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Analyzing the need of math geometry drawing tools in mathematics classroom A Hendroanto and H Fitriyani Universitas Ahmad Dahlan, Jl. Ringroad Selatan, Bantul, Yogyakarta, Indonesia E-mail: aan.hendroanto@pmat.uad.ac.id Abstract. Since ancient time, mathematician have used a set of tools for drawing many shapes of geometrical figures. These tools are a ruller, a compass, and a protactor.

Over the last centuries, these three tools does not have much changes on their features and functions. Even when the world has change drastically because of advancement of technology, the tools does not get too much attention. The question is whether people have already satisfied with the tools so that they do not need to be changed anymore.

The following study aims to determine and analyze matman'oinio ecy chers and students regarding the use of math geometry drawing tools. A survey was conducted to get their comments and whether a change is needed to the current tools. 44 respondents are involved and consists of 29 teachers and 15 students. The results showed that 44.83% teachers sometimes struggled to use the tools in class and 86.21% teachers agreed that the tools need to be developed into a more efficient one.

In line with the teachers, 46.6% students are struggling with the tools while 86.67% of them wanted the tools to be more efficient. 1. Introduction In geometry, there are numerous figures and objects that need to be drawn in order to learn them such as circles, line, rectangles, graphs, and many more [1]. To draw them, people use a set of drawing tools to make the figures precise and good looking.

The more precise and good looking the figures, the easier for people understanding them. Since ancient time, people have used numerous type of tool to draw geometrical

objects [2]. But there are some that are very popular called ruler, protractor, and compass. These three tools have been being used since ancient Greek [2].

Some popular drawings were made just by using a ruler and a compass by Euclid. Now, people still use these tools to draw many mathematics objects in daily basic. In order to use the tools, one must know the characteristic and the function of each tool. First, a ruler is made to measure length of an objects with a standardized scale.

In length measurement, we have many length measurement units such as centimeter, meter, mile, feet, and many more. Different region, sometime use a different unit of length measurement [3]. In Indonesia, it is common to use centimeter, meter, kilometer, and inch in a length measurement. Ruler usually is made from a straight objects like wood, iron, or plastic.

To use it, people just need to put ruler into the drawing plane as a guidance when drawing a straight line or when they want to measure the length of a line. Different from ruler, a protractor is a tool to measure the size of an angle. Mostly, a protractor is shaped like a half section of circle with standardized scale on its edge.

Standardized angle measurement used mostly is a degree but some others use a radiant. Similar with ruler, to use a protractor one must The Sixth Seminar Nasional Pendidikan Matematika Universitas Ahmad Dahlan 2018 IOP Conf. Series: Journal of Physics: Conf. Series 1188 (2019) 012051 IOP Publishing doi:10.1088/1742-6596/1188/1/012051 2 put it on the drawing plane with the center on the measured angle. Protractor also can be used to draw an angle with certain size. The last tool is a compass.

The characteristic of a compass is very different from ruler and protractor. Compass is made from two straight rods and they can be folded or extended. The function of a compass is to draw a circle or an arc. The first rod is used as a center point while the other has a pencil or something similar to draw the arc. Compass is just a drawing tool and cannot be used to measure both length and angle.

Nowadays, there are certain time when students are taught specifically to use all these tools in mathematics class [4]. The use of ruler, protractor and compass since ancient time until now seems to have no problem at all in our society. As a proof, there has been no significant development on the tools and their appearances are mostly the same. No new features are seen on them.

The recent development is on ruler that can also be a compass and a protractor made

by Feldhake, woods, and Lin [5-8]. They develop combination of ruler, protractor and compass by making a rectangular ruler. Differently, Henry and Klemm develop a combination of protractor and compass [9-10].

Meanwhile, the effort to combine ruler and protractor are also have been done by Heinz, Ferris, and Johnson [11-13]. However, these kinds of development on ruler are mostly for students only, not for teacher. Teac hers' em t tools is still unsolved. This is a drawback at some point since our technological advancement are significantly progressing into a new level of culture.

Why there is no evolutionary changes on the tools since ancient time is a question we need to find in our society, especially mathematician. There are some speculation on the answers. First, people are already satisfied with the tools and too lazy to make changes. Second, no problems or struggles have been found from people who use the tool.

