ME – 13

The Development of Module of Learning Quadrilateral Based on Van Hiele Theories

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Abstract— The aims of this research are to know the process and to develop a teaching and learning module using Van Hiele theories in learning quadrilateral for grade VII students in middle school. The relevant research state that nowadays students are instantly generalizing the concept of geometry without further understanding about the properties of geometry and the ability of proving and reasoning. Whereas, the purpose of learning geometry is to achieve the deductive thinking which is in level 2 informal deduction based on Van Hiele geometry thinking level. The survey result state that only 10% of students reached level 2 informal deduction, 56,6% students reached level 1 analysis and the rest of students are still in level 0 visualization. The book of reference for learning quadrilateral or module of learning is not written to reach level 2. The book is only consist of definition and properties of quadrilateral without further learning experience for increasing deductive thinking skill. In order to solve this problem, this research develops a module which is written based on phase of learning geometry. The purpose is to make students think and learn quadrilateral in higher geometry thinking level. The quality of this module is assessed based on contains, appearances, graphics, and language. The method of research is research and development with modification of Borg and Gall and Plump method. The module is verified through trial test in a class of students grade VII in order to get data of validity, effectivity, and practically. The result of this research is a module which is consist of two sections. Section one consist of activities in order to increase level 0 to level 1. Section two consist of activities in order to increase level 1 to level 2. Each section is designed as five phase of learning geometry by Van Hiele.

Keywords: Van Hiele, Quadrilateral, Research and Development, Modul of Learning

I. BACKGROUND

Even though learning geometry seems easy because it studies about shapes which is not too abstract, but students face difficulties and has a misconception about geometry (NCTM in Biber, 2013)[1]. Fujita & Jones (2007)[8] indicate that students face difficulties because they do not have enough understanding about the concepts so they overgeneralize the concepts. For example, in learning quadrilateral, mostly student memorize the properties rather than understanding the concept and link the implication of each quadrilateral's definition (Okazaki & Fujita, 2007[12]). This condition shows that students have not reach the goal of learning geometry which is having skills in reasoning and proving through deduction thinking process (Clements & Battista, 1992[3]).

Based on Van Hiele level of thinking geometry, students in junior high schools can be divided into three level of thinking: Level 0 Visualization, Level 1 Analysis, and Level 2 Informal Deduction (Crowley, 1987[5]). Pre-survey is done at grade 7 students at SMP N 1 Selogiri. The results show that only 10% students reach level 2 Informal Deduction, 56 % students reach level 1 Analysis, and the rest of students stay at level 0 Visualization. Students face difficulties in classification of quadrilateral which is the indicator of reaching level 2 informal deduction. Based on direct interview when students doing the survey, students face difficulties to relate each quadrilateral because previously they learn class of quadrilateral separately.

In theories of Van Hiele geometry thinking level, the level of geometry thinking can be increased using instruction. The instruction is given based on Five Phase of Learning Geometry (Erez & Yerushalmy, 2006[7]). This phase of learning is designed to help teacher design a teaching and learning activities in order to increase students' thinking. In this case, this phase can be designed to help all students reach level 1 Analysis. After that, this phase also can be done to help students reach level 2 Informal Deduction. Other than the design of activities, this phase of learning needs teacher's intervention in facilitating the learning activities. It is happened because the increasing of level of thinking cannot be done naturally, meaning that

teaching and learning geometry need to be done using activities designed based on five phase of learning geometry and teacher facilitation (Burger, 1986[2]).

This 5 phase of learning geometry is arranged systematically as inquiry phase, free orientation phase, explication phase, direct orientation, and integration phase. The teaching and learning activities is arranged based on these phase and should be arranged systematically. In other hand, students' ability of learning is variety. It means that the speed of learning will be different. Therefore, these phase of learning need to be written in module, so students are able to study individually based on their level of thinking (Daryanto, 2002[6]). In fact, module which contain this phase of level is hard to find in Indonesia. Pre-survey shows that commonly the quadrilateral topic is written with order such as definition of quadrilateral, properties of quadrilateral, area and perimeter of quadrilateral, and evaluation. Teacher also follow the order written in book of reference. Commonly, the book of reference does not provide activities to facilitate students to think deductively.

