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Integration of digital literacy in didactic design: Prospective analysis on algebra learning

Nyiayu Fahriza Fuadiah[1] *, Ety Septiati[2], Marhamah[3]

[1,2,3] Program Studi Pendidikan Matematika, Universitas PGRI Palembang. Jalan Jend. A. Yani Lr. Gotong Royong 9/10 Kota Palembang, Indonesia.
E-mail: [1]nyiayufahriza@univpgri-palembang.ac.id*, [2]etyseptiati@gmail.com, [3]marhamah1904@gmail.com.

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** Corresponding author.*

Abstract: This study aimed to formulate the Hypothetical Learning Trajectory (HLT) as part of the Didactical Design Research at the prospective analysis stage in the VIII class of Algebra learning, namely the Two-variable Linear Equation System (TVLES). HLT is based on a study of learning obstacles which includes aspects of repersonalization of material content, potential use of digital media in learning, curriculum analysis, and didactic aspects and is adapted to the needs of students and the development of digital literacy. This study involved 47 students of class VIII, 21 students of class IX, 3 mathematics teachers, and 5 model students. Based on a prospective analysis, the HLT on aspects of the TVLES concept is formulated as follows: 1) Considering the concept of "*The Meaning of the Equal Sign*" through an open context (*realtime thinking literacy*), recognize variables as unknown values and varying quantities; 2) Completing an open sentence using trial and error through the context of scales (*photo visual literacy*); 3) revealing the relationship between symbolic representations and straight-line graphs; the meaning of the point of intersection, using algebraic concepts in completing TVLES (*branching literacy*); 4) create a mathematical model of a problem related to TVLES (*information literacy*), and; 5) solving various problems related to TVLES through a logical algorithm. This HLT was expected to be developed into a didactic design which will later be implemented in learning.

***Keywords**:* didactical design research; hyphotetical learning trajectory; internet; linier equation

Integrasi Literasi Digital Pada Desain Didaktis: Analisis Prospektif Pembelajaran Aljabar

Abstrak: Penelitian ini bertujuan untuk merumuskan *Hypothetical Learning Trajectory* (HLT) sebagai bagian dari *Didactical Design Research* pada tahap analisis prospektif pada pembelajaran aljabar kelas VIII yaitu Sistem Persamaan Linier Dua Variabel. HLT disusun berdasarkan studi *learning obstacles* yang mencakup aspek repersonalisasi terhadap konten materi, potensi penggunaan media digital dalam pembelajaran, analisis kurikulum, dan aspek didaktis dan disesuaikan dengan kebutuhan peserta didik dan pengembangan literasi digital. Penelitian ini melibatkan responden 47 siswa kelas VIII, 21 siswa kelas IX, 3 guru matematika, dan 5 siswa model. Berdasarkan analisis prospektif, HLT pada aspek konsep TVLES dirumuskan sebagai berikut: 1) Mengingat konsep "*Arti Tanda Sama-Dengan*" melalui konteks terbuka (*realtime thinking literacy*), mengenal variabel sebagai nilai yang tidak diketahui dan kuantitas yang bervariasi; 2) Penyelesaian suatu kalimat terbuka menggunakan trial and error melalui konteks timbangan (*photo visual literacy*); 3) mengungkap hubungan antara penyajian simbolik dengan grafik garis lurus; makna dari titik potong, menggunakan konsep aljabar dalam menyelesaikan TVLES (*branching literacy*); 4) membuat model matematika dari suatu permasalahan terkait dengan TVLES (*information literacy*), dan; 5) menyelesaikan berbagai persoalan terkait TVLES melalui suatu algoritma yang logis. HLT ini diharapkan dapat dikembangkan menjadi desain didaktis yang nantinya di implementasikan dalam pembelajaran.