The current articles aims to determine and analyze mathematician opinion regarding the use of the tools. We want to identify whether people are actually struggle to use the tool and whether changes or more efficient tools are needed. 2. Method In order to achieve the aim, this study used a survey on some of the users of the tools.

Sample are taken from mathematics teachers and students in some of the school in Yogyakarta, Indonesia. We involved 44 respondents consisting of 29 teachers and 15 students. Data collection used an open questionnaire with 21 questions. So, the respondents must write their opinion on each question regarding the tools.

The teachers are scattered across two different districts from Bantul and Kota Yogyakarta while the students are from mostly college students in mathematics study program in Universitas Ahmad Dahlan. The data were analyzed qualitatively and descriptively with some basic statistics. Pictures and examples of the answer are provide in the text to validate the finding. ruler compass protractor Struggle e Agree with inovation Figure 1.

Highlighted result of survey on mathematics teachers The Sixth Seminar Nasional Pendidikan Matematika Universitas Ahmad Dahlan 2018 IOP Conf. Series: Journal of Physics: Conf. Series 1188 (2019) 012051 IOP Publishing doi:10.1088/1742-6596/1188/1/012051 3 3. Result and discussion After conducting the survey, the answers of the respondents are collected and categorized based on the main problem or point mentioned.

Table 1 and Table 2 in the appendix shows the overall result and Figure 1 tells about

some highlighted result from Table 1. The survey results in Figure 1 show that 100% of teachers use a ruler in drawing geometry objects, followed by 41.38% of teachers using protractor and 44.83% using compass. These three tools are the three most used tools by the teacher. The tools are 89.66% made of wood and from aluminum or plastic material respectively 10.34%. This shows that the tools with wood materials are in great demand in learning.

Although this tool is mostly available in schools, only 68.97% actually use it in drawing geometry objects. One of the reasons is because of the slippery blackboard because more than 90% of schools use whiteboards in class. Not a few teachers also feel the hassles with the use of these tools as much as 44.83%.

Some have difficulty because the device is too big, not practical, or the use of markers that are not compatible. Therefore, 86.21% of teachers agree that if there is a geometry learning tool that can function as a ruler, compass and protractor at once it will be better. The survey results on students in Figure 2 showed similar results to the teacher, namely 100% of students used a ruler in drawing geometry objects, followed by 73.33% of students using the term and 80% using the bow. These three tools are the three most used tools by students. However, as many as 46.6% of students find it difficult to use these tools. As many as 86.67% of students agree if there is a geometry learning tool that can function as a ruler, runner, and bow at once so that it will be better.

Based on the analysis of the data both in Table 1 and Table 2, we identify some problems faced by teachers and students. Below is the description of these problems. Inefficient and Ineffective Sometime, the use of drawing tools in the class is not as effective as they thought. This is because to draw by using the tools will cost considerable time than drawing objects without using them. There are 10.35% teachers agree that they struggled to use the tools and sometime even ask students to help them drawing.

Similarly, the tools are also seen to be inefficient since one must carry a lot of tools just to draw simple objects. For example, if you want to draw a 60 ° angle then you have to use ruler to draw its legs and protractor to measure the angle than draw the arc by using the compass. Drawing a simple angle cost teachers to bring all the three tools. Based on our survey in Table 1, 44.83% of the teachers has this experience and agree that the tools are not efficient.

Incompatible In Indonesia, most of the school used to have blackboards before they were replaced with whiteboards in 2000s. This affects the available tools around. For example, most compass in Indonesia were originally made for blackboard. It was

equipped with a spike as the center because it can perfectly ruler compass protractor Struggle e Agree with inovation Figure 2.

Highlighted result of survey on mathematics students The Sixth Seminar Nasional Pendidikan Matematika Universitas Ahmad Dahlan 2018 IOP Conf. Series: Journal of Physics: Conf. Series 1188 (2019) 012051 IOP Publishing doi:10.1088/1742-6596/1188/1/012051 4 grip on blackboard. However, after whiteboard was widely used, the spike was not compatible with the white surface. 41.38% of the teachers find this very problematic as the compass will slip on the surface and it do not grip tightly. Based on our survey, 96.55% of the school has used whiteboard in their class. This conclude that a compatible tool is needed.