In order to solve problems of limitation book which provide the five phase of learning geometry and urgency of increasing students' geometry thinking level. This research develops a module of learning quadrilateral based on five phase of learning geometry in order to increase the students' geometry thinking level.

Hence, the research question for this research is how is the process and result of development of a module of learning quadrilateral based on Van Hiele theories which is valid? The purpose of this research are to explain the process of develop and produce a valid module of learning quadrilateral based on Van Hiele theories.

II. LITERATURE REVIEW

Van Hiele model in geometry consist of exist of level, properties of level, and movement from one to another level. Exist of level consist of geometry thinking level of a students. It is consist of five level (Burger, 1986).

1) Level 0 is called visualization level. Students in this level are able to give name for selected quadrilateral but they are not able to give correct reason. They likely say "because it looks a like". Students also able to draw a quadrilateral based on its name. The drawing is not detil means there is no sign of similar sides or angles or others.

2) Level 1 is called analysis level. Students in this level are able to link the figure of quadrilateral with its properties. They are able to state the properties or analyze quadrilateral based on properties given. But, students in this level could not show the relationship of quadrilateral.

3) Level 2 is called Informal Deduction level. Students in this level are able to show how one class of quadrilateral has relation to others class of quadrilateral. Students are able to give reason based on properties of quadrilateral. But, students could not give a reason formally and systematically as proofing.

4) Level 3 is called Deduction level. Students in this level are able to proof the geometry statement using postulate, axioma, and proof systematically. This level of thinking is commonly shown by college students or university students.

5) Level 4 is called rigor level. Person in this level are expert in proofing deductively the axioma, prostulate in geometry. They are able to work on both Euclidean and Non-euclidean geometry.

Since, students in secondary level is asked to have ability in reasoning, so the level of thinking of students in sedondary is vary from level 0 to level 2. In properties of level is shown that each level is fix, meaning that students cannot naturally jump from one to another level. In order to move from one to another level, teh teaching and learning geometry should be consist of The Five Phase of Learning Geometry (Burger 1986, Clements & Battista, 1992).

1) Inquiry. This phase is consist of the activity in order to build students' attention towards the field of study that will be taught. Commonly, the activity of this phase is introducing the field of study or the application of the study.

2) Free Orientation. This phase will give experience for students to directly involve in knowing the field study that being taught. The activity of this phase are commonly design as grouping a figures, draw a figures, and others.

3) Explicitation. In this phase, students are ask to state their understanding towards the field study that being taught. Students experience how to link their prior knowledge to the new knowledge they got. Activity in this level is commonly design as identify properties of figures.

4) Direct Orientation. In this phase students get more complex problems in order to apply students' new knowledge.

5) Integration. This phase is designed to summarize all of knowledge that students learnt during the lesson. Activity of this phase is design as making summary of the lesson or making mind mapping of classification of the field study,

III. METHODS

The subject of the test of this research is students of SMP N 1 Selogiri. Subjects are randomly chosen from grade 7. Validator are purposively chosen from mathematics expert, mathematics practitioner, lecturer, and teacher.

This research use research and development method. Research and development method is a method of research which is used to produce a specific product whether software or hardware (Sugiyono, 2012[14]). This research modify the Plomp and Borg & Gall (in Sukmadinata, 2007[15]) model of research and development. The following are research procedure of this research: 1) Initial Investigation: In this stage, researcher do a literature review about Van Hiele theories, analyze students' level of thinking geometry, and analyze the book of reference which is used by students and teacher. 2) Design: In this stage, the plan of module is designed based on literature review result and analysis result from initial investigation. 3) Realization: In this stage, the researcher make realization of module based on theories and analysis into draft 1 module of learning quadrilateral. The systematic of writting module refer to Daryanto (2002). 4) Test, Evaluation, and Revision: In this stage, the draft 1 module is reviewed by validator of media experts and concept experts.

This research need a data of assessment result towards module which is coming from validator in education experts, mathematics experts, and practitioner and students' comments after using this module as learning media. The data contains a content validation of module of learning.