Kata Kunci: *didactical design research*; *hyphotetical learning trajectory;*internet; persamaan linier

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INTRODUCTION

Literacy awakening is very important. This is because "a nation with a very advanced literacy usually relates to the progress of the nation's civilization itself", said Deputy Minister of Culture Wiendu Nuryanti at the Indonesian stand at the Frankfurt Book Fair (FBF), Wednesday 8 October 2014 (Amalia, 2017). This statement emphasizes the importance of literacy for the progress of the nation's civilization. Consequently, if you want to build civilization, like it or not, literacy must be cultivated. The progress of a country can be seen from the strength of its literacy culture. Even UNESCO states that literacy is the heart of education (OECD, 2015).

To face learning in the 21st century, everyone must have critical thinking skills, knowledge and abilities of digital literacy, information literacy, media literacy and mastering information and communication technology (Frydenberg & Adone, 2011). Developing digital literacy is not only about mastering the technical aspects of digital media (Wijaya, Sudjimat, & Nyoto, 2016). Developing digital literacy is not only about mastering the technical aspects of digital media (Jones & Hafner, 2012). Furthermore, literacy refers to the practice of communicating, relationships, ways of thinking, and everything related to digital media (Jones & Hafner, 2012) as well as individual interests, attitudes and abilities in using digital technology and communication tools to access, manage, integrate, analyze and evaluate information, build new knowledge, create and communicate with others in order to participate effectively in society (Setyaningsih, Abdullah, Prihantono, & Hustinawaty, 2019).

Through the concept of 21st Century Education, education is becoming increasingly important to ensure that students have the skills to learn and innovate, the skills to use technology and information media, and can work, and survive by using life skills. The use of technology and applications in the field of education is also growing rapidly according to the demands of the times. The use of the internet as a learning media is increasingly widely known by the public and has increased from year to year. Internet users in Indonesia have experienced significant user growth and spend at least three hours per day browsing the internet (Adiarsi, Stellarosa, & Silaban, 2015). Learning is now no longer only done in the classroom but also in virtual space. Learning concepts like this can facilitate distance constraints so that knowledge can be obtained unlimitedly where students can find the learning resources they need.

As a branch of mathematics, algebra is the basic concept of further development of mathematical theory. In its most general form, algebra is the study of mathematical symbols and the rules for manipulating these symbols. Algebra is the amalgamation of rational, irrational, and geometric number theory. This factor encourages students to master literacy skills, so in this case called mathematical literacy, namely the individual's ability to formulate, use and interpret mathematics in various contexts. Mastery of number theory, symbols, and manipulation of symbols causes students to experience obstacles in understanding algebraic concepts. In addition, some students were found to tend to be not fluent in expressing their thoughts and find it difficult to use mathematical language appropriately to express their mathematical ideas (Mujulifah, Sugiatno, & Hamdani, 2015).

Given the importance of this algebraic theory in the application of mathematics to other exact scientific fields, including as a basic concept of algorithms and computer programs, the concept of algebra is an important material to be mastered by students.

The Covid-19 pandemic has encouraged the world of education to actively use learning by utilizing technology media through distance learning. The use of the internet has become an unavoidable necessity for both educators and students. Proficiency in internet digital technology is needed so that it can be used productively and appropriately and can determine credible learning resources. When they search for these sources via the internet from various sites, students need digital literacy that can equip them with the ability to properly sort out information, criticize, and communicate both directly and through social media. Therefore, digital skills, known as digital literacy, must be instilled in students who are integrated in every subject (Sugihartati, 2020). This forms the idea that digital literacy content can be integrated and can be developed in every subject matter, including algebraic concepts. Learning obstacles that are often found in algebra learning at the junior high school level, especially in grades VII and VIII, strengthen the reason for researchers to choose algebra as the subject matter in this study as well as strengthen the literacy skills of students, especially digital literacy.

Based on a study of expert opinions and research results, the researcher argues that digital literacy skills can be considered as one of the skills that must be developed in students. Conditions related to Covid-19 force us to change the way of learning by utilizing technological advances but still paying attention to the competencies that are expected and in accordance with the learning objectives. However, the meaning of learning as a form of education is not just an achievement in cognitive aspects and dry in social, behavioral, and moral meanings which are usually obtained in face-to-face learning. This is a challenge for researchers and education practitioners to create appropriate learning that can accommodate the meaning of education in online learning.

