

The Development Of Mathematics Learning Based On Double-Loop Learning: Preparing Independent And Dignified Learners

Sutama¹, Sofyan Anif², Harun Joko Prayitno³
{sut197@ums.ac.id¹, sa163@ums.ac.id², harun.prayitno@ums.ac.id³}

^{1,2,3}Universitas Muhammadiyah Surakarta, Surakarta, Indonesia

Abstract. In general, this study aims to develop a model of mathematics learning management based on double-loop learning that effectively increases learning output. The specific objectives of this study are to describe (1) the conditions of mathematics learning at the research site, (2) mathematics learning based on double-loop learning, and (3) preparation of independent and dignified learners. This study is a research and development with ethnographic qualitative design. The research subjects included mathematics teachers, school principals, and students of SMP (Junior High School) in Sukoharjo district. This study employed observation, interview, and documentation as the data collection method. Flow model qualitative analysis was then used as the data analysis technique. The results of the study: (1) Mathematics learning at the research site tends to be directed to make students think simple. Mathematics learning conditions at the research site occurred in the paradigm of “the teacher explains-the students listen.” (2) Mathematics learning based on double-loop learning in the paradigm of “active learners construct meaning-the teacher as a facilitator.” The mindset is a change in reflection and action. The management model went through three stages with five conditions. (3) Preparing independent and dignified learners based on strong religious value, core character, lifestyle character, character to respect others, and have intelligent, creative, and entrepreneurial potential.

Keywords: dignified, double loop learning, independent, mathematics learning

1 Introduction

The development of culture towards cyber-based life aroused the attention of teachers to the problem of character and independence. Education can be seen as one of the social forces that contributes to shape, style, and direction in the life of an intelligent, creative, and innovative future society. The work culture of the teacher both in his thought and action that is smart, creative, and innovative is expected to prepare tough and dignified students.

“What is wrong with the learning management that has been done by teachers?” Some did not feel the progress in the learning management, some even said that the learning management had a setback in independence. The statement of independence is a cultural statement [1]. The learning management without reflection and action will only lead to activism and verbalism. Only through praxis, which is a combination of action and reflection, management of mathematics learning becomes quality learning. To realize the quality mathematics learning

management, alternative solutions can be offered, namely “mathematics learning innovation based on double-loop learning.”

Double-loop learning is learning that encourages changes in values such as assumptions and strategies. Double-loop learning has a destructive aspect that always questions the norms, values, and assumptions that apply. Norms, strategies, and learning objectives are always explored deeper and reflected, questioned again, and corrected to encourage optimal learning outcomes [2]. According to Cartwright [3] double-loop learning is a transformation from a perspective that is highly held in the habit of working and acting, through communication, dialogue that involves a lot of interaction between students. Broadly speaking the objectives of double-loop learning are to 1) create a harmonious working relationship between the teacher and students; 2) develop the ability to solve mathematical learning problems more openly; 3) create openness in communication; and 4) develop the morale of the students and the ability to control themselves.

Building values in mathematics learning based on double-loop learning is in accordance with the learning characteristics of the 2013 curriculum which includes directing students to understand their potential, interests, and talents. For this reason, through mathematics learning based on double-loop learning, students are prepared to have the quality character and competence in accordance with the demands of 21st century skills. Competencies that are appropriate for 21st century skills, namely a) critical thinking and problem solving skills, b) communication skills, c) creativity and innovation, d) collaboration [4].

According to Paul and Elder [5], critical thinking is the process of analyzing and evaluating thinking with a view to improving it. Critical thinking skills that can be developed, namely a) reasoning; b) understanding interconnection between concepts; c) determining decisions effectively, d) testing the results and establishing connection between information and argument; e) processing, interpreting and testing information; f) solving non-routine problems; g) using the ability to solve problems; h) arranging and revealing, analyzing and solving problems.