The research instrument of this research is a validation sheet and students' comments. Students' comments is used to collect data of students's comments towards module. Validation sheet is designed as validator reference in assessing the module of learning quadrilateral based on Van Hiele theories. The components in assessing module are consist of (BNSP, 2007[16]) as: 1) Content aspect: Content aspect consist of validity for compatiblity of competence standard, accurate of contents, up to date of contents, compatibility of Van Hiele theories, compatiility of module's components, and effort of increasing geometry thinking level. 2) Presentation aspect: Presentation aspect contains of presentation technique, presentation of learning, and completeness of presentation based on module's components. 3) Language aspect: Language aspect contains of compatibility of students' development mental level, compatibility with Bahasa Indonesia, and systematically of thinking plot. 4) Graphics aspect: Graphics aspect consist of book size, cover design, content design, ilustration, compatibility of paper, compatibility of cover paper.

The data collected is analyzed using content validity analysis. All data coming from validators of content validator and media validity are compared and is analyze in order to do revisions for the module. Data of students' comments is analyze as qualitative data. Data collecting will stop until validator state that the module is valid and ready to use. Revisions are made based on validators' assessment and students' comments.

IV. RESULT

Based on validity contents from validator and students' test, the process and product of this research as follow:

A. Content Validity

Three validator of content expert validate the module based on BNSP's assessment of module. The corrections for module is given as follow:

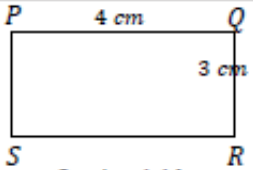
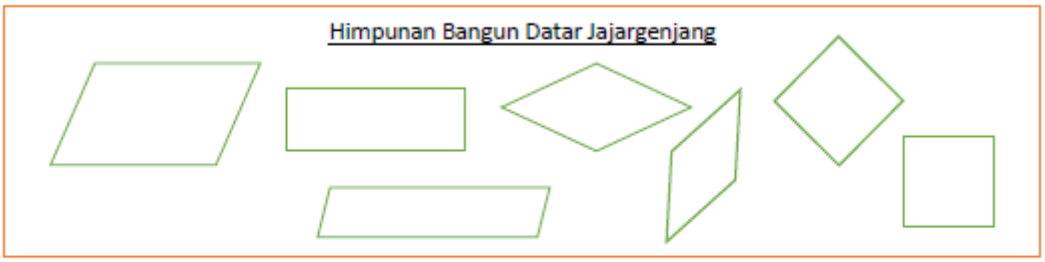
1) Module 1: This section contains of concept of definition and properties of quadrilateral. In this section, students learn about six class of quadrilateral including paralelogram, rectangle, square, rhombus, kite, and trapezoid. Activity of inquiry phase is designed to give a sufficient information for students about what quadrilateral is. The activity chosen is recognizing the quadrilateral shapes in real life. By recognize the quadrilateral shape in real life, students are expected to build their knowing about classes of quadrilateral that will be material of discussion at class. The revision is given to the instruction because the instruction is not clear and easy to understand. Validator suggest to give instruction one by one to make it easy to be understand. Other than that there is no link to classes of quadrilateral. Activity of free orientation is designed to give opportunities for students to getting involve in knowing the topic

discussion. The activity of this phase is grouping quadrilateral into six classes of quadrilateral. Students are expected to be able to grouping the quadrilateral based on its shapes. Revision for this phase is given to the instruction. The instruction is given one by one to make it clear and easy to understand. The revision is made as table 1. Activity of explication phase is designed to encourage students to be able to explain their opinion about topic discussion. The activity of this phase is identify the properties of each class of quadrilateral at section "Tugas". Revision is given to the illustration of the properties in order to help students with visualization level. The instruction of material also revised in order to be easily understand. The revision is made as table 1. Activity of direct orientation is designed to give opportunities for students to work on more complex task. In this phase, the activity is to identify the properties of certain quadrilateral problem. The detail is made as table 1. Activity of integration phase is designed to summarize the topic of discussion. The activity is making a definition for each class of quadrilateral. As addition, given shapes of set of certain quadrilateral in order to help students with visualization level. The detail is made as table 1. As addition for integration phase, the module provide a summary of the properties of quadrilateral. Validators suggest to add more accurate properties and accurate definition of quadrilateral. Other than that, validators suggest to add shapes with specific mark to help students in visualization level.

