**Original Research Article**

# Tetrahedral Representative-Based Reaction Kinetics Teaching Materials with an Ethnoscience Approach to Improve Students' Critical Thinking Ability

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## Abstract

Critical thinking is part of the skills needed in science learning in the 21st century. However, the PISA test results show that the level of critical thinking abilities of students in Indonesia is still relatively low. This research was carried out as an effort to overcome this, by developing teaching materials on reaction kinetics based on tetrahedral representations with an ethnoscience approach to improve students' critical thinking skills. This research was carried out in development stages involving 5 expert and practitioner validators and 66 students. Data was collected using questionnaires, observation sheets and test instruments. The data analysis technique used is descriptive data analysis technique, namely by describing the validity, practicality and effectiveness of the teaching materials being developed. The results of this research show that the teaching materials developed are very valid with a validity score of 90.91% and very practical with a practicality score of 90.97%. These results indicate that the teaching materials developed are suitable for use in order to improve students' critical thinking abilities.
**Keywords:** Ethnoscience, Reaction Kinetics, Tetrahedral Representation, Critical Thinking Skills.

# INTRODUCTION

literacy and thinking critically is part from something skills used for apply knowledge in construct knowledge new, take conclusion based on evidence scientific, giving explanation scientific, applied knowledge and develop pattern think evaluative and reflective (OECD, 2019). Scientific literacy has linkages tightly with results Study students, because competence scientific literacy plays a role important in achievement competence learning and improvement results Study. Indonesian students' scientific literacy from year to year experience significant decrease. If compared with other countries. This matter proven with results PISA test year the latest (2018), shows that score Indonesia's scientific literacy is 396 out of 500 (International average score) and is in 70th place out of 78 participating countries PISA 2018 test (OECD, 2018).

Literacy chemistry including part from one deep scientific literacy realm knowledge knowledge nature. Chemistry material studied at school or at college tall most of them nature abstract and difficult. Interpretation from a number of material learning chemistry need ability good literacy. Because his learning own three representation main that is macroscopic, symbolic and microscopic. Representation macroscopic concerning observation with senses. Explain all something symptom conscious chemistry or observed five senses is phenomena at the level of representation macroscopic (Khair *et al*., 2020). Representation symbolic explain representation chemistry at the symbolic level refers to atoms, molecules, and compounds like equality chemistry, formula chemistry, symbols, and numbers. Meanwhile, the microscopic level is an observable chemical process in a way macroscopic explained based on nature, form, change, and interaction from particles microscopic like molecule, atom, or electrons (Mater & Coote, 2019). Therefore That is, scientific literacy is Skills the main

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thing is to do it owned student or prospective teachers in Study chemistry.

In understanding for deepen mastery to material learning chemistry, students as well as teacher No can rule out one from three levels of representation the. The three levels of representation the must owned and controlled by students or candidate teacher in matter. This student in a way deep and comprehensive. However , learning takes place during This only emphasizes representation symbolic form mastery material theoretical and formula with rule out deepening material learning chemistry down to the microscopic level as well as student tend memorize sub- microscopic level rather than understanding it (Rohbou *et al*., 2015). This matter in line with studies Introduction to School level on or equal like high school in Banjarmasin, that in learning chemistry in class only focuses on theoretical and mathematical and ignores representation other.

One of material demanding chemistry scientific literacy and more think critical in his learning that is material kinetics reaction. Kinetics material reaction own characteristics related concepts in life daily. Apart from that, material This own representation submicroscopic like theory collision and molecular influencing factors rate reaction (Ain & Mitarlis, 2020). So, deep reach competence learning material kinetics reaction necessity good scientific literacy with maximizing learning in all representation chemistry.

Representation chemistry can be built by the teacher or lecturer with create atmosphere learn what doesn't only focus on knowledge theoretical and mathematical just one of them that is with use of learning media charged representation chemistry. Research result Hatimah & Khery (2021) shows positive data about the influence of learning media that contains multiple representations chemistry to enhancement participants' scientific literacy educate. This matter caused Because load representation chemistry in developed media will construct understanding student No only One side (symbolic) only, but capable process knowledge they to in third representation chemistry.

Researcher develop learning teaching materials kinetics reaction based tetrahedral representation as one teaching materials for increase student scientific literacy. This teaching material chosen Because is self-contained and self-instructional, i.e. material learning made for student can make use of any teaching materials increase literacy science student in a way comprehensive and

deep. Development based teaching materials This tetrahedral representation is advanced from multiple representations chemistry, however in tetrahedral representation exists element or element man. Draft representation This coined by Mahaffy with develop representation in learning chemistry from planar triangles become tetrahedrons. Difference mainly is at the peak fourth representation tetrahedal describe dimensions man in chemistry (Mahaffy, 2004). Existence element man will make it easier student or prospective teachers relate chemistry with problems that exist in the environment around and in depth material down to the sub- microscopic level will impact on students' scientific literacy or prospective teacher.