Communication is the process of transmitting information, ideas, emotions, and skills using symbols, words, pictures, graphics, and numbers. Communication skills that can be developed, namely a) understand, manage, and create effective oral, written, and multimedia communication (ICT Literacy); b) use the ability to express his ideas; c) use attitude to listen and respect the opinions of others; e) use a logical, structured mindset in accordance with the rules; and f) the possibility of multi-language communication.

Creativity is a divergent way of thinking, productive thinking, creative, heuristic thinking, and lateral thinking. Creativity skills that can be developed: a) have the ability to develop, implement, and convey new ideas; b) be open and responsive; c) able to express creative ideas d) use their knowledge in new and different situations; e) use failure as a vehicle for learning; f) have the ability to create; and g) able to adapt to new situations and make a positive contribution to the environment

Collaboration in the learning process is a form of cooperation with each other, helping each other and completing so that the specified goals are achieved optimally. Collaborative skills that can be developed, namely a) ability to work in groups; b) adapt in various roles and responsibilities, work productively with others; c) have empathy and respect for different perspectives; d) be able to compromise with others.

Associated with quality learning and provide opportunities to express themselves. Utama, Narimo, and Haryoto [6] stated that in learning mathematics begins with questions related to the lives of students to challenging questions. Questions related to the lives of students can be

used as an effective way to begin a development of teaching materials. Challenging questions (important, difficult, and useful in the future) provide opportunities for students to guess, discuss, and debate to get the answers.

On another occasion, Sutama, Narimo, and Haryoto [7] stated that in learning mathematics, there are practical principles, namely 1) starting from what is mastered by students not from what the teacher knows; 2) delivering mathematics in a pleasant atmosphere; 3) giving opportunity for students to speak, work, write; 4) using familiar language to students; 5) associating mathematical concepts with other concepts; 6) utilizing the results of technology; 7) using media that are easy to process and interesting; 8) familiarizing students to be active in groups.

In general, this research is aimed at developing a model of mathematics learning management based on double-loop learning that is effective in increasing the learning output of SMP Sukoharjo, Central Java. The specific objectives of this study are to describe (1) the conditions of mathematics learning at the research site, (2) mathematics learning based on double-loop learning, and (3) preparation of independent and dignified learners.

2 Method

This study is a research and development with ethnographic qualitative design [8]. This study employed a qualitative research approach with ethnographic design. The research subjects included mathematics teachers, school principals, and students of 65 SMP (Junior High Schools) in Sukoharjo district, Central Java. The sixty five (65) SMP in Sukoharjo district, Central Java were for exploration and analysis of research data needs. Exploration and analysis of research data needs were obtained using observation, interview, and documentation [9]. Data collection methods in the development were complemented with focus group discussion (FGD). Flow model qualitative analysis was then used in this study as the data analysis technique [10]. Research activities in the data collection to data analysis process are illustrated in Figure 1.

