school's profile through constant self-reflection in general. The implication here is that apart from the mathematics teachers, head teachers and school principals are deemed to play an integral part in the establishment of a school culture that encourages teachers to carry out research in their classrooms (Chow et al., 2015). Aside from collaboration among the teaching staff, parents' attitudes towards and support for research are vital since their consent must be obtained before any form of classroom intervention can take place.

Most Local Education Authorities (LEAs) across the country may have a number of support, advisory and inspection staff who can do much for the cause of teacher research. Hancock (1997) suggests that such staff can provide an important service to class teachers by drawing attention to any exciting and innovative practice that they see from the "privileged" position of a peripatetic observer. Such systematic collaboration will bring to bear on Basic Education the full benefits derivable from mathematics teacher research.

3. CONCLUSIONS

This review has attempted to advocate mathematics teacher research as a tool for improved professionalism in mathematics education. Pertinent issues surrounding teacher research and its relationship to professionalism among basic school teachers have been given detailed consideration. The role of higher educational institutions in fostering teacher research in mathematics education has been unveiled as that of collaboration, mentorship and hands-on practice involving the experts and front-line teachers. The implications of mathematics teacher researcher were considered along with the need to create the right environment to nurture a culture of evidence-informed practice within basic education.

Achieving mathematics teacher research prowess entails a conscious effort by both school management and mathematics teachers to translate research into practice in the classroom and nurture staff confidence by allowing them to take risks with practice informed research. The basic school system must make it easy for mathematics teachers to engage in research by creating the time and space through a special form, saving teachers' time where possible, making research findings accessible, identifying context-specific evidence for teachers and using appropriate internal and external support.

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RESEARCH ARTICLE

Application of Grey Numbers to Assessment of Mathematical Modeling Capacities

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ABSTRACT

Mathematical modeling appears today as a dynamic tool for teaching and learning mathematics, because it connects mathematics with real world applications thus increasing the student interest on the subject. In the present paper a method is developed that uses grey numbers for evaluating student mathematical modeling capacities and a classroom application is presented illustrating it. This new assessment method is useful in particular when the student performance is evaluated with linguistic characterizations (grades) and not with numerical scores, which makes non feasible the calculation of the mean value of those grades. Grey numbers are indeterminate numbers which are defined with the help of the real intervals and they have found nowadays many applications in real life, science and engineering for handling approximate data.

1. INTRODUCTION

The failure of the introduction during the 1960's of the "new mathematics" to school education (e.g. see Kline, 1973) turned the attention of specialists in the field of mathematical education on the use of the problem as a tool and motive to teach and understand better mathematics. The perceptions of this movement were expressed through two main directions: *Problem Solving (PS)*, where attention is given to the use of the proper heuristic strategies for solving mathematical problems (e.g. see Voskoglou, 2012; Nasir, 2018) and *Mathematical Modelling (MM),* i.e. the solution of a particular type of problems generated by real world situations (e.g. see Voskoglou, 2006).

It is recalled that a *model* is a simplified representation of the basic characteristics of a real system including only its entities and features under concern. The construction of a model usually involves a preliminary deep abstracting process on identifying the system's dominant variables and the relationships governing them. The resulting structure of this action is known as the *assumed real system*. The model, being a further abstraction of the assumed real system, identifies and simplifies the relationships among these variables in a form amenable to analysis. The above process is sketched in Figure 1.

There are several types of models in use according to the form of the corresponding problem (Taha 1967, Section 1.3.1). The representation of a system's operation through the use of a *mathematical model* is achieved by a set of mathematical expressions (equalities, inequalities, etc) and functions properly related to each other. The solutions provided by a mathematical model are more general and accurate than those provided by the other types of models.

Until the middle of 1970's Mathematical Modelling was mainly a tool in hands of scientists and engineers for solving real world problems related to their disciplines (physics, industry, constructions, economics, etc). One of the first who described the process of Mathematical Modelling in such a way that it could be used for teaching mathematics was Pollak (1979). He represented the interaction between mathematics and the other world with the scheme shown in Figure 2, which is known as the circle of modelling.

The direction of the arrows in Pollak's scheme represents a looping between the "universe" of mathematics and the other world which includes all the other sciences and the human activities of everyday life. Starting from a real world problem one transfers to the other part of the scheme, where he/she uses or develops suitable mathematics for its solution.

Then he/she returns to the other world interpreting and testing on the real situations the mathematical results obtained. If these results are not giving a reliable solution to the real problem, then the same circle is repeated again one or more times.

From the time that Pollak presented this scheme in ICME 3 (Karlsruhe, 1976) until nowadays much effort has been placed to analyze in detail the process of Mathematical Modelling. A brief but comprehensive account of the several models that have been used for the description of the Mathematical Modelling process, including the present author's Markov chain model (Voskoglou 1994, 2007) can be found in Haines and Crouch (2010).

Mathematical Modelling appears today as a dynamic tool for teaching/learning mathematics, because it connects mathematics with real world applications and therefore it increases the student interest on the subject. Towards this direction the assessment of student Mathematical Modelling skills is a very important task, because it helps the instructors in developing their future plans for a more effective teaching of the Mathematical Modelling process.

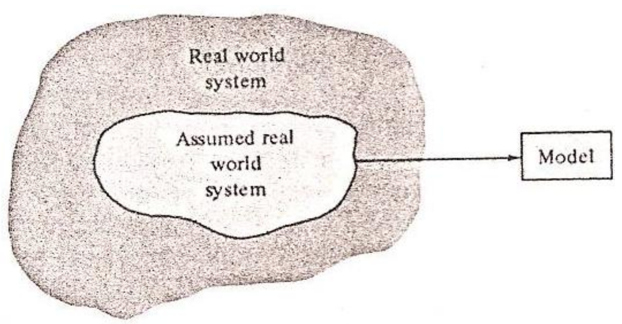

Figure 1. A graphical Representation of the Modelling Process

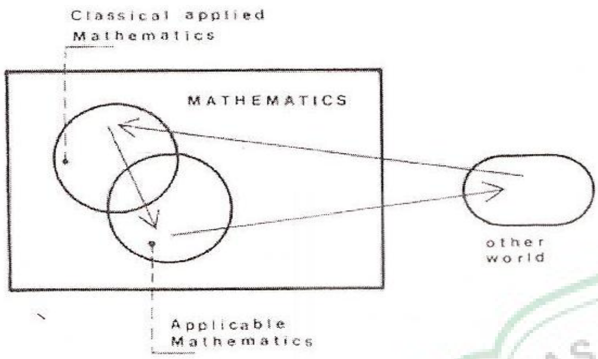

Figure 2. The circle of modelling

When the student performance is evaluated with numerical scores, then the traditional way to assess the *mean performance* of a student class is the calculation of the mean value of those scores. However, either for reasons of more elasticity or to comfort the teacher's existing uncertainty about the exact value of the numerical scores corresponding to each student's performance, frequently in practice the assessment is made not by numerical scores but by *linguistic grades*, like excellent, very good, good, etc. This involves a degree of vagueness and it makes the calculation of the mean value of the student grades non feasible. A popular in such cases method for evaluating the overall performance of a student class is the calculation of the *Grade Point Average (GPA) index* (e.g. see Voskoglou, 2017, Chapter 6, p.125). However, GPA is a weighted average in which greater coefficients (weights) are assigned to the higher grades. That means that GPA reflects not the mean, as we have in mind, but the *quality performance* of a student class.

In an effort to estimate the mean student performance in such vague assessment cases we have used in earlier works tools from *Fuzzy Logic*. More explicitly, representing the student class as a *fuzzy set* in the set of the linguistic grades used for the student assessment, we calculated the existing in it *uncertainty* **(**probabilistic or possibilistic**)**. This approach is based on the classical principle of information theory that the greater is the reduction of the uncertainty, the more the new information obtained by the class and therefore the better the student performance (e.g. see Chapter 5 of Voskoglou, 2017 or Voskoglou, 2011). Nevertheless, this method has two disadvantages. First it involves laborious calculations and second it can be used for comparing the performance of two different classes only under the assumption that the existing in both of them uncertainty is the same, before the corresponding activity (e.g. test, problem-solving, learning a new subject matter, etc.), a condition that frequently does not hold in real situations. For this reason we have used in later works *Triangular Fuzzy Numbers (TFNs)* for assessing the student mean performance (e.g. see Chapter 7 of Voskoglou, 2017). This method has been proved to be simpler in its application and more accurate than the calculation of the uncertainty.

In the present paper an alternative method will be developed for estimating the student mean performance in such vague cases by using *Grey Numbers (GNs)* instead of TFNs. Although the above two methods (GNs and TFNs) are finally proved to be equivalent, the use of the GNs reduces significantly the required computational burden.

The rest of the paper is formulated as follows: In Section 2 the necessary for the understanding of the paper background about GNs is introduced. In Section 3 our new assessment method is developed, while in Section 4 a classroom application for assessing student MM skills is presented illustrating our method. Finally, our conclusion is stated in Section 5 together with some hints for future research on the subject.

2. GREY NUMBERS

Frequently in the everyday life, as well as in many applications of science and engineering, a system's data cannot be easily determined precisely and in practice estimates of them are used. The reason for this is that in large and complex systems, like the socio–economic, the biological ones etc, many different and constantly changing factors are usually involved, the relationships among which are indeterminate, making their operation mechanisms to be not clear.

Nowadays two are the main tools for handling such approximate data: Fuzzy Logic, based on the notion of Fuzzy Set initiated by Zadeh (1965) and the theory of Grey System (GS) initiated by Deng (1982).

Roughly speaking, a GS is defined to be any investigated object with "poor" information. An effective tool for handling the approximate data of a GS is the use of GNs, which are introduced with the help of the real intervals.

A GN is an indeterminate number whose probable range is known, but which has unknown position within its boundaries. More explicitly, if R denotes the set of real numbers, a GN, say A, can be expressed mathematically by:

$$A \in [a, b] = \{x \in \mathbf{R} : a \leq x \leq b\}.$$

Compared to the interval [a, b] the GN *A* enriches its uncertainty representation with a *whitenization function*, defining a *degree of greyness* for each *x* in [*a, b*]. If *a*=*b,* then *A* is called a *white number* and if $A \in (-\infty, +\infty)$, then it is called a *black number*.

GNs have found nowadays very many applications including medicine diagnostics, psychology, sociology, control systems, economy price indices, opinion polls, etc. For general facts on GNs we refer to S. F. Liu, & Y. Lin (2010).

From the definition of the GNs it becomes evident that the well known arithmetic of the real intervals (Moore et al., 1995) can be used to define the basic arithmetic operations among the GNs. In fact, if $A \in [a_1, a_2]$ and $B \in [b_1, b_2]$ are two given GNs, we define:

1. *Addition by*: $A + B \in [a_1 + b_1, a_2 + b_2]$
2. *Subtraction by*: $A - B = A + (-B) \in [a_1 - b_2, a_2 - b_1]$, where $-B \in [-b_2, -b_1]$.
3. *Multiplication by*: $A \times B \in [\min\{a_1b_1, a_1b_2, a_2b_1, a_2b_2\}, \max\{a_1b_1, a_1b_2, a_2b_1, a_2b_2\}]$
4. *Division by*: $A : B = A \times B^{-1} \in [\min\{\frac{a_1}{b_1}, \frac{a_1}{b_2}, \frac{a_2}{b_1}, \frac{a_2}{b_2}\}$,

max{$\frac{a_1}{b_1}, \frac{a_1}{b_2}, \frac{a_2}{b_1}, \frac{a_2}{b_2}$ }], where 0 $\notin$ [b_1, b_2] and

$B^{-1} \in [\frac{1}{b_2}, \frac{1}{b_1}]$.

5. *Scalar multiplication by*: kA $\in$ [ka_1, ka_2], where k is a positive real number.

Observe that B + (-B) = (-B) + B $\in$ [b_1 - b_2, b_2 – b_1] $\neq$ [0, 0] and B x B^{-1} = B^{-1} x B $\in$ [a, b] $\neq$ [1, 1].

Let us denote by w(A) the white number with the highest probability to be the representative real value of the GN

A $\in$ [a, b]. The technique of determining the value of w (A) is called whitenization of A. One usually defines

w(A) = (1- t)a + tb, with t in [0, 1].

This is known as equal weight whitenization. When the distribution of A is unknown, we take t = $\frac{1}{2}$, which gives that w (A)

= $\frac{a+b}{2}$.

3. THE ASSESSMENT METHOD WITH THE GNs

Let *G* be a group of *n* students participating in a certain activity (e.g. learning a new subject matter, problem-solving, etc.). Assume that one wants to estimate the mean performance of *G* in terms of the linguistic grades A = Excellent, B = Very Good, C = Good, D = Fair and F = Unsatisfactory. For this, we introduce a numerical scale of scores from 0 to 100 and we assign these scores to the above linguistic grades as follows:

A (100-85), B (84-75), C (74-60), D (59-50) and F (49-0). The above assignment, although it satisfies the common sense, it is not unique, depending on the observer's personal goals. For example, for a more strict assessment one could take

A (100-90), B (89-80), C (79-70), D (69-60) and F (59-0), etc.