Researchers are motivated to create a learning trajectory on algebraic material by sticking to the principles of learning as well as being able to develop students' digital literacy skills that can be a guide for teachers in carrying out learning both online and offline. Through an emphasis on learning stages that pay attention to the needs and characteristics of students, it is expected to create teaching materials that are comprehensive enough to overcome the problems that have been described previously.

METHOD

This study tries to reveal the phenomena that occur in their natural conditions in learning mathematics and then develop a solution based on the related prospective theory. Researchers identified factors that became learning obstacles and designed a hypothetical learning trajectory (HLT) by integrating digital literacy skills in algebra learning.

The design of this study refers to the Didactical Design Research (DDR), which is a methodology that examines metapedadic and empirical didactic situations through an analysis of learning obstacles, learning trajectories, and gap thinking (Suryadi, 2019). In this

article, the researcher focuses on the prospective analysis stage. This stage is related to the interpretive paradigm in DDR, namely analyzing the impact of a didactic design that occurs on students due to the didactic situation and learning path experienced and how the process of new knowledge is obtained so that it becomes a very important part to be studied in more depth. This stage is in the form of an analysis of learning obstacles (LO), curriculum analysis on algebraic material, analysis of the use of the internet in learning as an illustration of digital literacy, literature study, and the formulation of the Hypothetical Learning Trajectory (HLT). The object in this research is teaching material for algebra learning TVLES material which is designed based on metapedadidactic theory by taking into account aspects of digital literacy each content. The participants in this study were 47 students of class VIII and 21 students of class IX as well as 2 mathematics teachers who taught in these classes. Data collection in this study was carried out through literature studies, interviews, tests, digital literacy questionnaires, and memos (field notes). The participants in this study were 47 students of class VIII and 21 students of class IX as well as 2 mathematics teachers who taught in these classes. Data collection in this study was carried out through literature studies, interviews, tests, digital literacy questionnaires, and memos (field notes). The participants in this study were 47 students of class VIII and 21 students of class IX as well as 2 mathematics teachers who taught in these classes. Data collection in this study was carried out through literature studies, interviews, tests, digital literacy questionnaires, and memos (field notes).

LO was identified through a diagnostic test in the form of questions related to algebraic concepts (grade VIII) and TVLES (grade IX). The digital literacy questionnaire consists of 15 questions referring to digital literacy based on Belshaw (2012), Ministry of Education and Culture (2017), and Sugihartati (2020). The HLT was then put into a hypothetical didactic design and validated by 4 experts, namely two lecturers and two teachers based on aspects of material content and learning design.

RESULTS AND DISCUSSION

Algebra is a separate part of the curriculum so it should be related to all areas of mathematics. There is general agreement that we must fulfill the development of this thought form from the very beginning of school so that students can learn to think productively with excellent mathematical ideas so that they can think mathematically.

Based on the analysis of the curriculum on algebraic material, there are algebraic materials studied in K.13 but previously not in the 2006 KTSP, namely Quadratic Equations and Quadratic Functions. Overall, the materials related to junior high school are: 1) Sets, 2) Relations and Functions 3) Algebraic Forms, 4) One Variable Linear Equations, 5) One Variable Linear Inequality, 6) Straight Line Equations, 7) Equation System Linear Two Variables, 9) Quadratic Equations, and 10) Quadratic Functions. In this study, the Algebra material that became the focus of the design was a Two Variable Linear Equation System.

Furthermore, the researchers also conducted an analysis of the teaching materials used by the teacher when teaching TVLES material. The teaching materials used by the two

teachers were a revised 2017 Junior High School/MTS mathematics textbook. In the textbooks used by the teachers there were contexts related to everyday life but students were not involved in how to solve the problem from the knowledge they understood. The problem is then immediately answered by writing a mathematical model from the given context. The solution is then directly written by making two equations with two variables and then writing down how to solve the two equations through elimination and substitution so that they only focus on the completion procedure.