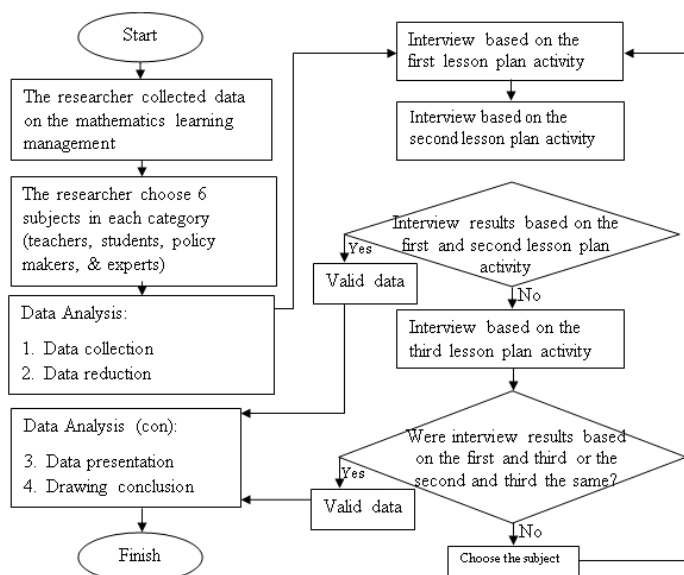


Figure 1. Activities of Data Collection to Data Analysis Process in the Study

3 Result and Discussion

A. Mathematics Learning Condition

Learning is basically a communication process to deliver educational messages in the form of teaching materials from learning resources to learners aiming to change the behavior [11]. The quality of learning is largely determined by the effectiveness of the communication that occurs in it, namely there is a two-way flow of information that is both responded to in accordance with the expectations of the two actors of communication. What is the trend of communication that occurs in mathematics learning at the research site?

The new education paradigm emphasizes learners as humans with the potential to learn and develop. However, the communication tendencies that occur in mathematics learning where monotone research is one-way. This is indicated by the learning of mathematics where research is influenced by the view that mathematics tools are ready to use. This view encourages teachers to be inclined to tell concepts/theorems and how to use them. This situation occurs because in the process of learning mathematics at the research site, students were less given the opportunity to express their ideas and the reasons for their answers.

The condition of mathematics learning at the research site tended to occur in the first paradigm of “the teacher explains - students listen,” not the second paradigm of “students actively construct the meaning - teacher helps.” Changing the paradigm adopted by the teacher from the first paradigm to the second paradigm is not easy. Why? Most mathematics teachers at the research site are familiar with the first paradigm.

The creativity of learning mathematics at the research site is needed to be continuously developed. The learning strategies applied in schools are too many, but not yet optimal in their implementation. Mathematics learning that is applied tends to be text book oriented and less related to the students' daily lives. This is getting worse because the mathematics teachers tend to derive the test items and assignments from the books they owned. Considering mathematics is a symbol language [12], the learning needs to start from what the students experienced.

Rediscovery, which is an informal way of solving in learning. The learning process with the invention is described by Purwaningsih, Utama, and Narimo [13], where the students in group construct the formula discovery of the trapezoidal area with different pieces, the results of the trapezoidal group work are cut into: 1) two triangles, 2) two triangles and squares, then between groups discuss the discovery of the trapezoid formula and the teacher plays a role as a facilitator. In order to strengthen students' understanding, the activity is continued by applying formulas in controlled and independent exercise.

B. Mathematics Learning based on Double-loop Learning

Mathematics learning management model based on double-loop learning offered is student-centered through three preliminary stages (conditioning, perception, motivation, and delivery of learning objective and learning process), core activities (integrating scientific approaches, strategies, methods, and learning media), and closing (reflection, conclusion, post-test, and follow-up), and with five additional provisions as follows.

1. To strengthen the scientific approach, mathematics teachers apply Problem-Based Learning (PBL), Discovery Learning (DL), and Project-Based Learning (PjBL) in accordance with the characteristics of the teaching material;
2. Space management changes every certain time period, to realize effective and productive mathematics learning in junior high school level. Media management varies, namely visual media and still and motion projections foster motivation and understanding of concepts in learning mathematics;
3. Management of teaching materials pay attention to the urgency, complexity, and depth of the material, to realize optimal learning outcomes; teaching material management varies which will create the development of students' reflective thinking;
4. Managing multi-directional interactions, making the learning process of mathematics conducive and enjoyable, and learning objectives are achieved; and
5. Managing the authentic assessment of learning processes and outcomes based on cognitive, affective, and psychomotor aspects

If it is agreed upon the mathematics learning task based on double-loop learning fostering character and building the character of the children, then the management of learning seeks to (1) develop all talents and abilities towards the traits of smart and skilled, honest, disciplined, know the abilities and limits of personal abilities and have a sense of self-respect and (2) place the Indonesian nation in a place of honor in the association between nations of the world. The characteristics of the character must be carried out with courage without inferiority that is not free of values, which is inseparable from the limits of the moral values of Pancasila ethics.