It is possible now to represent each linguistic grade by a GN, denoted with the same letter written in italic fond. Namely, we introduce the GNs: A $\in$ [85, 100], B $\in$ [75, 84], C $\in$ [60, 74], D $\in$ [50, 59] and F $\in$ [0, 49]. Let nA, n_B, n_C, n_D and n_F be the numbers of the students of G whose performance was assessed by the grades A, B, C, D and F respectively. Assigning to each student the corresponding GN we define the mean value of all those GNs to be the GN.

M = $\frac{1}{n}$ [n_AA + n_BB + n_CC + n_DD + n_FF].

Since n_AA $\in$ [85n_A, 100n_A], n_BB $\in$ [75n_B, 84nB],

n_CC $\in$ [60n_C, 74n_C], n_DD $\in$ [50n_D, 59n_D] and

n_FF $\in$ [0n_F, 49n_F], we have that M $\in$ [m_1, m_2], with

$m_1 = \frac{85n_A + 75n_B + 60n_C + 50n_D + 0n_F}{n}$ and

$m_2 = \frac{100n_A + 84n_B + 74n_C + 59n_D + 49n_F}{n}$.

In the extreme case where the maximal possible numerical score corresponds to each student for each linguistic grade (i.e. the n_A scores corresponding to A are equal to 100, the n_B scores corresponding to B are 84, etc.), the mean value of all those scores is equal to m_2. Also, in the opposite extreme case where the minimal possible numerical score corresponds to each student for each linguistic grade (i.e. the nA scores corresponding to A are 85, the nB scores corresponding to B are 75, etc.), the mean value of all those scores is equal to m_1.

Since the distributions of the GNs A, B, C, D and F, defined by the corresponding whitenization functions, are unknown, the same happens with the distribution of M.

Therefore one can take w (M) = $\frac{m_1 + m_2}{2}$

Consequently, the use of GNs provides a reliable approximation of the group's mean performance, which is useful when no numerical scores are used and the student performance is assessed by qualitative grades.

Remark: In earlier works (e.g. see Chapter 7 of Voskoglou, 2017) we have estimated the mean performance of G by using the TFNs *A* = (85, 92.5, 100), *B* = (75, 79.5, 84), *C* = (60, 67, 74), *D* = (50, 54.5, 59) and *F* = (0, 24.5 49) instead of the corresponding GNs used here. Assigning to each student the TFN corresponding to his/her performance we calculated the mean value of all those TFNs and by defuzzifying it with the *Centre of Gravity (COG) technique* we have found the same outcome $\frac{m_1 + m_2}{2}$.

Consequently the two assessment methods using TFNs and GNs respectively are equivalent to each other, providing the same assessment outcomes. However, the method using GNs reduces significantly the computational burden with respect to the other one.

4. A CLASSROOM APPLICATION

The following Table depicts the performance of two student groups, say G1 and G2, in a common mathematical test involving the solution of three MM problems on the use of the derivatives for finding the maxima/minima of a given function in one variable. The statements and solutions of those problems together with some useful remarks are presented in the Appendix at the end of the paper.

Table 1. Student performance

Grade	G1	G2
A	20	20
B	15	30
C	7	15
D	10	10
F	8	10
Total	60	85

For comparing the mean performance of the two groups we assign to each student the corresponding GN and we calculate the mean values M1 and M2 of all those GNs for the groups G1 and G2 respectively, which are approximately equal to:

$M_1 = \frac{1}{60}$ (20A+15B+7C+10D+8F) $\in$ [62.42, 79.33]

$M_2 = \frac{1}{85}$ (20A+30B+15C+10D+10F) $\in$ [62.94, 78.94]

Therefore w ($M_1 \approx \frac{62{,}42+79{,}33}{2} \approx$70.88 and w($M_2$) $\approx \frac{62{,}94+78{,}94}{2} \approx 70{,}94$

Consequently both groups demonstrated a good (C) mean performance, with the mean performance of the second group being slightly better.

Remark: The GPA index is calculated by the formula:

GPA = $\frac{0n_F + 1n_D + 2n_C + 3n_B + 4n_A}{n}$

(Voskoglou, 2017, Chapter 6, p.125).

Calculating it for the two groups one finds that:

GPA= $\frac{4.20+3.15+2.7+1.10}{60}$ $\approx$2.48 for the first group, and

GPA= $\frac{4.20+3.30+2.15+1.10}{85}$ $\approx$2.47 for the second group.

Therefore, in contrast to the mean performance, the first group demonstrated a slightly better quality performance than the second one.

5. CONCLUSION

The traditional method of assessing the mean performance of a student group by calculating the mean value of the numerical scores assigned to each student cannot be applied when the student performance is evaluated by qualitative grades. Also, the calculation of the GPA index that can be applied in such cases measures not the mean, but the group's quality performance, since greater coefficients are assigned to the higher grades. Motivated by the above two facts we have developed two methods for estimating the group's mean performance in such cases. The first one uses a combination of TFNs and the COG defuzzification technique, whereas the second method, developed in the present paper with the help of GNs, although it was proved to be equivalent with the first one, it reduces significantly the required computational burden.

GNs play in general an important role in science, engineering, and everyday life for handling approximate data. Therefore, the development of further applications of them to real-life problems (e.g. see Deng, 1989 and its references, Alevizos et al, 2016, Voskoglou, 2018, etc.) it is suggested as a promising area for future research.

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RESEARCH ARTICLE

Design of ARCSI Learning Model with Scientific Approach for Teaching Mathematics in School

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ABSTRACT

The study was aimed to obtain information regarding the design instructional of ARCSI learning model with the scientific approach for teaching mathematics in school. This learning model developed based on the learning conditions at Junior High School (SMP/MTs) in Bukittinggi City and Agam Districts of West Sumatera requiring a model of learning based on Islamic values, strategy in the motivation of ARCSI, and a scientific approach mandated in the curriculum of 2013. This learning model is designed for forming the character of learners in an Islamic way the learning process of mathematics that pleasant, and train students to think critically and comprehensively through a scientific approach. Synonymous ARCSI Learning Model with scientific approach, namely: (1) Attract the attention of learners by inviting praying/pleading to Allah Ta'ala, (2) Convey the purpose/benefit of learning and its application in daily activity, (3) The deliberations of the group to establish ukhuwah Islamiyah within the group, (4) a class discussion to establish ukhuwah Islamiyah classically, (5) Giving satisfaction to students with learning will make only because of Allah Ta'ala and the tradition of Prophet Muhammad SAW (6) Evaluate processes and the results of solving problems, and (7) Closing the learning by reading Hamdallah and greetings.

1. INTRODUCTION

The Teaching mathematics with the ARCSI learning model based on a scientific approach can help shape the ability of students to present concrete ideas and knowledge in the abstract, solve abstract problems, and practice rational, critical and creative thinking (Small, 2000; Herdiana, 2017). In the 2013 curriculum emphasizes the importance of the balance of attitude, knowledge and skills competencies (Nurhalim, 2015; Hakim, 2017). The mathematical abilities demanded are formed through continuous learning, which begins with increasing knowledge of mathematical methods, followed by the skill of presenting a problem mathematically and completing it, as well as the formation of honest, critical, creative, thorough, and obedient attitudes (Hakim, 2017; Thahir, 2018).

The ARCSI learning model with a scientific approach can describe the effort that must be made by the teacher and students to achieve the expected competencies (In'am, 2017; Herdiana, 2017; Small, 2000). This learning is in accordance with what is mandated in the 2013 curriculum, namely students must be brave to find other learning resources that are available and widely spread in the surrounding environment. The role of the teacher is very important to increase motivation and adjust the absorption of students with the availability of activities in the syntax of this learning model (Afandi, 2018; Fonna, 2018b). Teachers can enrich it with creations in the form of other activities that are appropriate and relevant to the social and natural environment..

According to (Keller, 1987; Mursalin et al, 2018) a teacher may change the learning environment so that students can motivate themselves. For example, in the learning process, there is a possibility that a teacher will teach well, but students actually learn nothing from it. Students sometimes feel heavy or do not want to learn something that is not felt meaningful to him. Students only memorize teaching material and often forget what they learned after they finished learning a teaching material. Students will choose not to apply what is learned because they are not interested in what has been learned.

One specific motivational strategy for the field of education has been developed by Keller. The four components of the motivation strategy are attention, relevance, confidence, and satisfaction with the acronym ARCS (Keller, 1987; Fonna, 2018a). This strategy emphasizes the design of a form of motivation that can be applied by the designer or instructor in the design of the form of teaching material. According to (Keller, 1984) and (Visser 1990), "studies evaluating this model have an evidence to support the validity of the four basic constructs and their positive effects on student attitude and performance".

The ARCS motivational strategy is a systematic strategy in the form of motivating instruction (Small, 2000). The motivation strategy has been used extensively (Means et al. 1997; Shellnut, Knowlton & Savage 1999; Song & Keller 2001; Hyland 2006). The ARCS strategy has also been applied in certain types of instructional settings such as computer-based instruction (Keller & Suzuki, 2004), textual material (Keller et al, 1987), instructor-led formal lecture (Visser et al, 1990) and online assessment (Hyland, 2006). The motivation of students towards mathematics learning collected in this study is related to (a) Attention, (b) Relevance, (c) Confidence, (d) Satisfaction.

The ARCSI learning model combined with a scientific approach according to the 2013 curriculum will be an interesting learning model for students, challenging, and provide an atmosphere that is different from other conventional learning models (Amalia et al, 2018).At present most teachers teach in schools using conventional learning models, although in the current curriculum it requires teachers to use creative, innovative learning models. Therefore, the purpose of this study was to design an ARCSI learning model with a scientific approach and practical steps for teachers. It is expected to be an innovative, creative model that makes it easier for students to learn.

ARCSI Learning model with the scientific approach is a new learning model developed through a study entitled "Development of ARCSI Learning Model with Scientific Approach" at the Junior High School in the Bukit Tinggi City and Agam District of West Sumatra. In order for educators can understand and apply this model so books learning model ARCSI by scientific approach is developed. This model integrating strategy motivation ARCS and Islamic values that required teachers in learning mathematics so can form the character of the student in an Islamic way can increase the involvement, motivation, and result of learning for the student.

This writing introduce to the teachers about the ARCSI learning model with scientific approach, these are:(a) Rational the preparation of book model;the formal, the theoretical ,and the fact learning in Junior High School, And also the purpose and usefulness of book model arranged, (b) The characteristic of ARCSI learning model with the scientific approach, (c) The social system, the principle of the reaction, and the support system, also the impact of instructional and accompanist that expected in ARCSI learning model with scientific approach.

2. METHODS

This type of research is the research design. The procedure uses a model development Plomp (2013) as shown in Table 1 below.

Tabel 1. Phase Development ARCSI Learning Model with Scientific Approach

No.	Development Phase	Criteria	Activity	Description of Activities
1.	Preliminary Research	Emphasis on the validity of the content	Needs Analysis and context	Initial investigations need ARCSI learning model with a scientific approach
				Collect a variety of information, including: the conditions of learners, curriculum and learning tools that are being used.
			Review of Literature	Analyze the theories and concepts associated with learning model development ARCSI with Scientific approach.
			Development of a concep-tual frame-work and theoretical framework	Designing and developing a conceptual framework and theoretical framework for learning model ARCSI with this scientific approach.
2.	Prototyping	Practicality and effectiveness	Designing Prototype	Designing learning model ARCSI with a scientific approach.
			Formative evaluation	To test the validity of (expert validity, focus groups and field test) to the prototype.
			Revision	Revised the prototype is based on the results of formative evaluation.
3.	Assesments	Practicality and effectiveness	Summative evaluation	Assess whether the user in the field can use the product and intends to apply in mathematics, and to test whether the product is effective.

Source: Modified by Plomp (2013).

3. RESULTS AND DISCUSSION

3.1 Rationable

The preparation of ARCSI learning model with scientific approach book based on: (1) laws and government regulations pertaining to education, (2) study theoretical pertaining to ARCSI learning model with the scientific approach, and (3) the fact learning that takes place in Junior High School.

Formal Fundament

Some of the formal foundations underlying the preparation of this model book include:

1) Law of the Republic of Indonesia Number 20 of 2003 on National Education System.
2) Government Regulation of the Republic of Indonesia Number 19 of 2005 on the National Education Standards of Education.
3) Regulation of the Minister of National Education of the Republic of Indonesia number 22 of 2006 on Content Standards for Primary and Secondary Education units.
4) Regulation of the Minister of National Education of the Republic of Indonesia number 23 of 2006 on Graduate Competency Standards for Basic and Secondary Education Units.

Regulation of the Minister of National Education of the Republic of Indonesia Number 41 of 2007 on Process Standards for Basic and Secondary Education Units.

Theoretical Foundation

The theoretical foundation in the development of the ARCSI learning model with the scientific approach is as follows.

1) Theory of Vygotsky's Social Constructivism.
2) David Ausabel's meaningful learning theory.
3) Learning Theory Piaget.