TABEL 1. ACTIVITY OF MODUL 1

<table>
<tr><th>Phase</th><th>Activity</th></tr>
<tr><td>Free Orientation</td><td>
KEGIATAN 1.1: MENGELOMPOKKAN SEGIEMPAT
Pada kegiatan sebelumnya, kamu menemukan beberapa jenis segiempat yaitu persegi panjang, persegi, jajargenjang, belah ketupat, layang-layang, dan trapesium.
Pada kegiatan dibawah ini kamu akan mengelompokkan keenam jenis bangun segiempat. Ikutilah petunjuk berikut!
1. Potonglah bangun-bangun segiempat dibawah ini.
2. Kelompokkan menjadi 6 jenis segiempat.
3. Tempelkan pada Tabel 3, serta beri nama jenis segiempatnya.

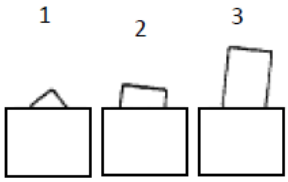
</td></tr>
<tr><td>Explicitation</td><td>
TUGAS 1.1 : Identifikasi sifat-sifat persegi panjang dengan tabel berikut ini!
Tabel 5. Sifat-sifat Persegi Panjang
<table>
<tr><th>Gambar</th><th>Sifat</th><th>(coret pernyataan yang salah)</th></tr>
<tr><td>  </td><td>Panjang sisi yang berhadapan.</td><td>Sama/tidak sama panjang.</td></tr>
<tr><td>  </td><td>Kedudukan sisi yang berdekatan.</td><td>Sejajar/berpotongan tegak lurus/ berpotongan tidak tegak lurus.</td></tr>
</table>
</td></tr>
</table>

Direct Orientation	**SOAL 1.1 : Jawablah pertanyaan berikut!**  Gambar 1.14 Gambar di samping adalah persegi panjang PQRS. 1. Sebutkan panjang dua pasang sisi persegi panjang PQRS yang sama panjang!
Integration	**DISKUSI 1.3 : Jawablah pertanyaan-pertanyaan diskusi berikut!**  1. "Jajargenjang adalah segiempat yang panjang sisi berhadapannya sama". Apakah pernyataan di atas cukup untuk menggambarkan jajargenjang? Jelaskan!

2) Module 2: Learning activity 2 contains a discussion about classificatin of quadrilateral. Through this activity, students are expected to reach level 2 informal deduction thinking level. Activity of inquiry phase is knowing about changes of sides or angles which imply a class of quadrilateral become another class of quadrilateral. Students are expected to aware about the relationship of each quadrilateral which is the topic discussion of this section. Validators suggest a revision to the instruction Activity of free orientation phase is experiment of changing sides or angles. Students are expected to experience the changing of sides or angle so they recognized the relationship. The detail is made as table 2. Activity of explication phase is making a Venn diagram of relationship of quadrilateral. Students are expected to show their opinion of quadrilateral relationship that has been discussed. Validators suggest to put a picture of the Venn diagram in order to make student easily understand the instruction. The revision is made as table 2. Activity of direct orientation is answering more complex problem about relationship of quadrilateral. Validators suggest to revise the instruction. The revision is made as table 2. Activity of integration is classify the quadrilateral. Students are expected to use all their knowledge about topic discussion to summarize the classification of quadrilateral. The activity is made as table 2.

TABEL 2. ACTIVITY OF MODUL 2

Phase	Activity

Free Orientation	**Eksperimen** **Lakukan eksperimen pada bangun segiempat dengan mengubah ukuran sisi atau sudutnya.** **Ikutilah petunjuk berikut!** 1. Buatlah **sebuah segiempat** (pilih persegi panjang, jajargenjang, atau belah ketupat)!
Explicitation	**TUGAS 2.1** **Buatlah diagram Venn yang menggambarkan hubungan antara himpunan bangun persegi panjang, persegi, jajargenjang, dan belah ketupat!**
Direct Orientation	2. **Misteri Gambar Segiempat**. Sebuah segiempat diambil dari sebuah amplop secara perlahan-lahan seperti gambar berikut. Gambar diambil dengan cara menarik atau merotasi bangun segiempat. Tebaklah kemungkinan gambar yang akan muncul! a.  Gambar 2.7 Kemungkinan bangun apa yang akan muncul? _____
Integration	**DISKUSI 2.1: Berdasarkan Diagram Venn pada Tugas 2.1, jawablah pertanyaan berikut!** (Sumber: Fuys, David., Geddes., & Tischler, Rosamond. 1988. The Van Hiele Model of Thinking in Geometry Am Adolescents) 1. Apakah persegi merupakan anggota kelompok persegi panjang?_____ Mengapa?_____ 2. Apakah persegi panjang merupakan anggota kelompok kelompok persegi?_____ Mengapa?_____

B. Media Validity

1) Cover: Cover is designed to illustrate the topic discussed in the module. Validators suggest to make a specific illustration according to the classification of quadrilateral. The illustration must contain the classification of quadrilateral because that is the uniqueness of this module. Revision is made as figure 1.