Heavy and Fragile Most of math geometry drawing tools are made from wood in Indonesia. In here, we have many kinds of woods with different characteristics, strength, and weakness. Some tools are made from poor quality woods that makes the tools fragile. If they fall when someone used it, it will most likely to break apart.

On the other hand, if the tools are made from high quality woods, then the tools will be much stronger. However, high quality woods will make the tools heavy and difficult to use. 20.69% of the teachers feels that the current tools are much too heavy or fragile. Bad condition and unavailable Some teachers have difficulty with the tools because they have been broken. 24.14% of the teachers have their drawing tools broken and they repaired the tools themselves. Tirelthe frle' problem mentioned above.

Unfortunately, the availability of the tools around the town in Indonesia is not easy to find. To buy new tools are not easy since there are only few sellers interested in this business. Sometimes, teachers must design the tools themselves than order to a carpenter to make the tools. 27.59% of the teachers has this kind of problem.

The availability of the tools they needed hinder them from performing best drawing in the class. 4. Conclusion Based on the description of the survey result, the description, and the analysis, we can conclude several things. First, teachers and students mostly used ruler, protractor, and compass to draw geometry objects more than any other drawing tools.

However, almost half of them did not use the tools to draw when needed. Although they have use the tools so many times, sometimes they still feel struggling with them. During the survey, some teachers argued that the current tools are inefficient and ineffective to be used in class, incompatible with the boards, and too heavy and also fragile. Some of the tools are also in bad condition and the availability of the new tools

around is rare. 5.

Acknowledgment This study was supported by Penelitian Dosen Pemula (PDP) grant from The Directorate of Research and Community Service. Ministry of Research,Technology and Higher Education. References [1] Hershkowitz R, Duval R, Bussi M G B, Boero P, Lehrer R, Romberg T, & Jones K, 1998 Reasoning in geometry In Perspectives on the Teaching of Geometry for the 21st Century Springer 29 [2] Albrecht W A, 1952 A critical and historical study of the role of ruler and compass constructions in the teaching of high school geometry in the United States (Doctoral dissertation, The Ohio State University) [3] Klein H A, 2012 The science of measurement: A historical survey (Courier Corporation) [4] Raphael D, & Wahlstrom M, 1989 The influence of instructional aids on mathematics achievement Journal for Research in Mathematics Education 173 The Sixth Seminar Nasional Pendidikan Matematika Universitas Ahmad Dahlan 2018 IOP Conf. Series: Journal of Physics: Conf. Series 1188 (2019) 012051 IOP Publishing doi:10.1088/1742-6596/1188/1/012051 5 [5] Owen J W E, 1931 U.S. Patent No. 1,808,705. (Washington, DC: U.S. Patent and Trademark Office) [6] Feldhake H J, 1958 U.S. Patent No. 2,857,674.

(Washington, DC: U.S. Patent and Trademark Office) [7] Woods W D, & Pigman, J. H. 1985 U.S. Patent No. 4,490,921. (Washington, DC: U.S. Patent and Trademark Office) [8] Lin F C, 2002 U.S. Patent No. 6,457,247. (Washington, DC: U.S. Patent and Trademark Office) [9] Henry T, 1926 U.S. Patent No. 1,576,800. (Washington, DC: U.S. Patent and Trademark Office) [10] Klemm W F, 1951 U.S. Patent No. 2,542,537. (Washington, DC: U.S.

Patent and Trademark Office) [11] Heinz R A, 1981 U.S. Patent No. 4,267,638. (Washington, DC: U.S. Patent and Trademark Office) [12] Ferris W H, 1904 U.S. Patent No. 776,897. (Washington, DC: U.S. Patent and Trademark Office) [13] Johnson M, 2007 U.S. Patent No. 7,188,427. (Washington, DC: U.S. Patent and Trademark Office) Appendix Table 1. Result teacher Answer No.