4) Learning Theory of Jerome Bruner.
5) Motivation Theory ARCS Motivation Strategy (attention, relevance, confidence and satisfaction).
6) Theory of Islamic Values.
7) The Scientific Approach in Mathematics Learning

Learning Facts

The fact of learning in the field in the form of data from the results of the early analysis on the implementation of the teaching process in SMP/MTs. These are; (1) the learning process has not been done well, (2) the learning process conducted by the teacher is still conventional, (3) the absence of serious effort from the teacher to change the pattern of learning with the application of learning models that can motivate and activate learners during the learning process as mandated by the 2013 curriculum. The facts in this field are further explored and processed in the form of a dissertation entitled Development of ARCSI Learning Model with the Scientific Approach (Studies at SMP/MTs in Bukittinggi and Agam districts).

a. Purpose

This model book is structured with the aim of increasing the understanding of teachers/education practitioners about the ARCSI learning model with the Scientific Approach that has been developed.

b. Usefulness

The usefulness of this model book is:

1) This model book is prepared in the hope that it can help teachers/education practitioners in order to perfect the learning process.
2) This model book is supposed to be an additional reference for teachers in crafting a fun lesson. The model is designed to integrate ARCS motivational strategies, Islamic values, and scientific approaches in line with the demands of the 2013 curriculum.

3.2 Characteristics of ARCSI Learning Model with Scientific Approach

Learning models relevant to mathematical characteristics and mathematics learning objectives are numerous, such as; (1) problem-based learning models, (2) contextual learning, (3) cooperative learning and many other learning models. However, the existing learning model has not been designed to make the learning process fun, and the teacher in the learning process has not applied the values of the character sourced Alqur'an, and hadith, and the learning process of mathematics concept has not followed the scientific approach mandated by the curriculum 2013.

The process of learning mathematics with ARCSI learning model with this scientific approach will form the ability of learners in presenting abstract concrete ideas and knowledge, solving abstract problems related, and practicing rational, critical and creative thinking. As part of the Curriculum 2013 that emphasizes the importance of balance of attitude, knowledge and skill competencies. The required mathematical skills are shaped through continuous learning, which begins by increasing the knowledge of mathematical methods, followed by the skill of presenting a problem mathematically and solving it, and leading to the formation of honest, critical, creative, meticulous, and principled attitude.

ARCSI learning model with this scientific approach describes the minimum effort that teachers and learners should do to achieve the expected competencies. Learning with a scientific approach in accordance with the mandated curriculum 2013, learners are encouraged to seek from other sources of learning available and stretched around it. The role of teachers is very important to improve motivation and adjust the absorption of learners with the availability of activities on the syntax of this learning model. Teachers can enrich it with creation in the form of other activities that are relevant and relevant to the social and natural environment.

Based on the theoretical basis, the design of the ARCSI learning model with the scientific approach applied follows the 5 main components of the learning model are: syntax, social system, reaction principle, support system, and instructional and accompanist effects (Joyce and Weil 1992: 14-16) as described below.

1. Syntaxs

a. Draw the attention of learners by inviting praying/pleading to Allah Ta'ala. so that science can be claimed to be closer to God Almighty

The activities performed in this syntax are:

1) Conditioning the class by asking students to read the Qur'an or pray (Islami).
2) The teacher reminds the students that we are obliged to always expect the pleasure of Allah Ta'ala in learning, because only Allah Ta'ala. which will give understanding to his servant to the knowledge learned (Islami).
3) The teacher displays the student's environment phenomenon related to the learning material, and asks some questions that aims to explore students' knowledge (Islami, Attention).

(Platform Theory: Ausabel Theory, Keller Motivation Theory (Attention), J. Bruner Theory, Alqur'an and Hadith).

b. Convey the purpose/benefits of learning and its application in everyday life

Activities performed on this syntax are:

1) The teacher displays the learning objectives to be achieved, and explains the learning process that the learners will do according to the ARCSI Learning Model with the Scientific Approach (Islami, Relevance).
2) Teachers outline about learning materials and problem-solving steps with varied methods and attractive appearance (Islamic, Relevance).
3) Teachers distribute teaching materials, students group work sheets (LKKPD), and object models to be observed (Attention, Confidence).

(Theory of Theory: Ausabel Theory, Keller Motivation Theory (Attention, Confidence, Relevance), The Scientific Approach, J. Bruner Theory, Alqur'an and Hadith).

c. Group deliberation to establish ukhuwah Islamiyah in the group

Activities performed on this syntax are:

1) The teacher assigns / asks the learners to observe, study, and formulate questions about the phenomena observed in LKKPD (Islami, Attention, PS 1, and PS 2).
2) The teacher assigns students to group meetings to gather information from various learning sources, as well as from the knowledge that the students have mastered to answer the questions that have been formulated, and the teacher acts as a mentor and supervisor in deliberation. Teachers always

remind and motivate learners to foster cooperation in groups (Islami, Attention, Satisfaction, PS3, PS4).

3) The teacher assigns students who already understand the learning materials, to help their uninformed friends. The help given to someone will be rewarded from Allah Ta'ala (Islami, Satisfaction).
4) Teachers are always going around in each group to motivate, monitor learners' work, and provide help when needed with great sincerity and affection. The teacher should always remember that the learners are new learners, do not know, and expect the attention and guidance from the teacher.
5) The assistance and attention given by teachers with full sincerity will not be in vain, for Allah Almighty. will always take into account all the actions of his servant (Islami, Attention, Relevance).
6) Teachers provide motivation to always cooperate and help each other, patient and eager in work (Islami).
7) Teachers provide guidance to learners when needed (Islami, Attention).

(Basis Theory: Piaget Theory, J. Bruner Theory, Keller Motivation Theory (Attention, Relevance, Satisfaction), Alqur'an and Hadith).

d. Deliberation Class to establish ukhuwah Islamiyah in classical

Activities performed on this syntax are:

1) The teacher provides facilities, and assigns classical deliberate participants, to communicate the results of the group meetings by asking each group's representatives to present their work (Islami, PS5, Attention, Relevance)
2) The teacher assigns to different groups to respond to the answer of the presenter group, and the teacher as a mediator in the deliberation (Islami, Relevance, Confidence).

(Basis Theory: Piaget Theory, J. Bruner Theory, Keller Motivation Theory (Attention, Relevance, Satisfaction), Alqur'an and Hadith).

e. *Giving satisfaction to the learners by sincerely intending to learn because of Allah Ta'ala. and the sunnah of Muhammad Saw.*

Activities performed on this syntax are:

1) The teacher gives confirmation (strengthen) about learning materials to omit the students' hesitant, and to convince the students about the truth of the concept concluded from the output of discussion. (Islamic, Satisfaction).
2) Teacher asks the students to formulate he conclusion from the learning materials that has been discussed and emphasized.
3) Teacher guides the students to conclude learning materials by asking the students to reveal important ideas that have been learned from the learning materials (Islamic).
4) Teacher gives reward to the group of students who work well (Islamic, Satisfaction).

(Base Theories: Piaget Theories, J. Bruner Theories, Keller Motivation Theories (Satisfaction), Alqur'an and Hadist).

f. Evaluating process and the result of resolving problems

The activities in this syntax are:

1) Teacher evaluates individually by using LKIPD (*Confidence, Satisfaction*).
2) Teacher reminds the students to be honest and sportive because honesty and being sportive will make us being appreciated (Islamic).

g. End the learning process by inviting the student's saying hamdallah and peace

The activities in this syntax are:

1) Teacher asks the students to do homework's at home based on the leaning materials of the students' book (Islamic, *Confidence*).
2) Teacher needs to remind/motivate the students to learn sincerely because Allah Ta'ala will raise the level of people who have faith and knowledge on some levels (Islamic).
3) Teacher asks the students to be grateful to Allah Ta'ala. For all learning activities which has been done, hope Allah will give understanding about what have been learned (Islamic).
4) Teacher ends the learning process by inviting the students to say Alhamdulillah (Islamic).

2. Social System

The organizing of students during the learning materials applies the cooperative learning style. In the interaction of socio-cultural between the students and friends, teacher always implements the Islamic values such as the value of Ukhuwah Islamiyah among the students by applying various ways: (1) Appreciating each other, (2) taking advantages each other, (3) helping each other, (4) being humble, (5) not underestimating other friends (6) not feeling as the most right one, (7) cooperating to solve problems, (8) asking and discussing between the clever students and the less clever students, (9) the freedom of conveying opinions, conversing, and debating (10) helping and cooperating to have a way for solving problems.

In addition, the other social system which is expected to appear is cooperating and helping each other to understand the materials concepts by the students , there is a responsibility in group and individually. (Base Theories: Joyce & Weil (2011), Kardi (1997), Dirjen PMD PSMA (2013), Alqur'an and Hadist)

3. Reaction Principles

The reaction principles which are designed and expected to appear in learning Model ARCSI by using scientific approach are; (1) Teaches gives supports by using the appropriate words, (2) teacher gives guidance if there is a student who finds difficulties in learning, (3) teacher gives learning facility for mastery of mathematic concepts,(4) teacher gives opportunity to the students by reconstructing and conveying the result of thinking, (5) teacher gives explanations/helps by using the wise words, and (6) teacher gives evaluation.

To bring the behaviors into reality, teacher has to give opportunities for the students to convey their results of thinking deliberately and open minded, observing the students' understanding about the mathematics' object that are obtained from the processes and problem solving, showing the weaknesses on students' understanding and stimulate them to find the way to solve problems.

If a student asks, before the teacher gives explanation/help, teacher gives other students' opportunity to convey their reaction and conclude the results. If the whole students face difficulties, it is a time for teacher to give explanations or help/ gives clue until the students can take over the problem solving on the next step. When the students are working on finishing the tasks, the teacher controls the discussion process and gives motivation to keep the students doing their tasks. (Base Theories: Joyce & Weil (2011), Kardi (1997), Dirjen PMD PSMA (2013), Alqur'an and Hadist).

4. Supporting System

The supporting system learning model ARCSI using scientific approach which is developed to be model book, teachers' work orientation book and students' work orientation book, learning materials and learning media based on learning model ARCSI using scientific approach.

The teachers' work orientation book is a guidance book in managing the learning process that has been designed in the form of Lesson Plan. While the students work orientation book is the guidance book about the steps on learning process that will be done by the students and consists of the group work sheets of the students and the individual work sheets of the students and learning materials also the learning media that has been compatible with the ARCSI learning media component using scientific approach. (Base Theories: Joyce & Weil (2011), Kardi (1997), Dirjen PMD PSMA (2013), Alqur'an and Hadist).

5. The expected instructional and accompanist impacts

The social and accompanist impacts that are designed in learning model ARSCI using scientific approach are:

a. Instructional impacts: (a) an ability to reconstruct concept and principle, (b) the ability to analyze logically and critically, (c) the ability to collaborate between the students.
b. Accompanist impacts: (a) to find again various concepts, (b) the essence of knowledge, (c) the occupation of sciences process, (d) the autonomy and thinking deliberately, (e) tolerance values, (f) motivation and learning output of math of students are high, (g) knowing and teachers and students (h)the willingness to do, (i) teacher's patience and students' patience. (Base Theories: Joyce & Weil (2011), Kardi (1997), Dirjen PMD PSMA (2013), Alqur'an dan Hadist).

4. CONCLUSION

Based on the discussion above, it can be concluded that the design of ARCIS learning with the Scientific approach can be used as learning that makes it easy for students to understand mathematics, make students challenging, turn on the atmosphere of cooperative learning. In addition, this learning model is designed to shape the character of students in an Islamic way with a fun learning process of mathematics, and train students to think critically and comprehensively through a scientific approach.

The ARCSI learning model is identical to the scientific approach, namely: (1) attracting the attention of students by inviting prayers/requests to Allah Ta'ala, (2) conveying the purpose/benefits of learning and its application in daily activities, (3) group discussion to establishing Ukhuwah Islamiyah in groups, (4) class discussions to establish Ukhuwah Islamiyah classically, (5) giving satisfaction to students by learning will make only because Allah Ta'ala and the traditions of the prophet Muhammad see (6) evaluating the process and results of problem-solving, and (7) close learning by reading Hamdalah and greetings.

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RESEARCH ARTICLE

The Effects of Type Learning Model Numbered Head Together And Think Pair Share

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ABSTRACT

The aim of this research is to know the difference of the average of mathematics learning outcomes between the students Whose learning using cooperative learning model of type Head Head Together (NHT) Whose learning with the students using Think Pair Share (TPS) on the subject matter of the Circle. The population in this research is the eighth class of the second half of SMP N 1 Adiluwih in the academic year 2017-2018. Sampling was taken by cluster random sampling technique. The research instrument used to Obtain the data in the form of the test while for the data analysis is done normality test and homogeneity test. Since the sample comes from a normal and homogeneous distributed the data then it is continued with t-Test. Result of the data analysis can be concluded that there is difference of the mean result of student learning of mathematics using NHT type cooperative learning models with a mean of mathematics learning result of student using TPS learning models and the mean of student learning result by using cooperative learning model of type NHT is greater than the average mathematics learning outcomes of students taught by using the TPS learning models.

1. INTRODUCTION

Mathematics is a science that has a big role in survival. Consciously or unconsciously, almost every time we find mathematics in everyday life, both in concept form, as well as its application. Judging from the overwhelming role of the lead math mathematics is a science that is very important to learn and understand (Amalia, 2018). The development of increasingly advanced education awakens people to the nature and usefulness of mathematics well as science. Whether it's the math that is taught in schools of education or mathematics as an applied science that can be used in everyday life. This is consistent with the statement: "we must realize that mathematics is important, both as a science (scientists), as supervisor patterns of thinking, as well as forming an attitude" (Rachmawati, 2005: 2).