Repersonalization and *recontextualization*, which aim to carefully examine the relationship between the structure of the concept and its contextual situation, are important things for teachers to pay attention to in predicting and anticipating the learning obstacles that may be experienced by their students. *Repersonalization* means mathematizing as mathematicians do in mapping the relationship between concepts. On the other hand, interpreting the situation in which the concept appears makes the teacher able to trace the history of the development of the concept and its application in everyday life is a process of *recontextualization* (Fuadiah, Suryadi, & Turmudi, 2018). So, it is very important for teachers to repersonalize and recontextualize for the purpose of minimizing the occurrence of learning obstacles.

Analysis of Learning Obstacles

Researchers conducted diagnostic tests on students in grades VIII and IX as well as interviews with two mathematics teachers who teach in one junior high school on didactic aspects, especially TVLES learning. provide information on how students understand the concept of TVLES, especially in solving problems. The results given show more or less the same picture as the diagnostic test results.

Based on the analysis of the diagnostic test of the respondents, it was found that: 1) students still had problems with prerequisite material, namely algebraic forms and variables, students did not fully understand the meaning of a variable as an unknown quantity, 2) students had problems operating algebraic forms, constraints in arithmetic, and the concept of solving the left and right sides (meaning equal sign) equal to, and 3) students do not fully understand the meaning of the problem, identify the problem, know the information contained in the problem, translate the context of the problem into an appropriate mathematical model, and determine the appropriate solution strategy.

Overall, learning obstacles that occur in algebra learning, especially in TVLES material are: a) ontogenic obstacles in the form of limited ability of students to understand questions, do not like to read questions in the form of long descriptions; b) didactic obstacles; the limited context of the problems posed by the teacher, such as only using the selling price example in the TVLES, the limitations of teaching materials according to the needs of students, obstacles in determining the appropriate anticipation of student responses, the limitations of teachers in integrating mathematical abilities in learning through the context of relevant problems, and teaching materials that have not provided space for students to explore the knowledge they already have on new concepts to be studied and emphasizes problem solving procedures rather than the repersonalization process; c) epistemologicall

obstacles, understanding of algebraic forms, operations on algebra, obstacles in determining unknown values in an equation, determining variables, determining unknown variable values, making mathematical models of problems related to TVLES, understanding the meaning of questions, and determining strategies and proper procedures for completing the TVLES.

Islamiyah, Rayitno, and Amrullah (2018) in their research found that students made mistakes in transforming, so that students experienced errors when solving problems and difficulties in process skills. such as calculation errors related to subtraction or division making students unable to continue solving to the end and not being able to translate the problem into a mathematical model correctly, students wrongly assuming, wrongly compiling equations, wrong in solving them, can make mathematical models but students experience difficulties when using the elimination method on TVLES the results obtained are not correct (Rahayuningsih & Qohar, 2014; Susanti, Hasinah, & Zanthy, 2020). In One Variable Linear Equation, it was found that students' learning obstacles in understanding the phrase "*a number*" became something unknown, for example the variable x, which could result the students not having the idea of using variables x and y to represent an object (Jufri & Drijvers, 2016; Pangaribuan, 2018).

Digital Literacy Analysis

Based on the questionnaire given to all respondents to get a digital picture of respondents' literacy, it was found that 73.1% of respondents had internet service facilities provided for learning in the adequate category. 46.2% of respondents use internet services for 3 to 4 hours per day, 15.4% for 5 to 6 hours, and 19.2% even more than 6 hours. Table 1 below shows the complete questionnaire results.

Table 1 Results of the Internet Utilization Questionnaire

No	Statement	Variety of Answers	Percentage
1	Internet service facilities provided for studying	Very Adequate	73.1
		Adequate	38.5
		Inadequate	26.9
		Very Inadequate	0
2	The length of time it takes to use internet services per day	More than 6 hours	19.2
		5 to 6 hours	15.4
		3 to 4 hours	46.2
		1 to 2 hours	19.2
3	Using internet services solely to get information related to lessons	Always	38.5
		Often	26.9
		Sometimes	30.8
		Never	3.8
4	Use internet services to get information to stay updated	Always	34.6
		Often	26.9
		Sometimes	30.8
		Never	7.7
5	Utilize internet services to get any information (including school lessons) faster	Always	50
		Often	42.3
		Sometimes	7.7
		Never	0