The implication of that description is that mathematics learning based on double-loop learning must be able to create intelligent life in politics, economics, social, and culture. Changes in reflection and action in the mathematics learning management based on double-loop learning is a driving force that brings every child to political, economic, social, and cultural life.

The mindset of the mathematics learning management based on double-loop learning with changes in reflection and action, that is the personal development of the students to be human beings. Through reflection, students are expected to be confident (not because they are obedient to tradition or regulations). Through action, students do it of their own volition (not because they are part of it or are afraid of sanctions).

Reflection is one of the keys in the learning process. Freire [14] considers that there are three types of reflection, namely 1) reflection on content; 2) reflection on the problem, and; 3) reflection on premise. The activities of teachers and students in the form of "action and reflection" are praxis that enable students to find themselves. Learning management with reflection and continued with dialogue will open opportunities for the change of one's mindset (perspective). As a praxis effort, reflection must be done by action (deciding to behave, intend, and act concretely), so that it becomes a new experience for students which then is reflected as an effort to improve future actions.

Stimulating students from passive to active communication is not a simple matter. Fullan [15] suggested that there are four phases in the process of change, namely 1) initiation, 2) implementation, 3) sustainability, and 4) results. According to Fullan's view, in developing students' potential through changes in reflection and action in the mathematics learning management based on double-loop learning involving five elements, namely context, experience, reflection, action, and evaluation.

Mathematics learning based on double-loop learning, also recommends that student learning is a shared responsibility of teachers and parents. Pestalozzi [16] provided several points about the role of teachers and parents in developing the students' potential. A teacher provides new knowledge, learning tasks in limited and directed scope, develops reasoning, places physical and intellect in a moral and spiritual experience. Parents as the first educators play a role in instilling faith through the affection given and providing concrete examples so that students can bring their faith experience into the classroom.

Teachers in double-loop learning organize students' learning experiences so that they significantly change their appearance, and the way mathematics teachers teach students will determine the success of their students. As stated by Even and Ball : "... teachers are key to students' opportunities to learn mathematics." Example of a mathematics teacher facilitating students learn the power of 0 of a number other than 0.

The steps of the learning process are as follows.

T = Teacher and S = Student

T: What happens if a non zero number is divided by itself? ... Mimin, please?

S: The result must be 1.

T: Right. What if am divided by am ?

S: The result must be 1 as well.

T: A few days ago, the formula of $a^m : a^n$ has been discussed, hasn't it? Then, what will happen with $a^m : a^m$?

S: Will $a^m : a^m$ be equal to $a^{m-m} = a^0$?

T: If so, how about a^0 ?

S: a^0 will be equal to 1.

T: Yes. In general, it can be concluded that $a^0 = 1$ for $a \neq 0$. Try to investigate why $a \neq 0$?

Examples of such learning are humanists, which emphasize the importance of preserving human existence, in the sense of helping humanity to be more humane, more cultured, as a fully developed human being. Mathematics learning should also be returned to the humanity aspects that need to be developed in students themselves [17].

The development of all power in a balanced manner can be realized if quality learning is applied. According to Utama [18] the quality of mathematics learning can be observed and measured from three aspects, namely planning, process, and learning assessment. The planning of mathematics learning is said to be of high quality, if students are involved in planning the learning media and teaching materials. The process of learning mathematics is said to be of quality, if students are actively involved in a pleasant and highly motivated atmosphere. Assessment of mathematics learning is said to be of quality, if assessment process is done authentically both in the process and the results as well as achieving completeness of more than or equal to 85%.