Based on informal interviews with some students of class VIII Public Junior High School (SMPN) 1 Adiluwih that in general, they think "math is hard". The presumption is raised, one of them is because mathematics is seen as a difficult subject to grasp. This is in line with the opinions Cockcroft (Wahyudin, 2009: 20) that "mathematics is a difficult subject to be taught and learned. This causes the students complained of unsatisfactory performance in mathematics, but may excel in other fields". This is reinforced by the results of pre-study that has been done in SMPN 1 Adiluwih. Observations show that mathematics is still regarded as a difficult subject and many students fear that the learning of mathematics. It is shown from the low average value of learning mathematics is still a lot to get a value below a minimum completeness criteria (KKM) of 62.

The average result of learning mathematics class VIII student on the subject of the circle in the second semester of the school year 2016-2017, ie 52. the details can be seen that approximately 31.78% eighth-grade students who have reached KKM, approximately 68.22% while eighth-grade students have not said to have reached KKM. This happens because of the tendency of teachers to deliver such materials in conventional, so it becomes less active students. Students just passively listening to a description of the material presented by the teacher. In addition, the activity in the classroom, teachers often do not provide the opportunity for students to study in groups, whereas in group learning activities can broaden the perspective and to build interpersonal skills to connect with other students.

One of the many learning models provides an opportunity to cooperate with fellow students in tasks are structured cooperative learning. which supposedly can improve the learning process and improve learning outcomes. This is supported by the results of research conducted by Zakaria and Ihsan (2007) concluded that cooperative learning model provides a better learning outcome than for traditional learning model (conventional). In the implementation of cooperative learning, the model requires the participation and cooperation in the learning group (Trisnawati, 2018). Cooperative learning is a learning model by using the grouping system or a small team of between four to six people who have a background in academic ability, gender, race or ethnicity different (heterogeneous) (Vienna Sanjaya, 2010: 220). Meanwhile, according to Isjoni (2010) "cooperative learning model can improve student learning towards better learning."

The main objective in the implementation of cooperative learning model is that the students can study in groups with their friends in a way respectful of opinions and give the opportunity to others to put forward ideas to express their opinions in groups. By implementing cooperative learning model student is possible to achieve success in learning, and also it can train students to have the skills, good thinking skills *(thinking skills)* and social skills *(social skills),* such as the skills to express their opinions, receive advice and input from people another, work together, a sense of solidarity, and reduce the incidence of deviant behavior in the classroom (Afandi, 2018).

This is supported by the results of research conducted by the Woods and Chen (2010) says that "cooperative learning provides an opportunity for students to work in teams, with the instruction of student teachers help other members of the group with the ability heterogen" and the results of research conducted Artut (2009) states that *the use of cooperative learning social skills (active listening, happy talk and everyone participating) should be checked throughout the* intervention. Summing up the cooperative learning using social skills that active listening, happy to talk and everyone participated.

Keep in mind that a lot of cooperative learning model offered. One of them is a model of learning offered cooperative learning model NHT and TPS. NHT learning model is the learning focused on the learning ability of students to construct the meaning of the concepts for themselves (Mursalin et al, 2018). According to Kagen in Ibrahim (2000: 28) to engage students in studying the material covered in the lesson and check their understanding of the lesson content. Also in this study students are directed to solve problems using mathematical concepts relationship. Based on the results of research conducted by Haydon, Mahedy, and Hunter (2010) says that the students with the ability heterogeneous implementation of cooperative learning model NHT can increase the activity that is relevant to learning (on-task) and give a significant impact on improving student achievement, At NHT learning model as well as another learning model that prioritizes learning and cooperation within the group. According to Trianto (2011: 62), is a type of cooperative learning NHT designed to influence the pattern of interaction of students and as an alternative to the traditional classroom structure.

In the process of cooperative learning, NHT students were divided into groups and each member of the group of 3-5 students and each student is given a number of members so that each student in the group has a different number. In a study group of teachers give students' worksheet (LKS) and each member of the group was asked to present the results of the discussion. The students think together to describe and ensure that each student knows the answer. Teachers call one number one student from each group, and then the students presented the results of the discussion. During the direct involvement of student learning so that each student acquire knowledge and learning experiences.

Another cooperative learning model that will be the focus of this study is a learning model Think Pair Share (TPS). According to Anita Lie (2008: 57) states that cooperative learning model TPS is learning that gives students the opportunity to work independently and in collaboration with others. The main characteristic of the type of cooperative learning model TPS is three main steps implemented in the learning process. That step thinks (think individually), pair (paired with a seatmate), and share (share your answers with another couple or the entire class). According to research conducted by Yusrina Pupils Nasution and Edy Surya (2017) "results of the class action, the researcher concluded that the students' learning outcomes by using cooperative learning of Think Pair Share (TPS) were improved. Results were expressed that the TPS teaching models can be developed as an enhancement of student learning.

Based on the results of research conducted by Hasanah Uswatun AK et al. (2016) suggested that the NHT cooperative learning model provides better learning outcomes of the learning model TPS. The same thing was also stated by the results of research conducted by Flora Astyna Puri Tarin et al (2017) stated that Differences in visual thinking development of larger students occurred in the models of learning Head Number Together (NHT) than on the models of learning Think Pair Share (TPS).

Both are suspected of cooperative learning model can improve students' mathematics learning outcomes is low. But between the learning model would provide different results if implemented to the students on the same material and the class that has the same characteristics. Therefore, this study aimed to determine (1) whether there are differences in the results of students' mathematics learning that is subject to cooperative learning model NHT and cooperative learning TPS models on the subject of circles, (2) whether the cooperative learning NHT learning outcomes models are better compared to TPS type learning models on the subject of the circle.

2. METHODS

This research is a comparative quantitative research. The study variables are independent variables and the dependent variable. The independent variables cooperative learning NHT and learning model TPS while the dependent model is the result of learning mathematics students on the subject of the circle. Adiluwih Academic Year 2016/2017, all of the students of class VIII Middle School 1, amounting to 268 students with the techniques of sampling using cluster random sampling and elected VIII. G class as a class experiment that subject and classroom learning the NHT VIII.C model as the control class that is subject to the learning of TPS models. The data collection test after students acquired learning with cooperative learning NHT and TPS models. The test is given in the form of essays, amount to 4 items. Based on the data obtained after the test, it will be analyzed using a t-test to test the prerequisite test of normality and homogeneity.

3. RESULTS AND DISCUSSION

The results showed the average results of students who study mathematics learning through cooperative learning model NHT at 69.75, while the average results of students who study mathematics learning through learning model TPS amounted to 60.71 so that the average difference between the two is 9.04. It can be concluded that the average results of students who study mathematics learning through cooperative learning model NHT higher than the average yield of the mathematics that gets learning through conventional learning models.

From the analysis of the experimental class normality obtained χ^2_{count} = 1.8364 and χ^2_{table} with a significance level of 5% = 11.070. Of test criteria $\chi^2_{count} < \chi^2_{table}$ then accept H_0 and reject H_1 which indicates that the data on the experimental class in normal distribution. Similarly, the data on the control class, from calculations obtained $\chi^2_{arithmetic}$ = 1.1296and χ^2_{table} with 5% significance level so that χ= $11.070^2_{count} < \chi^2_{tables}$ causing thank H_0 and reject H_1, which indicates that the data on a normal distribution control class. This resulted in the data on the control class derived from the normal distribution. Then based on the analysis of variance equality test two can be seen that the 5% significance level obtained F_{count} = 1.3515 and $F_{table\ (0,025)\ (27.27)}$ = 1.78. Based on test criteria turned out to $F_{the\ hit}$ <

$F_{(1/2\alpha)\ (n1-1,\ n2-1)}$ accept Ho and Hi is rejected, meaning that the second variance is equal or homogeneous samples.

The prerequisite test is obtained throughout the normal and homogeneous distribution data. This means hypothesis testing can proceed, namely by using t-test. From the analysis of test two parties at the 5% significance level showed that t = 4.22 and t_{table} = 2.0063, based on test criteria turned out $t > t_{table}$ then reject H_0 and accept H_1 which means there is a price difference mean mathematics student learning outcomes gained through the implementation of cooperative learning model *NHT* with average math student learning outcomes acquired through conventional learning model. Then of t-test data analysis of the parties with a significant level of 5% obtained that t = 4, 22 and t_{table} = 1.6749. Based on test criteria turned out $t > t_{table}$ then reject H_0 and accept H_1 which means the average results of students 'mathematics learning gained through the implementation of cooperative learning model *NHT* higher than the average results of students' mathematics learning acquired through learning model TPS.

This means that mathematics learning using cooperative learning in the NHT model is better than the TPS model learning on the subject set. This is because the TPS learning model that has been used by students in pairs only with sitting friends. Information is less than the current maximum thinking stage. The main characteristic of cooperative learning is the Think Pair Share model which is the three main steps implemented in the learning process. The step is to think (think individually), partner (paired with a sitting friend), and share (share your answer with another partner or the whole class).

Think (think individually), on stage think, the teacher asked a question or problem that is associated with learning and students are asked to think independently about the question or problem posed. At this stage, students should write their answers, it is because the teacher can not monitor all the answers the students so that through the notes the teacher can know the answer to that must be repaired or straightened end of learning. In determining the time limit for this stage, teachers should consider the students the basic knowledge to answer the questions, the type and form of the questions, as well as learning schedule for each meeting.

Pair (paired with a seatmate), the second step is the teacher asked the students to pair up and discuss what has been thought. Interaction during this period can produce answers together. Allow teachers usually no more than 4 or 5 minutes for pairs. Each pair of students were in discussions about the results of their answers in advance so that the final result obtained for the better because students receive additional information and solving other problems.

Share (share your answers with another couple or the entire class) at the end of this step the teacher asks the pairs to share their ideas with another couple or with the whole class. At this step would be effective if the teacher around the classroom from one partner to the other partner, so that a quarter or half of the pairs have the opportunity to report. This step is a refinement of the previous steps, in the sense that this step helps that all groups become more understanding about troubleshooting explanation given by other groups. It is also so that students truly understand when the teacher gives a correction or reinforcement at the end of learning.

4. CONCLUSION

Based on the results of data analysis and hypothesis testing in this study, it can be concluded that there is a difference in the average results of mathematics learning among students whose learning using cooperative learning NHT models with the average results of students' mathematics learning that learning using TPS learning model the NHT model using TPS learning models using TPS learning models using TPS learning models on the subject of the circle.

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RESEARCH ARTICLE

The Effect of Discovery Learning Model Using Sunflowers in Circles on Mathematics Learning Outcomes

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ABSTRACT

This study aims to describe the effect of discovery learning model using sunflowers in circles on mathematics learning outcomes of grade VIII Junior High School Number (SMPN) 1 Pagaralam. The methods used in this study is descriptive method quantitative pretest-posttest design with control group design. The population in this study is the entire class VIII students of Junior High School Number (SMPN) 1 Pagaralam that amounted to 270 students with samples at 60 students. Data collection was taken by way of documentation and test be reserved in the form of the essay. The test was analyzed by documentation photograph and statistician with compare data result class experiment and class control, with the significance level of 5%. The result found in the discovery learning approach using sunflowers give good effect the result of learning, this is average experiment class is better than with control class.

1. INTRODUCTION

The learning process in general is an activity that resulted in changes in behavior, then understanding of learning is an activity undertaken by the teacher in such a way so that student behavior changes to a better direction. To improve student learning outcomes required an educational tool or learning media. Application of learning model should be able to train ways to obtain new information, selecting so that there is an answer to a problem. Student learning outcomes can be improved if students' learning interest in the subject also increases (Setiawaty, 2018).

The circle is a collection of dots that form a closed arch where the points on the arch are equidistant to a particular point in the arch (Blackwell et al, 2001; Coombe, 2002; Nicol, 2002). The particular point in the arch is called the center of the circle and that distance is called the radius of the circle (Metha, 2014, p.20).

In everyday life, of course, there are many circles that we can find, ranging from trivial objects like donuts, where the CD player even to more complicated objects such as rolling coaster games. Therefore, the circle has many uses for example in measuring the diameter and area of the circle. Through these examples, we can understand that it is very important to know the principles of the circle. Starting from simple things like the circumference of the circle (πd) and the circle area formula (πr^2 to other more complex circle principles that will be studied at higher levels (Herbst, 2006).

Designing learning activities in the classroom to find the formula of the area circle, the teacher must have a guess or hypothesis and be able to consider students' reactions to each stage of the learning path towards the learning objectives being carried out (Mursalin et al, 2018). Teachers can select appropriate learning activities as a basis to stimulate students to think and act when constructing mathematical concepts.

There are still many students who have difficulty understanding the circumference and the formula of the circle area. If the student is asked how the circumference of the circles or circle area which radius or diameter are known, the student does not answer immediately. Some say forget the formula and something is wrong in using the formula. Moreover, if asked why the formula of the circumference of the circle and the formula of the circle area is $2\pi r$ (or πd) or πr^2 or (1/4 πd), the student can not give the answer at all. Students' difficulties in understanding the material are thought to be the way teachers teach. The teacher is only fixated on the lecture method by writing formulas, giving examples of problems and assigning tasks. Students simply accept and memorize the circumference formula and the area of the circle. As a result, the knowledge obtained by students only temporarily survives because the knowledge is not constructed by the students themselves (Abdussakir & Achaiyah, 2009, p.6).