No	Statement	Variety of Answers	Percentage
6	Utilize internet services to get more sources of information	Always	34.6
		Often	26.9
		Sometimes	34.6
		Never	3.9
7	Utilize internet services to get more complete learning resources	Always	50
		Often	19.2
		Sometimes	30.8
		Never	0
8	Determine in advance what information to look for before looking for information	Always	50
		Often	30.8
		Sometimes	15.4
		Never	3.8
9	First determine the web address to be opened before looking for information	Always	26.9
		Often	15.4
		Sometimes	42.3
		Never	15.4
10	Find the information you need on the site when opening a web address on the internet,	Always	15.4
		Often	26.9
		Sometimes	50
		Never	7.7
11	Checking the truth of the information after getting some information via the internet	Always	42.3
		Often	36.6
		Sometimes	23.1
		Never	0
12	Collect and store all the information that has been obtained after successfully obtaining the required information	Always	50
		Often	15.4
		Sometimes	30.8
		Never	0
13	Apply this information in daily life after successfully finding the information that suits your needs	Always	30.8
		Often	30.8
		Sometimes	34.6
		Never	3.8
14	Share the link obtained from the internet with friends when you get information that you think is useful	Always	26.9
		Often	11.5
		Sometimes	46.2
		Never	15.4
15	Actions when you get information or images that do not match your age when opening a web address	Read or open the information	23.1
		Ignoring the information	50
		Report to parents or teachers	26.9
		Share with friends	0

Respondents are active internet users and use information obtained from the internet as a source of learning, but sometimes they receive information that is not appropriate for their age (Table 1). The internet has an effect on student and student learning motivation such as ease of finding information, providing ease of learning, especially in completing assignments, providing insight and knowledge, and as a means of exchanging information (Ricoibah & Pibriana, 2016; Srinadi, 2015). In addition, learning by utilizing the internet has been proven to be able to encourage independent learning of students and is flexible

(Ningsih, Misdalina, & Marhamah, 2017). Therefore, learning designs designed by teachers should pay attention to this as a great potential to be able to integrate digital literacy in teaching and learning activities so that they can use information obtained through the internet for positive things.

Preparation of Hypothetical Learning Trajectory (HLT)

HLT is prepared based on the overall analysis of perspectives related to algebra and literacy material. In addition, HLT is also prepared based on a supporting theoretical perspective. In accordance with the focus of the research, in compiling HLT and design by integrating in addition to prioritizing the objectives of algebra learning materials in mathematics subjects, researchers also pay attention to aspects of digital literacy. So there are two aspects of activity in HLT, namely activities related to material as well as integrating aspects of digital literacy in TVLES learning activities (Figure 2).

The digital literacy aspects that appear in the HLT refer to the scope of digital literacy according to Sugihartati (2020), namely:

1) *Photo visual literacy*, technical skills in the form of the ability to understand visual illustrations that exist on digital devices
2) *Reproduction literacy*, the ability to compose digital text.
3) *Branching literacy*, the ability to search for complex web sites so that they are focused, not distracted and lost.
4) *Information literacy*, the ability to determine and find the information needed via the internet and identify the accuracy of that information critically.
5) *Social-emotional literacy*, the awareness to see elements of the act of searching internet sites that are harmful to personal or not.
6) *Real-time thinking literacy*, namely the ability of users to be able to ignore information on a site, such as advertisements or other pop-up displays that are not needed.

HLT is designed to facilitate five forms of algebraic logic which are the basis of the preparation of HLT in this research. Algebraic logic (Kaput, 1999), namely: 1) generalization of arithmetic and patterns in Mathematics; 2) the use of symbols that are quite useful; 3) learning about number structure; 4) learning about patterns and functions; and 5) the mathematical modeling process, which brings together the four previous ideas (Figure 2). Based on this, the researcher emphasizes the concept of understanding the "=" sign, the meaning of variables, and symbolism; determine the value of the variable; presenting and analyzing mathematical situations and structures using algebraic symbols; and create mathematical models and determine TVLES solutions. The context of daily life that is close to students is deliberately chosen by the researcher so that students can learn from real life experiences and previous knowledge. This method can help students to explore, discover and then lead to an understanding of mathematics (Mawarni, Syahbana, & Septiati, 2019).