Learning media developed is carried out approach Ethnoscience in the media as representation (elements man). Approach ethnoscience in tetrahedral representation forms teaching materials consisting of from elements tetrahedral representation with stages learning ethnoscience. Learning that uses draft culture as source learn, can increase ability student or student in use science knowledge, p This in accordance with opinion expressed by Dewi *et al*., (2019) via learning based culture prospective teachers will do observation in a way direct so that can identify question scientific, explaining phenomenon scientific as well as interesting relevant conclusions with condition nature and the changes it makes to natural through activity man.

Loaded teaching materials tetrahedral representation with approach ethnoscience this can introduce student or prospective teachers in learn and understand for describe material learning chemistry in a way comprehensive. Problem or issues circulating in society can presented in teaching materials with different views, so student or prospective teachers can looking problem or issues with corner look comprehensive chemistry. Additionally, aspects microscopic in teaching materials will give more understanding deep and comprehensive to student related learned content like kinetics reaction this.

## METHOD
Study this is type study development or *Research and Development* (R&D). The products produced is worship learning teaching materials kinetics reaction based tetrahedral representation with approach ethnoscience with a development model is Tessmer model.
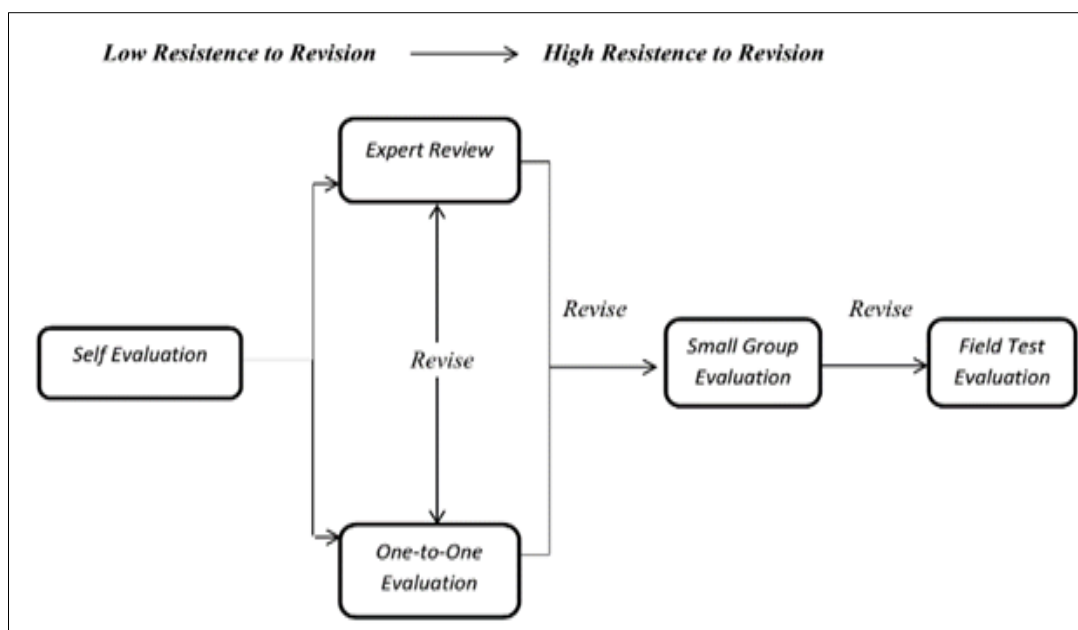
**Figure 1: Tessmer Model Research Design Flow**

There are two types subject in study This namely 5 validators and 66 students chemistry Class of 2020/2021 study program education chemistry FKIP Lambung University mangkurat Banjarmasin, meanwhile object study This are learning teaching materials kinetics reaction based tetrahedral representation with approach ethnoscience as well as instruments and devices study. Instrument research used in study This are (1) instruments validity that is through questionnaire validation teaching materials and devices, (2) instruments practicality that is through questionnaire readability, questionnaire response teacher, questionnaire response student, sheet observation ability teacher use teaching materials and sheets observation implementation learning, and (3) instruments practicality that is through test ability think critical and literacy science. Data obtained analyzed with use analysis descriptive based on category or criteria validity, practicality and effectiveness teaching materials. As for categories validity Teaching materials are presented in Table 1 below This.