Many factors affect the success of students and things that often hinder the achievement of learning goals (Afandi, 2018; Herbst, 2003). Because basically, every child is not the same way of learning, so too in understanding abstract concepts. Student activity in the learning process in the classroom is still very less (Hidayati, 2017; Fonna, 2018a; Mursalin, 2014). In the curriculum of 2013 mathematics learning should be started with the introduction of the problem according to the situation (contextual problem). By posing contextual problems, learners are gradually guided to master mathematical concepts. One approach related to the real world is the use of context. Context is a specific situation or an environment involving students. The context used should not be a real-world problem but can be in the form of games, use of props, or other situations as long as it is meaningful and imaginable in the minds of students.

Previous research (Rahayu, 2017, p.47) using the context of hurdle jumps can help students in learning especially in the field of mathematics studies. Sunflower is a flower that we often encounter in Indonesia, but the sunflower originally came from North America that is Mexico (Katja, 2012, p.234), because the flower is growing in a tropical climate it is not difficult to plant in Indonesia. This flower is also a lot of benefits for research as a source of food, medicines, and cosmetics (Suprapto & Supanjani, 2009, p.89), these flowers are circular and have different diameters, this is intended as a context and props in learning, in this case, one of the learning methods is expected to provide help in solving problems in an effort to improve student learning outcomes. A visual aid is something that can be a means of connecting to achieve the learning message. The props work to help and model something in the learning process (Arsyad, 2014; Amalia, 2018).

One of the learning models that provide opportunities for students to develop and find their own understanding, the information presented is easily absorbed, processed and stored well by the student memory system as well as provide opportunities for students to play the more active role in the classroom is a model discovery learning (Fonna, 2018b: Alfieri et al, 2011).

Discovery learning is a method of learning that emphasizes more on the discovery of previously unknown concept or principle (Rizta, 2016, p.15). Meanwhile, according to (Suprianto, 2014, p.19) Discovery Learning method is a teaching method that regulates teaching in such a way that children acquire knowledge that they have not previously known without direct notification, partially or wholly found alone. Discovery occurs when individuals are involved, especially in the use of their mental processes to discover some concepts and principles. Discovery is done through observation, classification, measurement, prediction, and determination. The point is that this learning emphasizes for students to be more active so that students can find themselves indirectly in the learning process activities (Lefrancois, 2000, p.209.

The discovery learning strategy in explaining broad circle material is best carried out in small study groups. But many are also carried out in larger study groups. While not all students may be involved in the discovery process, the discovery approach can benefit learners. This approach can be implemented in the form of one-way communication or two-way communication. Therefore, in this study using sunflower props to build motivation and attract the attention of students in learning a circle that can be searched through the context of sunflower so that affect student learning outcomes at the end of learning.

Based on the some of the description above, it is necessary to conduct study using discovery learning model using sunflower on the circles material at the Junior High School Number (SMPN) 1 Pagaralam to see the effect on learning outcomes.

2. METHODS

The type of this research is an experimental research method. The research design that will be used in this research is pretest-posttest control group design. In this design, there are two classes each chosen randomly (R). Then given a pretest to know the initial state is there a difference between the experimental group and the control group. A good pretest result when the experimental group score is not significantly different from the control group. In the data collection, the research conducted experimental research by teaching in the classes that become the sample that is the experimental class and the control class.This research was conducted from March 5 to May 10, 2017, at SMPN 1 Pagaralam academic year 2016/2017.

The population of this study is all students of class VIII, while the sample of this study is the class VIII.C as an experimental class of 32 students but there are 2 students who are absent so that only 30 students, then class VIII.E serve as control class 31 students and 1 student who was absent during the research process was implemented so that only 30 students. Here is a pretest-posttest control group design research table.

Table 1. Research design of pretest-posttest control group design

E	O_C	X	O_C
K	O_E		O_E

From the above design the researcher develops into a research model which can be seen in the following figure.

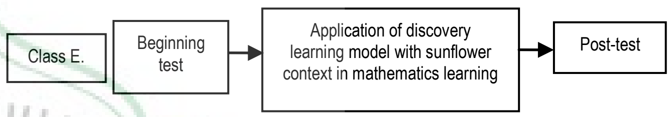

Figure 1. Design of Discovery Learning Models Using the Sunflowers

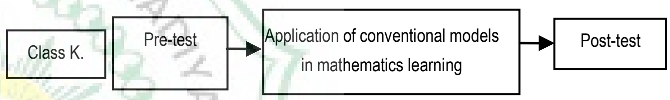

Figure 2. Design of Conventional Models in Mathematics Learning

Independent variable (Independent Variable) Discovery Learning Learning Model with sunflower context. Dependent Variable (Dependent Variable) is the result of learning mathematics class VIII SMP Negeri 1 Pagaralam academic year 2016/2017. The techniques used to collect data are the Test Instruments given before (Pretest) and after (Posttest) the learning process in the experimental class and the control class.

The instrument used to measure student's ability data is by giving the question of instrument test which amounts to 10 questions in essay form. Furthermore, the test instrument of first learning outcomes in validation, in the reliability test, calculate the level of difficulty and distinguishing power of the problem assisted by statistical program SPSS 22.

To collect data required in this study conducted direct application of the model of discovery learning with the sunflower context on the influence of learning outcomes students in the classroom. So that can be seen the influence of learning through the learning model.

The technique used to collect data in this research that is documentation and test. Then before the hypothesis tested first in the test of data normality and homogeneity. Furthermore, the test data is analyzed, to test the hypothesis of the researcher using t-test statistic with a significant level of 5% with the formula:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{s\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}} \text{, and } s^2 = \frac{(n_1-1)s_1{}^2+(n_2-1)s_2{}^2}{n_1+n_2-1}$$

(Sudjana, 2005, p.241)

3. RESULTS AND DISCUSSION

Based on the validation of the items from the 10 questions tested try everything valid or meet the criteria.

Table 2. Results of Problem Reality Questions

Cronbach's Alpha	N of Item
0,736	10

If the result $r_{xy} = 0{,}736$ consulted with the value of table t product moment with dk = n−1 = 30−1 = 29 significant 5% then obtained t_{tabel}= 0,367. Because $r_{xy} = 0{,}736 > t_{tabel}$ = 0,367 then all data analyzed using SPSS system is reliable.

Based on the results of testing the level of difficulty and distinguishing power of the item obtained results, all questions meet the criteria that have been adjusted with the validation results. The calculation of the level of difficulty criteria obtained 9 items of medium matter and 1 item is easy. And for the power dissection obtained criteria 2 items of good question, 7 items enough and 1 item about ugly.

Table 3. Normality Test Results Before and After Treatment Tabel

Class	Before	After
Exsperiment	6,92	6,818
Control	3,041	2,204

From the calculation result χ^2_{count} = 6,962 with n = 30 and dk = 6 - 3 =3 and α = 5% obtained χ^2_{table} = 7,81. Because $\chi^2_{count} < \chi^2_{table}$ or 6,962 < 7,81 then the test value data of the experimental class students is normally distributed. From the calculation result χ^2_{count} = 3,041 with n = 30 and dk = 6 - 3 = 3 and α = 5% obtained χ^2_{table} = 7,81. Because $\chi^2_{count} < \chi^2_{table}$ or 3,041 < 7,81 the test grade data of the control class students is normally distributed.

Table 4. Homogeneity Test

Description	Before	After
F_{count}	1,012	1,242

In table 4 at the time before the treatment of the distribution of F with $dk_1 = 29$ and $dk_2 = 29$ with a significant level of 5 % is $F_{29:29} = 1{,}861$. So from the calculation above, it can be concluded that $F_{count} < F_{table}$ or $1{,}012$ < 1,861 so it has a homogeneous variance. After the treatment $F_{count} < F_{table}$ atau 1,242 < 1,861. so it has a homogeneous variance as well.

Table 5. Results of Post-test Students

Description	Score	
	Discovery Learning	Convensional
Average	85	78,63
Deviation Standard	6,48	5,82
Maximum Score	100	92
Minimum score	67	71
Theorytic Maximum Score	100	100
Theorytic Minimum Score	0	0

After the average and standard deviations from the test results of the students of the experimental class and control class are obtained, then the hypothesis test is performed. A list of average and standard deviations of the experiment class and control class can be seen below:

Table 6. Average and Standard deviations

Experiment Class	Control Class
n = 30	n = 30
$\bar{x}$ = 85	$\bar{x}$ = 78,63
$s_1 =$ 6,48	s_2 =5,82

This study was conducted using two cycles. Application of learning discovery learning with the sunflower context to improve student learning outcomes of the wide circle in the class VIII SMP Negeri 1 Pagaralam run well, students are motivated and interested in following the lesson so that the student activity is quite conducive in the classroom. In learning the students learn in the form of groups, researchers divide the students into 5 groups. Each group consists of 6 students. The researcher then gives the LAS and asks the students to discuss and work together with their group members to solve the problems in the LAS. The next activity is a presentation that can train students to dare to appear in front of their friends in presenting the results of the discussion.

In the first learning, there are still some obstacles, this is because students are not familiar with the method of learning discovery learning with the sunflower context. Obstacles experienced by researchers when doing research are still many students who have difficulty and error when solving a wide circle problem, such as (1) At the beginning of learning is a bit crowded in finding the group, some even less agree with its members due to less familiar; (2) student activity in innovation, presentation and inquiring still low; (3) some students are less careful in answering the problem so that many errors occur; and (4) the teacher invites the students to present the results of their discussion but many of them are shy and afraid, this may be due to their habit of passive previous activities in learning.

Based on the results of the analysis of the test data above, obtained the result of the average grade of experimental $\bar{x}$=85 with the category of excellent learning results that use the learning model of Discovery Learning with the sunflower context. While the control class using the conventional method obtained an average value of $\bar{x}$=78,63 with good learning category. After viewed from the test results and got the average value then drawn experimental class that uses the learning model of discovery learning with sunflower context average value is greater than the average value of the control class.

Table 7. Summary of Hypothesis Test Results

Description	T_{count}	T_{table}
Hypotesis	2,894	1,462

Based on the calculation results are obtained $t = 2{,}894$ and $t_{table} = 1{,}462$ $(t_{count} > t_{table})$. So that the result of learning mathematics in the circle area using discovery learning model with sunflower context in class VIII SMP Negeri 1 Pagaralam have influenced or better than conventional learning model.

4. CONCLUSION

Based on the results of this study, it can be concluded that in general students who follow the learning using the model of Discovery Learning with the sunflower context showed better results in learning mathematics when compared with students who learning conventionally. This is possible because learning using the Discovery Learning model with the sunflower context provides flexibility for students to find and express answers with the use of various open issues, because in solving the problem students are required to be more active in understanding, reviewing and transferring knowledge gained. The researcher also found that students are more active with learning discovery learning and coupled with the props that they did not expect that will learn the circle using sunflowers.

The results of this study also aligned with the research by Siregar & Marsigit (2015, p.6) and Hidayati (2016, p.85) study they found that discovery learning is effective against achievement and motivating students. The use of Discovery Learning model with the context of sunflower run well and contribute positively to the students 'learning outcomes in class VIII SMP Negeri 1 Pagaralam, which is seen from the analysis of test results obtained students' mathematics results in the experimental class is better than the control class.

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RESEARCH ARTICLE

The Use of Undo Process in Improving Self-Efficacy

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ABSTRACT

The aims of this research are to know the use of the undo process method in the completion of the inverse function. This type of research is a quasi-experiment. The group used in this study consisted of two groups. One group as a control group uses conventional learning methods that use the conventional inverse method of solving conventional function, and one group as an experimental group which in learning use undo process method in solving inverse function. This research was conducted at SMA Negeri 1 Buntu Pane, Asahan Regency, North Sumatra province, Indonesia. The population of this study is the students of class XI IA in the academic year 2016/2017 even semester. The sample was obtained by using cluster random sampling method. The study sample is two classes of 5 existing classes. Implementation of this research by using the undo process method to student ability to solve the problem given. The technique of collecting data using test and questionnaire given to student which become sample. Research data show that by applying this method of learning can improve self-efficacy in the following material about inverse function.

1. INTRODUCTION

Mathematics is a universal science underlying the development of modern technology, has an important role in various disciplines and develop the human mind power (Thahir, 2018; Fonna, 2018b; Mursalin et al, 2018). This is the basis so that mathematics is regarded as a science queen. In addition, rapid development in information technology and communications today is based on the development of mathematics in the field of number theory, algebra, analysis, discretionary theories of opportunity and mathematics (Trisnawati, 2018; Winarso, 2018). To master and create technology in the future requires a strong mastery of mathematics from an early age.

Mathematics courses need to be provided to all students from elementary school to equipping students with logical, analytical, systematic, critical, creative thinking skills, and the ability to work together (Masitoh, 2018; Mursalin, 2014). These competencies are needed so that students can have the ability to acquire, manage, and utilize information to survive in an ever-changing, uncertain, and competitive state. Thus mathematics will greatly assist students in tackling the problem of his life.