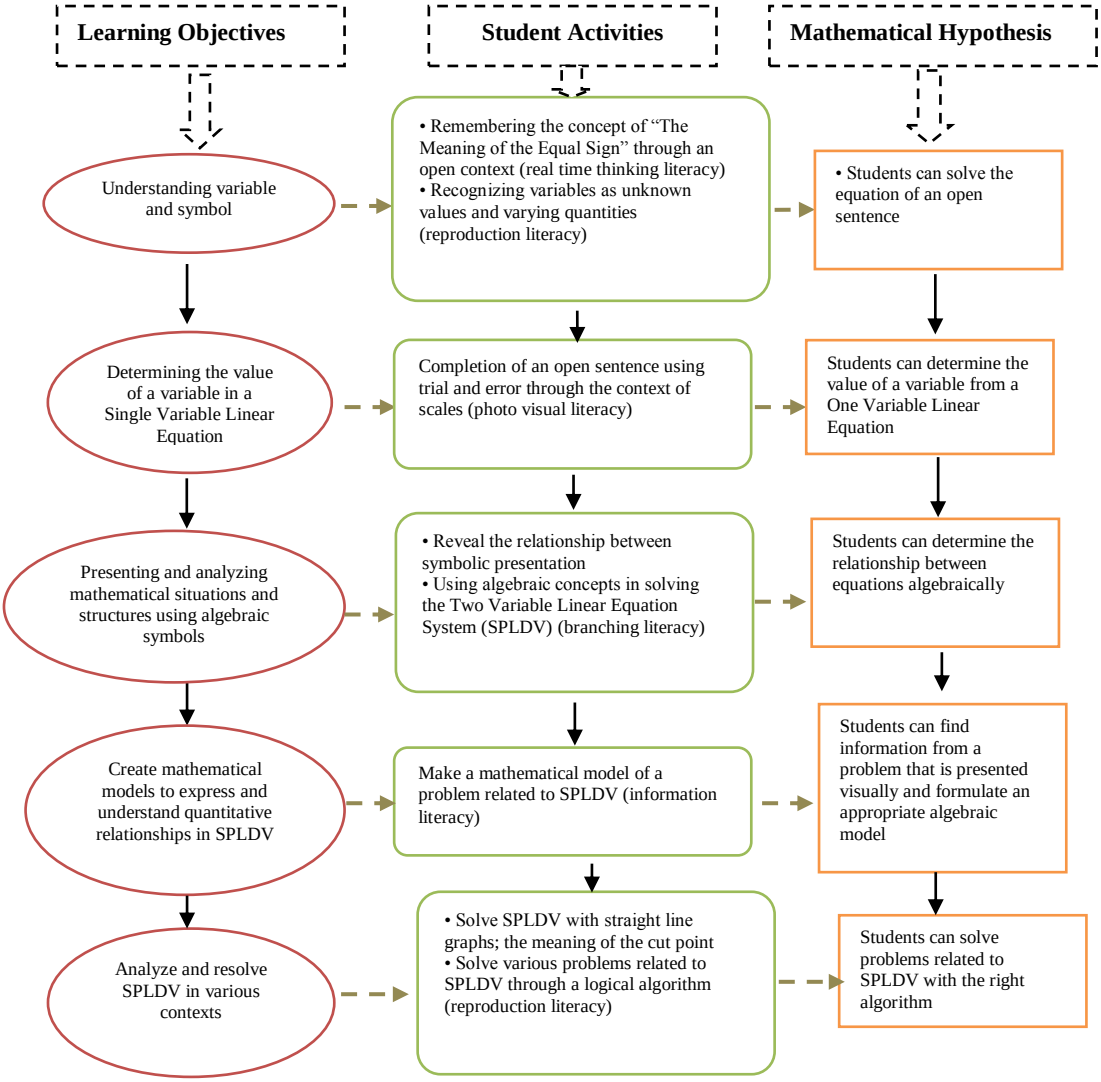

Figure 2 HLT TVLES integrated with digital literacy

The mathematical modelling is a specific concern of researchers and becomes one of the focuses that must be instilled in students as one of the abilities that need to be taught to students. Mathematical modeling has become a special concern for several countries in mathematics education in schools. This is spurred by the existence of the PISA international mathematics assessment which has included mathematical modeling in the student's mathematical ability test (Hartono & Karnasi, 2017)