To achieve the quality that has been designed, mathematics learning activities based on double-loop learning use principles, 1) students are facilitated to find out, 2) students learn from various learning sources, 3) use scientific approaches, 4) competency-based learning, 5) emphasize divergent answers that have multi-dimensional truth, 6) applicative skill-based learning, 7) improve balance, continuity, and the relationship between hard skills and soft skills,

8) prioritize the culture and empowerment of students as lifelong learners, 9) apply values by setting an example, developing students' will and creativity, 10) learning that takes place at home, school, and in the community, 11) utilization of Information and Communication Technology (ICT) to improve efficiency and effectiveness as in the Flipped Classroom [19], 12) recognition of students' individual differences and cultural background, 13) a pleasant and challenging learning environment, and 14) authentic assessment..

C. Preparing Independent and Dignified Students

The image of mathematics teachers in double-loop learning is expected to be able to bring changes to this country. The teacher is no longer a source of knowledge, but rather a student partner in learning. Therefore, mathematics teachers must take part in preparing the golden generation by requiring mathematics teachers to be wise and tough in double-loop learning.

It is time that globalization era is interpreted in a positive sense and faced with professional teachers who prioritized the dignity and independence of the nation. Dignity [20] [21], explains that self-esteem as a respectable nation, born from a process of blood, tears, and bones of the nation's hero which should not be mortgaged for the sake of food. Independence [22], emphasized that Indonesia's economic direction must be sovereign, it must become a master in its own country. Preparing students to become fully independent and dignified requires a balanced development of all forces (affective, positive, psychomotor). Independent and dignified students are the results of mathematics learning based on double-loop learning based on strong religious, honest personality, responsibility, discipline, hard work, humble, and respect for others, and have entrepreneur soul.

4 Conclusion

Mathematics learning based on double-loop learning, in the paradigm of "active learners construct - teacher as a facilitator." The mindset is a change in reflection and action which is to develop learners' personalities into humanities. The management model through three preliminary stages (conditioning, perception, motivation, and delivery of learning objectives and processes), core activities (integrating scientific approach, strategies, methods, and learning media according to teaching material), and closing (reflection, conclusion, post-test, and follow-up), with five conditions: (1) to strengthen the scientific approach, mathematics teachers apply Problem-Based Learning (PBL), Discovery Learning (DL), or Project-Based Learning (PjBL); (2) space management changes every certain time period, media management varies, (3) teaching material management pays attention to urgency, complexity, and depth of material, management of teaching materials varies; (4) management of multi-directional interaction; and (5) management of authentic assessment process and learning outcomes according to cognitive, affective, and psychomotor aspects.

5 Acknowledgment

We would like to thank various parties who have supported this research. Our gratitude goes to the Directorate of Research and Community Service at the Directorate General of Research and Technology Development of the Ministry of Research, Technology, and Higher

Education who have assisted in funding multi-year research through the Postgraduate Research Grant. Our gratitude goes to the Director of the Graduate School and the Chair of the UMS Research Institute and its staff who have provided facilities and encouragement so that we can conduct this study. We would also like to thank the head of the Department of Education, the principals and mathematics teachers of SMP Sukoharjo, Central Java who have helped the research process so that it goes according to plan.