To achieve this goal, in high school Mathematics has several aspects, namely: logic, algebra, geometry, trigonometry, calculus, statistics and opportunities (Fonna, 2018a; Setiawaty et al, 2018). Calculus as one of the aspect of Mathematics has an important role in the success of learning Mathematics itself. One element of calculus is the inverse function. You (2018) in general the student is said to be familiar with the inverse function if he can explain the meaning of the inverse of a function, explain the meaning and importance of studying the inverse function, knowing the consequences if not understanding the inverse of a function, explaining why the inverse function is created.

But the fact is that at this time the subject of Mathematics is still a scourge for the students, as well as in SMA Negeri 1 Buntu Pane. There are still many students who think that math is a subject that is scary and hard to understand. Feelings of fear will lead the students to regard mathematics as an unpleasant and annoying lesson, especially if it can not be done in math problems. Most students immediately give up if facing math problems that are considered difficult and can not, but from the difficult problems that they will be able to know and understand.

The mathematics that seems uninteresting, can be made possible the use of inappropriate learning methods (Afandi, 2018; Nasir, 2018). So as a teacher must be able to use a variety of appropriate learning methods in each material submitted. Not possible in some delivery of material using several variations of the method, this is so that the understanding of the material more acceptable to students and most importantly students are happy with mathematics itself so it does not seem monotonous in learning mathematics. Students who love mathematics will have a positive impact on learning outcomes (Margolis, 2006). Learning outcomes are influenced by several factors, including internal factors and external factors (Amalia et al, 2018; Mursalin,2016). The internal factors, among others, include intelligence, interest, motivation and cognitive abilities. While external factors include learning methods/learning models used by teachers in teaching, curriculum, facilities, and environment (Margolis, 2006; Graham et al, 2005).

In general, the learning process is still using conventional methods as well as on the process of learning the inverse function (Kendal, 1999; Hohenwarter, 2008).Conventional learning methods applied to the inverse function cause still dominant teachers in the learning process and the lack of creativity of students in providing an alternative answer to a question (Ball, 2000). In general, teachers in providing materials to students more to provide examples of questions and provide answers to the problem. This causes the students will not feel challenged to find yourself let alone another alternative to answering the issue. It is this habit that will unwittingly lead to misconceptions about the matter, especially about the inverse function. González (2018) Even though instructors' teaching styles in higher education are an issue of major importance because these interactions affect students' self-perceptions, involvement, and achievement.

Responding to that the researcher tried to study an alternative learning that is expected to be one option in overcoming the problem of learning the inverse function by using the undo process.

Undo process is defined as a process of retreat from an event (Wood, 2008). This description of the undo process is easier to see in everyday life. Various events can be ensured there are flashbacks. For example, Bob walks 4 steps forward, then 4 steps back. The final result of the trip, Budi back to its original position. In the computer there is the term "undo typing" used when wanting to go back to before. So, an undo process is an attempt to get back to the original with regard to the sequence of events.

The function is a sequence of events a composition of various events, of course with the help of operations. The undo process of a function is called the inverse of the function (Tay et al, 2012). Suppose a function contains a forward sequence, then the inverse of the function is the reverse order. In the formal teaching of function, the sequencing process of the function is not known so that the term "undoing" of the function is also unknown (Beckmann, 2004). As a result, students will be foreign when undoing is used to determine the inverse of a function (Fulton, 2012).

Providing an understanding of the inverse function to the student is an absolute thing to do. Learning with an undo process should begin by providing a basic understanding to students about the inverse in general. Using Algorithms, in mathematics and computation, algorithms are a collection of commands to solve a problem. These commands can be translated gradually from beginning to end. The algorithm will always be over for some problems that meet the criteria. The criteria of an algorithm are as follows: (a) there are input and output; (b) effectiveness and efficiency; (c) structured (Usher, 2009).

Algorithms for a particular problem often have repetitive steps or require decisions until the task is completed. Broadly speaking, the algorithm is a sequence of steps to solve a problem systematically. In determining the inverse function there are several things to be considered in using the algorithm, in the reduction is the inverse for the addition operation, and the division is the inverse for the multiplication operation (Tay et al, 2012).

2. METHODS

This type of research is a quasi-experiment. The group used in this study consisted of two groups. One group as a control group uses conventional learning methods that use the conventional inverse method of solving conventional function, and one group as an experimental group which in learning use undo process method in solving inverse function.

This research was conducted at SMA Negeri 1 Buntu Pane, Asahan Regency, North Sumatra province, Indonesia. The population of this study is the students of class XI IA in the academic year 2016/2017 even semester. The population of this study consists of 160 students divided into five classes. The sample of this research is obtained by using cluster random sampling technique. The study sample consisted of two classes, one class for the experimental group and one class for the control group.

This research data is quantitative data in the form of student self-efficacy data on mathematics only. Research data in the form of questions and answers results at the beginning of learning and at the end of learning related to student self- efficacy on learning in discrete mathematics lessons.

Quantitative techniques are used in data analysis. To determine the different teaching methods from the self-efficacy test t independent score is used. To find out the relationship between applying the competition in learning by rewarding and ranking and using conventional learning methods, Pear-son product-moment correlation is applied to the data.

3. RESULTS AND DISCUSSION

To improve student self-efficacy especially in the eyes of inverse function material, the researcher changed the conventional method commonly used by the teacher into a method using the undo process in the completion of the inverse function.

Before the treatment is given, the two sample classes are pre-tested first. The pre-test relates to the student's self-efficacy from both sample classes regarding the function of the composition and the inverse function. The composition function is used as a benchmark because the material is an apperception of the material of the inverse function. While the question of the inverse function should be based on the cloud knowledge of all sample students in this study. The mean and standard deviation values of the self-efficacy pre-test in the experimental class and control class for the survey items appear are shown in table 1 and table 2.

The data in table 1 and table 2 it was found that before treatment there was no significant difference from the two sample groups. Both groups of samples had statistically different values for mathematics lecturers' efficacy in teaching, make to motivate and take on responsibility, and effective teaching. For the purpose of determining whether the method of learning with respect and self-efficacy beliefs on the teaching of mathematics on discrete mathematics shows significant differences according to sample groups, independent t-test was applied to the data with a significance level of 0.05 As seen from table 5 independent t-test results show that there is no significant statistical difference between averages ($t(144)=0.900$, $p<0.05$).

After reporting different treatment in both groups, in table 3 and table 4 it was found that there was a difference of self- efficacy from both groups of samples. in the experimental group that reported treatment by providing an undo process method on the learning of inverse function has a higher value than the control group treated by conventional methods.

Table 1. Descriptive statistics of dimension of before learning model at experiment class

Item	N	Lowest Score	Highest Score	Mean	SD
Mathematics teachers' efficacy in teaching	32	4	13	11.53	2.45
Make to Motivate and Take on Responsibility	32	8	16	14.75	2.26
Effective Teaching	32	7	11	9.31	2.48

Table 2. Descriptive statistics of dimension of before learning model at control class

Item	N	Lowest Score	Highest Score	Mean	SD
Mathematics teachers' efficacy in teaching	32	4	12	11.50	2.38
Make to Motivate and Take on Responsibility	32	7	15	13.95	2.20
Effective Teaching	32	7	8	7.55	2.50

Table 3. Descriptive statistics of dimension of after learning model at experiment class

Item	N	Lowest Score	Highest Score	Mean	SD
Mathematics teachers' efficacy in teaching	32	12	28	24.83	1.13
Make to Motivate and Take on Responsibility	32	15	25	25.12	1.46
Effective Teaching	32	15	27	22.56	1.55

Table 4. Descriptive statistics of dimension of after learning model at control class

Item	N	Lowest Score	Highest Score	Mean	SD
Mathematics teachers' efficacy in teaching	32	10	28	20.56	2.22
Make to Motivate and Take on Responsibility	32	12	23	19.98	2.10
Effective Teaching	32	11	25	20.74	2.38

For the purpose of determining whether the experimental group that reported the treatment by providing an undo process method in the inverse function settlement had a higher value than the control group treated by conventional methods, independent t-test was applied to data with a 0.05 level of significance.

After reporting different treatment in both groups, in table 3 and table 4 it was found that there was a difference of self-efficacy from both groups of samples. in the experimental group that reported treatment by providing an undo process method on the learning of inverse function has a higher value than the control group treated by conventional methods.

For the purpose of determining whether the experimental group that reported the treatment by providing an undo process method in the inverse function settlement had a higher value than the control group treated by conventional methods, independent t-test was applied to data with a 0.05 level of significance

As seen from table 6, independent t-test results show that there is significant statistical difference between averages ($t_{(62)} = 0.451$, $p > 0.05$)

Table 5. T-test by sample groups of before learning model

Group	N	df	t	p
Experiment Class	32	62	0.900	0.370
Control Class	32			

Table 6. T-test by sample groups of after learning model

Group	N	df	t	p
Experiment Class	32	62	0.416	0.580
Control Class	32			

The relationship between mathematics teaching the method of learning with respect and self-efficacy score and the teaching of mathematics on discrete mathematics score was investigated by using the Pearson product-moment correlation coefficient. preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity, and homoscedasticity. there was a positive effect associated with high levels of mathematics self-efficacy.

At the beginning of learning many students are pessimistic able to solve problems related to inverse function. This is due to many students from the sample class who find it difficult in completing the composition function. Many students consider the next lesson less difficult.

As students in the experimental class introduced the undo process method in solving the inverse function, many students were happy and easily solved the problem. Students feel confident in working on the inverse function assigned to them. This is certainly data increase student persistence in learning. You (2018) persistence is an important indicator of academic success in higher education.

This condition is different from the students who are in the control class. Student perceptions of the difficulty of completing the composition function are affected by student self-efficacy while working on the inverse function. This is due to the conventional methods teachers used when learning inverse function does not help students' self-confidence and student motivation in working on inverse functions.

4. CONCLUSION

The use of process process in the inverse function is correct in learning because it can improve student self-efficacy. This is due to the process of canceling the process of making the students easier. By improving self-efficacy students can improve student learning outcomes.

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RESEARCH ARTICLE

Guided Discovery Worksheet for Increasing Mathematical Creative Thinking and Self-Efficacy

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ABSTRACT

This research development aimed to develop of worksheet based on guided discovery for increasing mathematical creative thinking and student's self-efficacy. Development stage in this study is a preliminary study, planning, development of worksheet, worksheet validation, and field testing. The subject of this research is the students of class 10A[3] and 10A[5] MAN 1 Central Lampung in the Academic of 2017/2018. The data of this research were obtained by observation, interview, mathematicalcreative thinking ability test and self-efficacy scale. The result of the validity by subject matter expert and media expert showed that the worksheet is considered excellent. The Initial field testing results indicate that worksheet is included in either category. The field testing results showed that (1) the student's mathematical creative thinking aspect was effective because seen from the N-Gain of 0,54 which included in the category of moderate improvement and (2) the student's self-efficacy was effective because seen from the N-Gain of 0,36 which included in the category of moderate improvement. It can be concluded that worksheet based on guided discovery effective way to improve the mathematical creative thinking ability and student's self-efficacy.

1. INTRODUCTION

The curriculum of primary and secondary education that is used today is the 2013 curriculum. 2013 Curriculum is a curriculum applied to replace the 2006 curriculum or Education Unit Level Curriculum. The 2013 curriculum began to be piloted in 2013 by turning some schools into stub schools. Currently, almost all levels of education from basic to upper secondary by using the 2013 Curriculum.

In the 2013 Curriculum, there are changes, including in the aspects of assessment and learning materials. In the learning material, there is a streamlined material and material added. Suppose that at the senior high school level, there are compulsory subjects and specializations. From class X students have taken majors according to their interests and talents consisting of IPA, IPS, Language, and Religion (especially for Madrasah Aliyah). All majors receive mandatory compulsory mathematics, while science majors get additional lessons as lessons of interest such as specialist mathematics.

Mathematics is an important lesson because it is universal (Mursalin, 2016; Amalia, 2018; Setiawaty, 2018). Mathematics also has a role to increase the quality of students to act logically, rationally, critically, and creatively (Fonna, 2018; Mursalin, 2014). Thus, mathematics cannot be separated from the ability to think. One of the ability to think in learning mathematics is the creative thinking ability. Some scholars say that creative thinking in mathematics is a combination of logical and divergent thinking based on intuition but in consciousness that takes into account flexibility, eloquence and novelty (Noer, 2011; Afandi, 2018; Winarso, 2018), further the ability to think creatively in mathematics is called the mathematical creative thinking ability.

The mathematical creative thinking ability is one of ability to discover new ideas and solve math problems creatively (Mursalin et al, 2018; Gonzalez, 2017). According to Purwaningrum (2016) indicates the creative thinking ability is the ability to find many possible answers to a problem. In addition to the creative thinking ability, it is also necessary independence in problems solving. The independence of this learning will lead to confidence in students. This was supported by Liu and Koirala (2009:1) who stated that mathematical achievement and self-confidence had a positive relationship.Confidence in problems solving presented hereinafter called self-efficacy.

According to Ormrod (2008: 20), self-efficacy is the assessment of a person about his own ability to run certain behaviors or achieve certain goals. More simply according to Somakim (2010: 49) self-efficacy is synonymous with "Self-Confidence". Based on the opinion of the expert's self-efficacy is one of confidence in his ability to do something for a purpose. Self-efficacy refers to the perception of an individual's ability to organize and implement actions to display specific skills (Turgut, 2013; Graham; 2005; Margolis, 2006).