Trying to prove that an approximation is a truth is a significant form of algebraic reasoning and is at the heart of doing math. How students try to prove that a question is always true is something new and interesting to study (Ball & Bass, 2003; Carpenter, Fanke, & Levi, 2003; Schifter, Monk, Russel, & Bastable, 2017; Schifter, 1999). All of these researchers believe that there is a real benefit in challenging students from grade two to prove a conjecture.

Regarding digital literacy, according to Turner (2016), the context of mathematics in literacy is divided into four situations and these are the main things in designing HLT in this

study, namely: 1) personal context which is directly related to students' daily personal activities. day, 2) educational and work contexts related to the lives of students at school and or in the workplace, and 3) general contexts related to the use of mathematical knowledge in social life and the wider environment in everyday life.

In accordance with the results of several studies on digital literacy, the lowest ability possessed by internet users is the ability to think critically. This ability can be trained through learning mathematics. One is analyzing information (for example: relating several variables) to follow or create a multi-step argument; give reasons from related sources of information (Turner, 2016). In this HLT algebra material, these skills are integrated in the use of internet resources in learning that starts from the beginning of learning, for example in *the Meaning of the Equal Sign* and *Open Sentence* materials. It aims to provide an example so that students can choose sources of information that are relevant to learning and in line with aspects of mathematical literacy abilities according to PISA, namely being able to sort out relevant information from a single source and using a single presentation methodl (Khikmiah & Midjan, 2017; OECD, 2018) From the comments of students who became respondents, through one of the sources obtained from the internet they gained new knowledge about open sentences which were previously only known through Indonesian language lessons.

Another presentation that includes digital literacy in this didactic design is to give students the freedom to search for information sources via the internet regarding the completion of the *Two-Variable Linear Equation System* (TVLES). From the Learning Obstacles study, the TVLES solution method is still an obstacle. Therefore, assigning students to find their own method of completion aims to: 1) provide a stimulus that is more interesting and not boring (*photo-visual literacy*), 2) give students the freedom to determine the source of learning information, and 3) foster a *social-emotional literacy* attitude, an awareness to see the elements of the act of surfing in cyberspace that are useful. Students are then assigned to make a resume on the information they get (*reproduction literacy*). This is in line with the three subject positions that are connected to the digital literacy section, namely (1) students as technology users; (2) students as technology questioners; (3) students as technology producers (Selber, 2004).

CONCLUSION

Based on the research findings, it can be concluded that: Learning Obstacles that occur in algebra learning, especially in TVLES material are: a) ontogenic obstacles in the form of limited ability of students to understand questions, do not like to read questions in the form of long descriptions; b) didactical obstacles, the limited context of the problems posed by the teacher, such as only using the example of selling prices in the TVLES, limited teaching materials according to student needs, obstacles in determining the right anticipation of student responses, c) epistemological obstacles, obstacles in determining grades the unknown in an equation, determine the variable, determine the value of the unknown variable, create a mathematical model of the problem related to TVLES, understand the meaning of the problem, determine the right strategy and procedure to solve the TVLES.

Learning trajectories containing digital literacy in SPLDV materials are: 1) Remembering the concept of "*The Meaning of the Equal Sign*" through an open context (*real-time thinking literacy*), recognizing variables as unknown values and varying quantities; 2) Completing an open sentence using trial and error through the context of the scales (*photo-visual literacy*); 3) revealing the relationship between symbolic representations and straight-line graphs; the meaning of the point of intersection, using algebraic concepts in completing TVLES (*branching literacy*); 4) create a mathematical model of a problem related to TVLES (*information literacy*), and; 5) solve various problems related to TVLES through a logical algorithm.

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