References

- [1] Swasono, S.E. 2014. "Entrepreneurship Indonesia: Agent Of Modernization". Makalah kunci kewirausahaan kampus dan "Peningkatan Pengusaha Pemula" (Small and Medium Enterprise Boost), Kerjasama UST dengan PT IBM Indonesia. Yogyakarta: UST.
- [2] Argyris, C. 2013. "Theories of action, double-loop learning and organizational learning". The work of Chris Argyris (1923-2013) has influenced thinking about the relationship of people and organizations, organizational learning and action research. Here we examine some key aspects of his thinking. <http://infed.org/mobi/chris-argyris-theories-of-action-double-loop-learning-and-organizational-learning/>
- [3] Cartwright, S. 2002. "Double_loop Learning: A Concept and Proses for Leadership Educators". *Journal of Leadership Education*. Vo. 1, Issue 1, 68-71.
- [4] Dit. PSMA Ditjen Dikdasmen. 2017. Panduan implementasi kecakapan abad 21 kurikulum 2013 di Sekolah Menengah Atas. Jakarta: Dit. PSMA Ditjen Dikdasmen
- [5] Paul, R. dan Elder, L. 2007. "Critical Thinking Competency Standards: Standards, Principles, Performance Indicators, and Outcomes With a Critical Thinking Master Rubric". Foundation for Critical Thinking Press. www.criticalthinking.org
- [6] Utama, Narimo, S., dan Haryoto. 2012. "Mathematics Learning Management at Elementary School Post Merapi Eruption". *International Journal of Education*. Vol. 4, No. 4, 192-203.
- [7] Utama, Narimo, S., dan Haryoto. 2013. "Contextual Math Learning Based on Lesson Study Can Increase Study Communication". *International Journal of Education*. Vol. 5, No. 4, 48-60.
- [8] Utama. 2012. "Metode Penelitian Pendidikan (Kuantitatif, Kualitatif, PTK, R&D)". Surakarta: Fairuz Media.
- [9] Denzin, N.K. & Lincoln, Y.S. 2009. *Handbook of Qualitative Research (Edisi Bahasa Indonesia)*. Yogyakarta: Pustaka Pelajar.
- [10] Flick, U., Kardorff, E.V., and Steinke, I. 2004. *A Companion to Qualitative Research*. London: SAGE Publication Ltd.
- [11] Utama, 2016. Darurat Pembelajaran Matematika: Guru Matematika Profesional Untuk Menyiapkan Generasi Emas. Artikel Seminar Nasional Pendidikan Matematika FKIP UMS, 15 Mei 2016.
- [12] Heruman. 2010. *Model Pembelajaran Matematika di Sekolah Dasar*. Bandung: PT Remaja Rosdakarya.
- [13] Purwaningsih, N., Utama, Narimo, S. 2013. "Pengembangan Pembelajaran Matematika Kontekstual Pada Sekolah Dasar Penyelenggara Pendidikan Inklusi". *Jurnal Pendidikan Matematika*, Vol. 1, No. 2, 99-111.
- [14] Freire, P. 2011. *Pendidikan Kaum Tertindas*. Jakarta: Pustaka LP3ES Indonesia
- [15] Fullan, M. 1982). *The meaning of educational change*. New York: Teachaers College Press.
- [16] Brühlmeier, A. (2010). *Head, Heart and Hand. Education in the spirit of Pestalozzi*. Cambridge: Sophia Books.
- [17] Utama. 2015. Budaya kerja guru intelektual transformatif:Perubahan refleksi dan aksi guru matematika dalam menghadapi PPG, artikel Seminar Nasional Pend. Matematika: Pemberdayaan Guru Intelektuan Transformatif Menghadapi PPG Surakarta, 10 Mei 2015.
- [18] Utama. 2011. "Pengelolaan Pembelajaran Matematika Berbasis Aptitude Treatment Interaction". Pidato Pengukuhan Guru Besar. Surakarta: Muhammadiyah University Press.
- [19] Damayanti, H.N.; & Utama. 2016. Efektivitas Flipped Classroom Terhadap Sikap dan Keterampilan Belajar Matematika di SMK. *Jurnal Manajemen Pendidikan*. Vol. 11, No. 1, 2-7.
- [20] Swasono, S.E. 2013. *Pendekatan Teoritis-Akademis dan Ideologis: menjadi Tuan Di Negeri Sendiri*. Yogyakarta: UST-Press.
- [21] Swasono, Sri E. dan Macaryus, S. (ed). (2013). *Kebudayaan Mendesain Masa Depan*. Yogyakarta: UST-Press
- [22] Pakkanna, M. 2014. "Menjadi Tuan Di Negeri Sendiri". <http://www.stiead.ac.id/index.php/kolom-ketua/140-menjadi-tuan-di-negeri-sendiri>, Ahad, 07 September 2014, 07:25.