Some research conducted by Kisti, H.H and Fardana, N.A (2012) states that the development of self-efficacy is important to support student's mathematics learning achievement because self-efficacy can support students' creativity ability. A student who has a high self-efficacy will be high also creativity. Achievement of mathematics learning in Indonesia is under other countries. This is supported by survey results from Trends International Mathematics and Science Study (TIMSS) 2015 (Rahmawati, 2016; Nasir, 2018) which states that the achievement of science and math of elementary school students in 48 and 50 countries that follow the study. The achievement of the science of Indonesian students' grade 4 is ranked 45th out of 48 countries, while mathematics is ranked 45th out of 50 participating countries. In general Indonesian students are weak in all aspects of content and cognition, both for math and science.

Alleged cause of the low ability of students' mathematical creative thinking is teacher-centered learning (Evers et al, 2002). This model causes students do not develop their mindset. The teacher explains the subject matter and gives an example of the problem, then gives the exercise a matter of which the process of completion is similar to the example. So that the ability and potential of students less well explored in particular the mathematical creative thinking ability and student's self-efficacy. To overcome these problems, one effort to improve the mathematical creative thinking ability and self-efficacy through learning that involves learners directly, so that learners will be more leverage in interpreting a knowledge gained (Masitoh, 2018; Akay, 2010). This is in line with the learning process in the curriculum of 2013 that is student-centered. Student-centered learning one can use guided discovery learning models (Katuuk, 2014;Faisal, 2015; Uce, 2016; Hakim, 2017)

Guided discovery model is a teaching method that regulates teaching so that learners acquire knowledge that has not been known, in part or entirely found itself with teacher guidance. To facilitate the learning process using guided discovery learning model, a tool such as the Student Activity Sheet (worksheet). The worksheet is a student activity sheet that can be done independently as well as a group that contains guides for learning activities. This worksheet aims to maximize the students' comprehension capabilities in accordance with indicators in learning. One of the mathematics materials that match the guided discovery learning model and the mathematical creative thinking ability and self-efficacy is the Three-Variable Linear Equation System (TVLES), because this material is creatively and confidently found in the concept by the learners with the teacher's guidance. Thus, in order to construct a solid mathematical understanding, it is necessary to develop a worksheet.

The purpose of this research is to produce a worksheet product based on guided discovery to improve the mathematical creative thinking ability and student's self-efficacy, to find out how the effectiveness of learning using the worksheet in improving the student's mathematical creative thinking ability, to know how the effectiveness of learning using the worksheet in improving the student's self-efficacy.

2. METHODS

This type of research is Research and Development (R & D). The developed product is based Guided Student Worksheets to improve the mathematical creative thinking ability and student's self-efficacy.

Borg & Gall (1989) states that there are 10 steps for implementing research and development strategies: (1) Research and information collecting, (2) Planning, (3) Design/preliminary form of product, Preliminary field testing, (5) revision of Main product revision, (6) Main Field Testing, (8) Operational product revision test, (9) Final product revision, (10) Dissemination and implementation.

This worksheet development research is limited, meaning that the R & D stage in this research is its implementation only until step seven. This is due to limited time, energy and cost. The explanation of the research development steps is explained as follows:

1. Introduction Study Stage
   At this stage, a preliminary study is analyzed needs either by observation, interview or questionnaire.
2. Product Design
   The design stage of the product and the instrument is to make the design of the worksheet to be developed and the instruments to be used as an assessment
3. Expert and Revision Validation
   The initial product generated is a mathematical worksheet that is tested by an expert through an expert validation questionnaire. Expert tests conducted are media expert test and expert material test
4. Initial Field Test and Revision
   Initial products that have been tested are tested by the initial field test. Individual test by testing the draft on a class that has not received TVLES material in order to know the legibility and attractiveness of the worksheet
5. Field Test
   The draft that has been tested in the initial group test, it is tested to a larger group. In the field test stage uses pretest-posttest control group design.

Instruments used in this study consisted of two types of instruments, namely nontest and tests. The instruments are described as follows:

The non-test instrument, this non-test instrument consists of several forms that are tailored to the steps in development research. There are two types of non-test instruments used, namely interviews and questionnaires. Interviews were used during the preliminary study in the form of interview guidelines, to determine the initial conditions of students and the use of textbooks in schools. The questionnaire uses a Likert scale with four choices of answers that are tailored to the research stage and the purpose of the questionnaire.

Test Instruments, this instrument is a test of mathematical creative thinking ability. This test is to find the effectiveness of learning with guided discovery models. This test is given individually and aims to measure the mathematical creative thinking ability.

The data of the research was obtained from the interview in the preliminary study stage, review, various relevant research journals, and the review of mathematics textbooks of class-X senior high school curriculum in 2013, and the test instrument of mathematical creative thinking ability. The data are used as the reference for the preparation of the worksheet based on guided discovery.

Data analysis techniques in this study are explained based on the type of instruments used in each stage of development research, namely preliminary data analysis, worksheet validation analysis, and analysis of the effectiveness of learning using worksheet based guided discovery.

Data from the questionnaire results at the worksheet validation stage were analyzed qualitatively. In the worksheet validation stage, the data obtained are expert suggestions and comments, which are used as guidelines to improve worksheet. The data analysis of questionnaire result of the legibility and interest of the students is done descriptively qualitative.

Quantitative data is obtained from the test of mathematical creative ability. The data collection of this research is done by giving the test of mathematical creative thinking before and after learning. The data obtained were analyzed using inductive statistics.

The analyzing of the test used is t-test. The t-test is used to find the effectiveness of worksheet. Furthermore, from the pretest and posttest data computed the gain index to find out the improvement of the mathematical creative thinking ability before and after learning.

3. RESULTS AND DISCUSSION

Based on the identification of emerging problems, the development of worksheet-based guided discovery becomes an alternative to overcome them. Some things of concern from the preliminary research results are as follows:

a) The results of observation indicate that the teacher still uses conventional learning method in mathematics learning.
b) Teaching textbooks used by teachers in the form of private publications worksheet and textbook Curriculum 2013.
c) Percentage of students who achieve mastery learning below 50% on TVLES material.
d) From the scale of the list of questions about the ability of creative thinking, students' difficulties are in TVLES material.
e) Some suggestions given by teachers during interviews are using the worksheet tailored specifically to support student's mathematical creative thinking ability, using guided discovery models.

The next step is to develop a worksheet. The results of Preparation worksheet preliminary study indicate the need for product development in the form of the worksheet to support student independence in learning. The worksheet is based on KI, KD, and material indicators. Based on these guidelines, the writing of the worksheet is divided into (1) The initial section; (2) core parts; and (3) The closing section. The prepared worksheet includes components: title page, worksheet title and worksheet identity,Group Identity, basic competencies and achievement indicators, tools/materials, and instructions for using the worksheet.

The worksheet begins with the presentation of problems and drawings to help students get into the stage of formulating the problem of looking at the overall what will be learned and then write down the problem to be solved. Next, there are some questions related to the problem presented. The next stage students are directed to collect data that has been obtained from the formulation of the problem. The material section is presented to facilitate the students in the construction phase of the conjecture. The stage of conjecture preparation is used to solve the mathematical problem in the form of calculation. The next stage is the withdrawal of conclusions from the completion of mathematical problems given. The worksheet final stage is the application of the concept.

The next step is expert validation. The worksheet that has been prepared then submitted to the material experts and media experts in order to get validation. The validation of the material experts indicates that the assessment of the worksheet content or material aspects is in the very good category. However, in terms of content, it takes some revision on the suggestion of the validator.

Further validation results from media experts indicate that aspects of construction and technical aspects already have very good criteria, but the worksheet should be revised before being used in the field. Revision is made by fixing the worksheet that is replacing the words that are less precise, correct typing errors, or changes the design worksheet. The revised results are reconstructed with material experts and media experts until a reasonable the worksheet is obtained and declared ready for use in the initial field trial phase.

The next step is an initial field trial. Initial field trials were conducted on grade X students who had not received TVLES material but had obtained two linear equations in class IX. This trial aims to determine the legibility and interest of students who use the worksheet based guided discovery before being used in field tests. The subject of the initial field trials was six students of class X with different abilities. The results of improvements from this trial are the accuracy of writing a page with a list of contents. The instrument used in this trial is the scale of student response. Based on the results of the scale, the worksheet is included in either category.

The results of worksheet material expert validation test are included in the very good category, and the result of the validation test of media expert on the worksheet is included in the very good category. Based on the results of the validation test, the worksheet meets the feasibility so that it can be tested.

The test performed after the expert test is the initial field test. The field trials were conducted in class XA^5 as an experimental class and class XA^3 as control class at MAN 1 Central Lampung with 45 students for each class. At this stage, the worksheet is based on the discovery of guided revisions in the previous stage. During learning, each group is given on the worksheet of development outcomes and the teacher plays a facilitator that directs learning to work effectively.

Field testing is a test conducted to determine the effectiveness of the worksheet based guided discovery of the mathematical creative thinking ability.

Table 1. The Average of Mathematical Creative Thinking

Data	Experiment	Control
Pre-test	14,56	15,67
Post-test	61,06	38,89
Index gain	0,54	0,28

Based on the results of data analysis, obtained scores of student's mathematical creative thinking ability as presented in Table 1. Furthermore, the test of two average equation to the final score (post-test) ability of mathematical creative thinking. After the test, obtained sig value for the ability of mathematical creative thinking of 0.00 is smaller than 0.05. It means there is a difference in the ability of students' mathematical creative thinking using the worksheet based on guided discovery and students who do not use the worksheet based guided discovery. Furthermore, when viewed from the value of the gain index in the experimental class that is 0.54, the improvement of students' creative thinking ability using the worksheet based guided discovery including the category of being, concluded the worksheet based guided discovery effectively improve the ability of mathematical creative thinking.

Further tests conducted to determine the effectiveness of the worksheet based guided discovery of students' self-efficacy. Based on the results of data analysis, obtained the self-efficacy score of students as presented in Table 2.

Table 2. The Average Student's Self Efficacy

Data	Experiment	Control
Pre-test	51,50	51,37
Post-test	69,08	63,27
Index gain	0,36	0,24

Based on the results of data analysis, obtained the self-efficacy score of students as presented in Table 2. Furthermore, the two-point equality test with the students' self-efficacy posttest. After the test, obtained sig value for student self-efficacy of 0.00 which is smaller than 0,05. This means that there is a difference in self-efficacy of students using the worksheet based on guided discovery and students who do not use the worksheet based on guided discovery. Furthermore, when viewed from the value of the gain index in the experimental class that is 0.36 then the increase of self-efficacy of students using the worksheet based guided discovery including the category is, it can be concluded the worksheet based guided discovery effectively improve the students' self-efficacy.

Causes of students using the worksheet based guided discovery have better mathematical creative thinking abilities than students who do not use it (conventional learning) because when working on the worksheet based guided discovery, students are familiarized with challenging issues and cognitive conflicts within themselves students who stimulate students to do exploration and investigation to solve the problem.

In the problem solving, students are trained to explore ideas and construct knowledge independently without being too dependent on the teacher. In addition, each of the guided discovery-based learning stages present in the worksheet provides students with opportunities to develop students' mathematical creative thinking ability.

Based on the analysis of achievement indicators of mathematical creative thinking ability, it was found that for all aspects, the percentage of achievement of class indicators using the worksheet based guided discovery higher than the class that did not use the worksheet based guided discovery. The highest indicator percentage is in the fluency indicator and the originality of the student's ability to spark a lot of ideas and be able to provide relevant ideas to solve the mathematical problems and able to express his own opinion in giving an answer. While the indicator with the lowest percentage is the indicator of flexibility is the ability of students to be able to solve math problems thoroughly in various ways. Achievement of indicators of mathematical creative thinking after learning can be seen in Table 3.

Tabel 3. Data for Achieving Creative Thinking Indicators Mathematically After Learning

No.	Indicator	Percentage	
		Experiment	Control
1.	Sensitivity	66,11	53,89
2.	Fluency	80,00	42,50
3.	Flexibility	24,72	24,44
4.	Originality	72,78	44,72
5.	Elaboration	61,94	28,61
	Average	56,13	61,11

The worksheet based guided discovery that increases the mathematical creative thinking ability to be derived from effectiveness standards caused by several factors. The first factor is the formulation of the worksheet based guided discovery in accordance with the learning steps so as not to cause inequality between the learning process and the media used. Second, the presentation of mathematical creative thinking questions attracts students to find the mathematical concepts learned because mathematical creative thinking makes the students more thorough in understanding a concept and can relate it to other concepts in general. So finding this deep concept makes learning mathematics more meaningful. Students need peers to become special learning partners in working on the problem of mathematical creative thinking. From the observation of the achievement of the indicator, it can be concluded that the students not only need guidance from the teacher but from their peers. This is in line with Vygotsky's opinion (in Abidin, 2012) that social interaction through the zone of proximal development (ZPD) can enhance students' intellectual development.