Question Answer Teachers Number of answer Percentage 1 Have you ever drawn geometry objects such as lines, angle, squares, or cubes in class? yes 29 100,00% 2 Do you use certain tools when drawing these objects? yes 26 89,66% sometimes 3 10,34% 3 What tools do you need to draw the geometry object on the board? Mention! ruler 29 100,00% protractor 12 41,38% marker 7 24,14% compas 13 44,83% computer 1 3,45% projector 1 3,45% chalkboard 3 10,34% chalk 1 3,45% Triangle ruler 2 6,90% 4 Do you have learning tools such as compass, protractor and rulers for learning mathematics in class? Mention anything! yes 29 100,00% Ruler 23 79,31% Compas 13 44,83% Protractor 16 55,17% chalkboard 1 3,45% 5 Not feasible 7 24,14% The Sixth Seminar Nasional

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Series: Journal of Physics: Conf. Series 1188 (2019) 012051 IOP Publishing doi:10.1088/1742-6596/1188/1/012051 6 No. Question Answer Teachers Number of answer Percentage What conditions of learning tools (compass, protractor and ruler) do you have? Made from what materials it is feasible 17 58,62% limited 1 3,45% What material is the tool made of? aluminum 3 10,34% wood 26 89,66% plastic 3 10,34% stainless 2 6,90% mica 1 3,45% Iron/metal 1 3,45% plywood 1 3,45% 6 Are there any learning tools such as compass, protractor and rulers in each class in your school? No 12 41,38% yes 17 58,62% 7 During teaching and learning activities, especially the topic of geometry, do you really use compass, protractor and rulers to draw geometrical shapes? Explain! sometimes 7 24,14% yes 20 68,97% No 2 6,90% 8 In your opinion, is the current use of compass, protractor and ruler useful and effective for drawing on the board? Explain your reason! yes 25 86,21% sometimes it is difficult to use a protractor because of an unclear angle 1 3,45% less effective, time consuming 2 6,90% 9 Have you ever felt the hassles of carrying and using these tools for drawing? explain your reason! Yes 12 41,38% No 14 48,28% Sometimes 2 6,90% 10 What type of board (black or white whiteboard) is mostly used in your school? whiteboard 28 96,55% Absent 1 3,45% 11 Have you ever had trouble using these tools on a specific type of board? Explain! no 17 58,62% ever, the blackboard is slippery 12 41,38% 12 What do you do to overcome these difficulties? there are students who help hold 3 10,34% slowly 2 6,90% pressing rather strongly 3 10,34% look for other possible tools 2 6,90% draw on the chalkboard 1 3,45% bind / modify tools 2 6,90% The Sixth Seminar Nasional Pendidikan Matematika Universitas Ahmad Dahlan 2018 IOP Conf. Series: Journal of Physics: Conf. Series 1188 (2019) 012051 IOP Publishing doi:10.1088/1742-6596/1188/1/012051 7 No.

Question Answer Teachers Number of answer Percentage 13 Do you think that the current drawing tools are efficient and practical to use? Explain! yes 16 55,17% No 13 44,83% 14 What is the availability of compass, protractor and ruler for the blackboard in your city? Are you having trouble buying the learning tool? procurement difficulties 8 27,59% No 11 37,93% 15 Do you develop the tool yourself or buy it? provided a school / school to buy 29 100,00% 16 What obstacles do you encounter when using the current of compass, protractor and ruler? there are no obstacles 11 37,93% slippery blackboard 3 10,34% bother, not practical 3 10,34% wood material so easily broken and heavy 6 20,69% use of markers on the compass 1 3,45% too big a tool 3 10,34% often alternating with other classes 1 3,45% the device does not meet the standards 1 3,45% the storage device 1 3,45% 17 Have you ever heard or seen a geometric object drawing tool other than rulers, compass and protractor? yes 12 41,38% Mention and explan! Not yet 17 58,62% Geogebra 5 17,24% Electronic media 1 3,45% active inspire 1 3,45% pantograph 1 3,45% computer 3 10,34% 19 Are the tools above available at your

school? No 12 41,38% absent 8 27,58% available 9 31,03% 20 What do you think if there is a more practical tool of compass, protractor and ruler? ready to use 14 48,28% welcome 15 51,72% 21 Do you think it would be easier if the compass, protractor and ruler were combined into one practical tool? no 4 13,79% yes 25 86,21% The Sixth Seminar Nasional Pendidikan Matematika Universitas Ahmad Dahlan 2018 IOP Conf. Series: Journal of Physics: Conf.