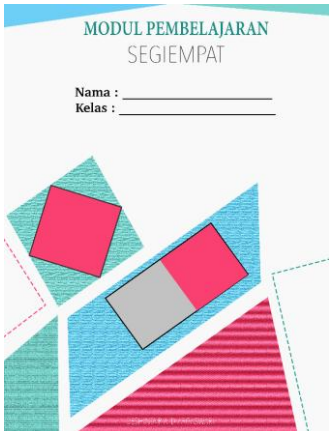


FIGURE 1. MODULE COVER

2) *Clipart:* Cliparts is used to gain students attention to the module. Validator suggest to use a pictures of application of quadrilateral in real life rather than using clipart. It is used to gain more attention and avoid students' boredom. The revision is made as tabel 3.

TABEL 3.CLIPART

Section	Picture
Clipart before revision	
Clipart after revision	 

C. Students' Test

The module is tested to 11 subjects coming from grade 7 students using random sampling. The purpose of this test is to see how well this module help students to learn quadrilateral. Some revision is made due to students' comments after using the module as learning media. All of students agree that the module help students to learn quadrilateral. For module 1, 63,6 % of students like to work on quadrilateral introduction on inquiry phase, 18,1 % students likes identification of quadrilateral's properties, 9,09 % students like matching pair, and 9,09% students like others. Students who like quadrilateral intoduction state that they like this activity because they enjoy to grouping the quadrilateral and they are able to directly learn how to distinguish the quadrilateral into six groups of quadrilateral. Students who like identify the quadrilateral's property state that they like this activity because they are able to understand easily the properties of quadrilateral.

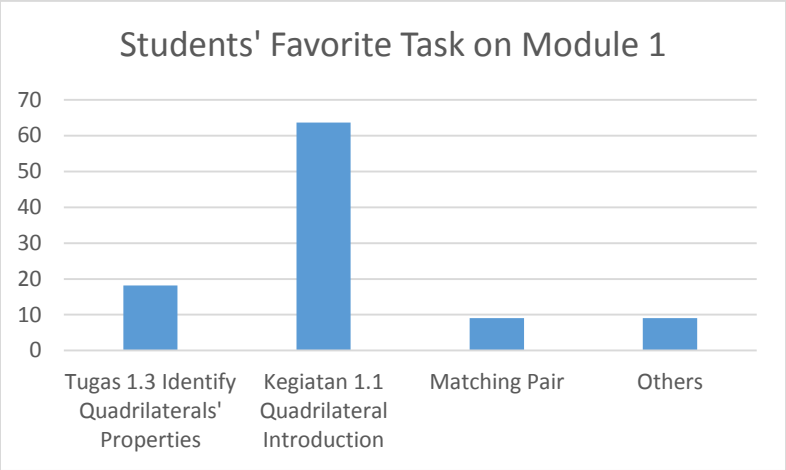


FIGURE 2. STUDENTS' FAVORITE TASK ON MODULE 1

For module 2, 45,5 % students like to work on experiment task, 18,2 % students like Venn Diagram, 18,2 % students like Soal 2.1, and 18,2% students like others. Students who like experiment task state that they like this activity because they learn something new about quadrilateral. They just know that there are relationship of quadrilateral by changing the angles or the sides. Venn Diagram also being liked by students because students can easily understand the relationship of quadrilateral. Soal 2.1 is impressed students as students state that it was fun answering the problem.