Based on the analysis of achievement of self-efficacy indicator it is estimated that for all aspects, the percentage of achievement of class indicators using the worksheet based discovery is guided higher than the class that does not use the worksheet based guided discovery. The highest percentage of indicators is in the vicarious experiences indicator, ie the ability of students to compare their mathematical ability with others and the students' view of their mathematical ability and others. While the indicator with the lowest percentage is the verbal indicator persuasions is the ability of students to understand the meaning of mathematical sentences in the problems of mathematical creative thinking. The achievement of indicators of mathematical creative thinking after learning can be seen in Table 4.

Tabel 4. Data Achieving Self Efficacy Indicators After Learning

No.	Indicator	Percentage	
		Experiment	Control
1.	Authentic Mastery	69,56	61,22
2.	Vicarious Experiences	70,37	59,63
3.	Verbal Persuasions	68,52	64,81
4.	Physiological Indexes	68,79	64,35
	Average	69,31	62,50

Increased self-efficacy occurs because of social interaction between groups, students' self-confidence began to look in cooperation when problem-solving. Students can identify themselves with peers. When a peer succeeds in doing a task well, then the student will have a good judgment about his own success in doing the same task, so that the process of self-confidence can develop. This is similar to that disclosed by Zeldin (2000) states that observing the success of others, students can do an assessment of his own ability.

Verbal persuasion indicator is one indicator of self-efficacy. This indicator explains the direct feedback of the words of the teacher or the more mature person. This indicator is one of the indicators in improving self-efficacy. This is because teachers often give positive confidence to the students so that students are more passionate about doing the task. The words of teacher motivation make students have positive beliefs to encourage and empower their abilities. This reinforces student self-efficacy. The application of the group work system also enables students to gain support from peers when they feel incapable of performing a given task.

Psychological index of students is the last indicator of self-efficacy. This indicator explains the students' assessment of the abilities, advantages, and disadvantages of a given task. In learning using the worksheet based guided discovery that contains questions of mathematical creative thinking, make students interested to find the mathematical concepts studied, and they are accustomed to doing the questions that are numerical and related to the numbers. This makes students have a positive view of their math abilities.

Based on the description above, it can be concluded that learning by using the worksheet based guided discovery effectively in improving the mathematical creative thinking ability and student's self-efficacy. This is because, in the process of discovery in learning by using the worksheet based guided discovery, the problem builds on the knowledge reconstructed by the students themselves through the knowledge they have and the students develop their ideas according to their perceptions, as revealed in the theory of constructivism.

As students construct the knowledge they possess and develop their ideas, students must think mathematically to keep students away from erroneous and hasty decisions and must have confidence in their abilities so that no matter how difficult a given mathematical problem is, they can finish it well and more thoroughly. This is in line with the opinion of Victoriana (2012: 6), that the characteristics of individuals who have high self-efficacy is looking at the problem as a challenge to overcome not a threat, give high effort to what is done, and increase efforts when faced with failure.

4. CONCLUSION

Based on the results and research discussion obtained that the worksheet based guided discovery development stage is based on the following stages: preliminary study using interview and observation guidelines, planning the study starting with reviewing the materials to be prepared in the worksheet, the worksheet drafting for draft for guided discovery-based learning, initial field trials, revise the results of initial field trials, field trials, then improvements to the product of field trials.

The guided discovery-based worksheet is effective to improve students' mathematical creative thinking ability. This can be seen from the improvement of mathematical creative thinking ability using the guided discovery-based worksheet in the medium category. The guided discovery-based worksheet is effective for improving student's self-efficacy. This can be seen from the improvement of self-efficacy using on the guided discovery-based worksheet in the medium category.

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RESEARCH ARTICLE

The Effectiveness of Mathematics Teaching Material Based on Ethnomathematics

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ABSTRACT

The study aims to know the effectiveness of mathematics teaching material used based on ethnomathematics toward mathematical solving problem skill and student critical thinking and to know how student activity on mathematics learning by applying mathematics teaching material based on ethnomathematics. Research method applies a quantitative method with post-test only control design research type. Sampling technique applies cluster random sampling. Data collection technique applies documentation, observation, and test method. Data analysis technique applies quantitative data analysis by using t-test. Based on data analysis result, mathematics teaching material based on ethnomathematics proves effective toward solving problem skill and student mathematical critical thinking. Besides, by applying mathematics teaching material can raise student activity.

1. INTRODUCTION

Mathematics is an important science to be learned because mathematics is a science that has a unique characteristic as science, which has an abstract object, the pattern on axiomatic and deductive thinking, and based on truth (Afandi, 2018; Mursalin et al, 2018; Fonna, 2018; Amalia et al, 2018). With such unique characteristic, mathematics is useful in developing skill and creating learner personality (Mawaddah, 2015; Flora, 2017; Setiawan, 2006; Trisnawati, 2018). Mathematics as base science is also needed to achieve high-quality success. Therefore, mathematics is thought to all level school from elementary to university. Besides, mathematics is applied science to solve the problem in daily life.

One of mathematics role is to prepare learner in order to be able to face the changing condition or challenge in life, which always develops (Haydon, 2010; Woods, 2010). Besides, the learner is expected to be able to apply mathematics and think mathematical in daily life (Yusrina, 2017; Artut, 2009). That's why in learning mathematics is not only to understand mathematics concept and theory in solving problems. According to Mawadah (2015), the way of solving a problem that is obtained by the learner is a result from knowledge and experience, which is had by learner relates to the problem that wants to solve. So that, the teacher must be able to help learner give meaning in learning mathematics and build the skill of student mathematical problem solving to deepen student's comprehension toward mathematics.

According to Regulation of the Minister for Education Indonesia (Permendiknas) No. 23, 2006, mentioned mathematics lesson needs to be given to all learners in every education level as a base to provide the learner with the skill of thinking logical, analysis, systematic, critical, creative, and cooperate. Based on such thing, one of skill that must be had by learner after learning mathematics is a skill to think critically. Critical thinking skill is needed to solve a problem that is faced in daily life (Zakaria, 2007; A.K. Uswatun, 2016; Isjoni, 2010). Therefore, Critical thinking skill particularly doing math needs special attention in the learning process. In learning process at class, the teacher has to instill solving problem skill and to think critically in mathematics by relating mathematics problem with daily life and culture values in society (Alangui, 2017; Cimen, 2014; Eyal, 2018). So that learner is not only to get knowledge about mathematics but know culture values in society as well.

The fact that solving problem skill and Indonesian student mathematical critical thinking is still far from what is expected. It shows from Indonesian student achievement according to the Programme for International Student Assessment (PISA) survey in mathematics 2016 is in 63 ranks from 69 countries. Besides, based on observation in some schools in Sukabumi Municipality, in mathematics learning, the teacher still applies conventional learning which learning process usually begins by explaining concept informatively, giving example test, and is ended by giving exercise test. It causes the result from such learning is more focused to memorize process than solving the problem or to think critically in mathematics.

Based on an interview with mathematics teacher in Sukabumi Municipality, the teacher still has difficulty in learning that aims to increase critical thinking skill because the teacher is not used to develop learning which aims to increase critical thinking skill. Availability of mathematics book for Junior High School and High School that gives exercises based on critical thinking skill or solving problem is still less. Therefore, it needs teaching the material, which can help the teacher in developing critical thinking skill and learner solving problem skill whether in Junior High School level or High School.

Teaching material that is used should be able to facilitate teacher to transfer value and knowledge. So that, the teacher is not only transfer knowledge about mathematics but also transfer local wisdom value in leaner's environment. According to Fitroh and Himawati (2015) education and culture is something that can not be avoided in daily life because culture is a unity which is applied in society. One of that is able to be a bridge between culture and education is ethnomathematics (Verner, 2013). According to Fitroh and Himawati (2015), ethnomathematics is mathematics, which it had an influence or is based on culture. So far as it needs mathematics teaching material based on ethnomathematics that relates mathematics to real condition and culture in society. With mathematics teaching material, which relates mathematics material with culture is expected to be able to train leaner in solving problem and mathematical critical thinking skill.

Regardless of importance problem above mentioned, so that it is applied mathematics learning that uses mathematics teaching material based on ethnomathematics, which aims to increase mathematics solving problem skill and student mathematical critical thinking. The research aims at knowing how the effectiveness of applying mathematics teaching material based on ethnomathematics toward student mathematical solving problem skill and observing how student activity on applying mathematics teaching material based on ethnomathematics student.

2. METHODS

The research method used are a qualitative method with research type of post-test only control design. The population is all VII grade students of Public Junior High School (SMPN) 2 Cibadak Sukabumi Regency. Sampling technique applies cluster random sampling. From sampling, the result is obtained two classes that each class becomes experiment class and control class. Experiment class is a class that applies mathematics teaching material based on ethnomathematics learning meanwhile control class is a class that does not apply mathematics teaching material based on ethnomathematics learning. Data collection technique applies documentation, observation, and test method. Data analysis technique applies quantitative data analysis by using t-test.

3. RESULTS AND DISCUSSION

Based on the research results, an average score of experiment class is higher than the average score of control class, whether from critical thinking skill test or solving problem skill, the result can be seen from the table as follows.

Table 1. Results of final ability test

	Solving Problem Skill			Critical Thinking Skill		
	Max	Mean	St.Dev	Max	Mean	St.Dev
Experiment Class	81	51,226	18,581	95	67,903	15,202
Control Class	50	31,323	13,328	73	41,258	17,624

Based on the table can be concluded that average score of solving problem skill and student critical thinking skill that applies mathematics teaching material based on ethnomathematics is higher than the student does not apply mathematics teaching material based on ethnomathematics. If it is seen from t-test analysis, based on the result of t-test calculation between experiment class and control class on solving problem test is got the score to be as much as 2,222 meanwhile t-$_{table}$ = 1,671. From the result, it can be seen that to be > t$_{table}$. It shows that the average score of experiment class is better than the average score of the control class. It can be concluded that applying mathematics teaching material based on ethnomathematics is better than learning, which does not apply mathematics teaching material based on ethnomathematics on student solving problem skill. For student critical thinking skill test, if it is seen from t-test analysis, is obtained a score to be as much as 2,225 with t$_{table}$ = 1,671. From such result, it can be seen that to be > t$_{table}$. It shows that the average score of experiment class is better than the average score of the control class. From such a result, it can be concluded that applying mathematics teaching material based on ethnomathematics is better than learning, which does not apply mathematics teaching material based on ethnomathematics on student mathematical critical thinking skill.

The use of mathematics teaching material based on ethnomathematics proves effective toward solving problem skill and student mathematical critical thinking skill because this teaching material has a group of material and mathematics question that is related to local culture and contextual problem in the field that aims learner get experience in mathematics learning. According to Arisetyawan et al (2014), mathematics learning approach that is viewed from a culture point of view has a purpose to build a bridge between student knowledge background and formal mathematics learning at school. Dahlan and Permatasari (2018) stated that teaching material based on ethnomathematics on collection topic affords to facilitate students in constructing their knowledge inductively though they are still difficult in compiling form of mathematics formal.

The student is introduced to some objects that have culture and mathematics element in teaching material based on ethnomathematics. In this case, the student is introduced and is remembered about the shape and Sundanese local unique object, which is always seen then it is related to mathematics elements. For example in this teaching material is Leuit. Leuit is a building to keep paddy. From the leuit picture, there are some geometries among another trapezoid, triangle, square, and parallelogram. With the relation between mathematics learning and local culture so that student will have more motivation in studying mathematics and student will also obtain local cultural knowledge. See the Figure 1.

Figure 1. Examples of display teaching materials

This teaching material is also given the problem to open students knowledge about material that is going to be studied. The given problem is a problems that relates to society local wisdom in Sukabumi area. In solving the problem, a student is given stimulation to find some concepts about the definition, characteristic, circumference, and rectangular large by conducting an experiment with tool and object around the area.

To raise student's solving problem skill, in this teaching material is also given some solving problems questions which solution is designed based on Polya solving problems, there are (1) Making or arranging mathematic model that covers skill to formulate problem of daily situation in mathematics, (2) Choosing and developing strategy of solving problem that covers skill to bring up some possibilities or alternative formula solution or which knowledge that can be used in solving such problem, and (3) Enable to explain and to check the true answer that is got, covers skill to identify calculation mistakes, mistake of formula use, and enable to interpret obtained solution. Therefore, student's solving problem skill can be trained well by using this mathematics teaching material based on ethnomathematics.

This teaching material also has critical thinking questions that aim to raise student skill in critical thinking. According to Johnson (2007), critical thinking is a directed process and clear which is used in mental activity such as, solving problem, taking a decision, persuading, analyzing assumption, and conducting scientific research. In this teaching material, the student is given a problems and the student is demanded to solve the problems, take a decision, analyze assumption, and conduct scientific research so that by applying such teaching material, student's critical thinking skill will be trained.

Besides that, effective toward critical thinking skill and solving problem skill, this teaching material can also raise student learning activity. Based on observations, student learning activity by applying this teaching material has an increase. This increase can be seen from student motivation in the learning activity. Students are more enthusiastic and more active to learn mathematics because there is an activity to solve problems and direct practice uses media, which comes from the objects around them. Students are also interested to study mathematics because it is related to culture and local wisdom around their area so that students not only get information about mathematics material but also students get information about culture in student's area.

4. CONCLUSION

Based on the results of data analysis and hypothesis testing in this study, it can be concluded that mathematics teaching material based on ethnomathematics proves effective toward solving problem skill and student mathematical critical thinking. Besides, by applying mathematics teaching material can raise student activity.

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