Series 1188 (2019) 012051 IOP Publishing doi:10.1088/1742-6596/1188/1/012051 8 Table 2. Result ts's No. Question Answer Teachers Number of answer Percentage 1 Have you ever drawn geometry objects such as lines, angle, squares, or cubes in class? yes 15 100,00% 2 Do you use certain tools when drawing these objects? yes 14 93,33% no, depending on whether there is a tool or not 1 6,67% 3 What tools do you need to draw the geometry object on the board? Mention! pencil 15 100,00% Ruler 15 100,00% eraser 3 20,00% compass 11 73,33% protractor 12 80,00% book 1 6,67% coin 1 6,67% rope 1 6,67% 4 Do you have learning tools such as compass, protractor and rulers for learning mathematics in class? Mention anything! yes 15 100,00% Pencil, compass, ruler 13 86,67% Pencil, compass, protractor, ruler, eraser 1 6,67% Pencil, bolpoitn, compass, protractor, ruler, eraser pencil, 1 6,67% 5 Among these tools, which tools do you carry in your bag at this time? Mention! pencil 15 100,00% eraser 2 13,33% compass 3 20,00% Ruler 12 80,00% Protractor 6 40,00% ballpointt 2 13,33% Rope 1 6,67% Do nor carry in at all 1 6,67% 6 During mathematics learning, especially geometry, do you really use compass, protractor and rulers to draw geometrical shapes? Yes 11 73,33% sometimes 4 26,67% 7 In your opinion, is the current compass, protractor and ruler use useful and effective for drawing? explain your reason! Usefull 14 93,33% sometimes 1 6,67% The reason? objects become more precise and good in shape and size 8 53,33% neat and clear 2 13,33% help draw objects 4 26,67% 8 Have you ever felt the hassles of carrying and using these tools for drawing? explain your reason! Yes 6 40,00% No 8 53,33% Sometimes 1 6,67% The Sixth Seminar Nasional Pendidikan Matematika Universitas Ahmad Dahlan 2018 IOP Conf. Series: Journal of Physics: Conf. Series 1188 (2019) 012051 IOP Publishing doi:10.1088/1742-6596/1188/1/012051 9 No.

Question Answer Teachers Number of answer Percentage The reason for the eve answer less able to regulate the term pressure so the result is a different thickness of the painting 1 6,67% drawing must be sized to be difficult and long 3 20,00% It must change between rulers and run so long 1 6,67% Teh reason for the never answer can find steps to use it 1 6,67% often do exercises at home 2 13,33% the tool is easy to use 2 13,33% The reason for the sometimes answer hassles if the time given is short 1 6,67% 9 Have you ever lost your compass, protractor and ruler in class? Yes 15 100,00% 10 What kind of rulers do you like? Explain your choice! Iron 3 20,00% Trasnsparant ruler, makes it easy to release the size 1 6,67% small, short, easy to carry 3 20,00% Triangle

ruler 4 26,67% long, made from plastic 1 6,67% long straight ruler 3 20,00% 11 What kind of compass do you like? Explain your choice! Compass in general 1 6,67% compass made of iron 6 40,00% the architect's compass can be replaced by the size of his arm 1 6,67% The compass which the pencil does not have to be dirty 1 6,67% Compass with pencil clamb, there is no need to change the contents of the pencil 1 6,67% small, practical to carry 3 20,00% Compass made from plastic 1 6,67% compass that is not easily broken by a pencil 1 6,67% 12 What protractor do you like? Explain your choice! Protractor made from plastic 4 26,67% Transparent protractor 1 6,67% small protractor, easy to carry 5 33,33% ordinary protractor, there are degrees 4 26,67% protractor made from thick mica 1 6,67% 13 Have you ever heard or seen a geometry drawing tool other than a ruler, compass and protractor? No 12 80,00% Mention and explain! ever, using coin 1 6,67% The Sixth Seminar Nasional Pendidikan Matematika Universitas Ahmad Dahlan 2018 IOP Conf.

Series: Journal of Physics: Conf. Series 1188 (2019) 012051 IOP Publishing doi:10.1088/1742-6596/1188/1/012051 10 No. Question Answer Teachers Number of answer Percentage ever, from the rope pendulum 1 6,67% Ever, using geogebra 1 6,67% 14 What do you think if there is a more practical tool of compass, protractor and ruler? Very appreciate 1 6,67% agree, happy, easier 13 86,67% Better 1 6,67% 15 Do you think it will be easier if the compass, protractor, and ruler are combined into one practical tool? obviously easier, practical 12 80,00% more hassles like, difficult in drawing 3 20,00%

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