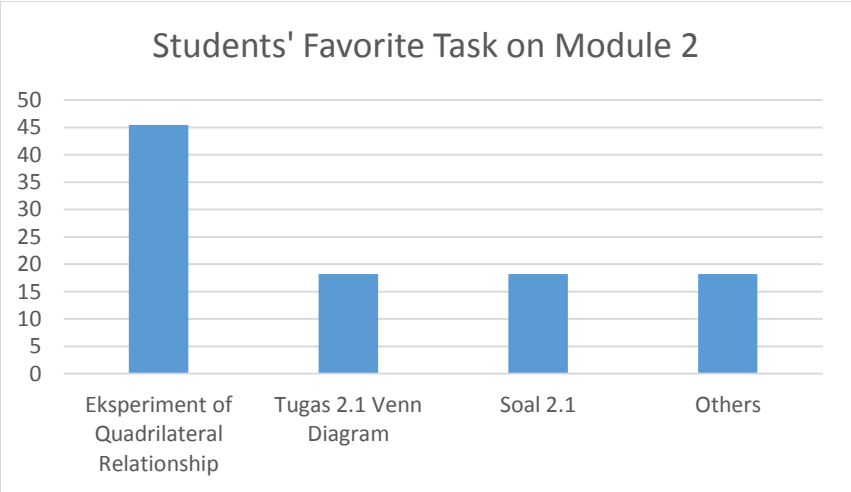


FIGURE 3. STUDENTS' FAVORITE TASK ON MODULE 2

Students face some difficulties to work on module. 9,09% students difficult to work on "Diskusi" where students are ask to summarize the minimum properties of quadrilateral. 18,2 % students face difficulties to understand the definition of parallelogram.

V. DISCUSSION

Through this result, it shows how to implement The Five Phase of Learning Geometry by Van Hiele step by step. For Module 1 which contain of the definition and properties of quadrilateral, the inquiry phase supposed to stimulus students to know the application of quadrilateral in the real life. As addition to gain students interest, module should use the variety of picture of application of quadrilateral. Free orientation phase can be given by grouping the quadrilateral because it helps students to distinguish the classes of quadrilateral. 63,6% students like to work on this activity because students experience by them self how to distinguish the quadrilateral and it is easy to use by the students in visualization level. Because it is the beginning of module, module should be able to help students in the lowest level. Explicitation phase can be given by identify the quadrilateral properties. Based on test result, it can be seen that the format of picture and table of this activity helps students easily understand the properties of each quadrilateral. But students face difficulties on parallelogram topic. It is happened because the

definition used in this module is different from the previous one. Naturally, students get confused at the first time, but then by using this definition in the following activity, students can build their undertanding deeply about parallelogram. The direct orientation phase is given by working on complex problem. Last, integration phase can be given by discussion of the minimum properties. 9,09% students state that this activity is quite difficult for them because they need to understand the minimum properties. The next revision of module 1 is given to integration phase consider to the level of difficulties for students.

For module 2 which contains of the relationship of quadrilateral, the inquiry phase is given by build the students' awareness of the relationship of quadrilateral. After that, the free orientation phase is given by experiment to make specific quadrilateral become another class of quadrilateral. Students show enthusiasm in this activity by giving positive comments because they learn something new about quadrilateral. This activity success to give students an experience by themselves in proving the relationship of quadrilateral. The next phase is given by asking students to make a Venn Diagram of the relationship of quadrilateral. Students give positive comments because they feel easily understand the relationship through Venn Diagram. The direct orientation phase is given by working on problems. Mostly problems are posted to gain students' ability in reasoning. On problem quadrilateral mystery, students state that it was fun to guess the quadrilateral. Last, the integration phase is given by asking the relationship. In this phase, students are ask to proving and reasoning by the definition and properties of quadrilateral.

VI. SUMMARY

The process of making the module is summarize as: 1) Review Van Hiele theories especially The Five Phase of Learning and review the topic quadrilateral, 2) Design the activities and questions, 3) Write the draft 1 Module, 4) Test to students and test to validators, 5) Revise based on validators and students' feedback. The module is assessed based on its contents validity of validators. The valid module consist of activities based on the five phase of learning geometry. The valid module consist of: 1) Be familiar with quadrilateral in real life as inquiry phase, 2) Grouping quadrilateral as free orientation phase, 3) Identify quadrilateral's properties as explicitation phase, 4) Solving problem as direct orientation phase, and 5) Summarize the definition of quadrilateral as integration phase. The suggestion for futher research is to consider the integration phase. Some students face difficulties when they need to express their ideas in writting. The module design might included an activity as pre-activity before activity which ask students to write their ideas or opinion.

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