**Table 1: Categories Validity of teaching materials**

| Percentage Validity | Category | Information |
|---|---|---|
| 85.01– 100.00 % | Very Valid | Small Scale Revision |
| 70.01– 85.00 % | Valid | Small Scale Revision |
| 50.01 – 70.00 % | Less Valid | Revision scale big |
| ≤50.00 % | Invalid | Can not used |

(Akbar, 2015)

Teaching materials validated with using 4 aspects that is, aspect content, aspect presentation, aspect linguistic and media aspects. Apart from testing the validity of teaching materials, one of the must criteria fulfilled in determine quality product development learning is product development learning must practical.

Media learning must can with easily accessible and easy studied although limited will tool supporter learning so that possible student can Study with good (Priatna *et al.*, 2017). As for the criteria the practicality of teaching materials is presented in Table 2 below This.

**Table 2: Categories Practicality of Teaching Materials**

| The percentage Practicality (%) | Category |
|---|---|
| 81 – 100 | Very Practical |
| 61 – 80 | Practical |
| 41 – 60 | Enough Practical |
| 21 - 40 | Impractical |
| ≤ 20 | Very Impractical |

(Widoyoko, 2018)

Effectiveness teaching materials be measured with use ability instrument think critical and literacy science, test done before use media (*pretest*) And after use media (*posttest*). Results the test analyzed and categorized as into the based on category OECD 2019. Besides that, done calculation effectiveness teaching materials through n-gain using formula Meltzer as following.

$$\text{N-Gain} = \frac{\text{S post - S pre}}{\text{S max - S pre}}$$

**Description:**
1. N-Gain = nilai uji normalitas gain
2. S post = shoes *test*
3. S pre = shoes postal test
4. S ideal = shoes max

The results of the n-gain calculation are then processed become deep n-gain score form percentage and categorized in Table 3 below This.

**Table 3: Categories Interpretation N-Gain Effectiveness**

| Effectiveness Score % | Interpretation |
|---|---|
| >76 | Effective |
| 56-75 | Enough Effective |
| 40-55 | Less effective |
| <40 | Ineffective |

(Hake, 1999)

# RESEARCH RESULTS AND DISCUSSION

Development of teaching materials in study this using the Tessmer development model. Stages First done in development this teaching material is analysis students and analysis material. Based on studies preliminary work done with interview to teacher from several chemistry teachers at school Banjarmasin State Upper Middle School shows that use of media in learning chemistry still classified low. Results interview state that student or student most reluctant Study chemistry because has a stigma is formed that material learning chemistry that difficult for studied. Next, review from facet material learning influencing factorsrate reaction own characteristics abstract and unique concept. If explained with method teach lecture of course, then student or prospective teachers do not capable reach objective learning for understand and deepen material to the molecular level and how application material in real life. Based on analysis carried out, researchers interesting conclusion that development This teaching material is very necessary for developed, implemented as well as tested as a learning medium chemistry interactive.

Based on results stages analysis, researcher do preparation teaching materials in form draft with gather resource materialsand compile device and instruments study for help data collection and recapitulation quantitative on moment study. As for results from stages this is form framework ready teaching materials developed and devices study who is ready used. Teaching materials and devices study then enter stages development. In stages this, researcher develop teaching materials with using the website *flippingbook.com* with do inputting videos, images as well as ingredients shaper

teaching materials. Besides That, on stages development done test validation teaching materials and devices study. Result of stages This is ready teaching materials tested as well as device worthy research used.

Teaching materials and devices research that has been validated enter stages revision (evaluation) before tried out. Results revision teaching materials and device study Then used in stage implementation that is use teaching materials in learning chemistry Which Can used direct by prospective teacher or student as well as teacher. Before and after learning ongoing, researcher do test literacy science with share ten question to participant educate who will compared to the increase. Apart from that, researchers also shared questionnaire response for now practicality from developed teaching materials. Result of stages this form data *pretest* and posttest as well as data response student who then processed become results study. Through a number of stages above produces 3 analyses, namely analysis validity, practicality and effectiveness teaching materials after group testing held.

## A. To the Validity of Teaching Materials

Teaching materials that have been developed Then validated by a team of validators with objective for test validity as well as appropriateness before next to stage furthermore that is stage implementation. The combination of validators includes 5 suitable lecturers his competence. There is a number of Rated aspect in validation this teaching material that is aspect appropriateness content, appropriateness presentation, appropriateness language and appropriateness media. Results test validation developed served in table following This.

**Table 4: Test Results Validity of teaching materials**

| Aspect | Validator | | | | | Mean | % |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | | |
| Contents | 54 | 55 | 53 | 56 | 55 | 54.60 | 91.00 |
| Presentation | 61 | 61 | 56 | 60 | 58 | 59.20 | 91.08 |
| Language | 47 | 48 | 43 | 47 | 44 | 45.80 | 91.60 |
| Media | 43 | 40 | 41 | 41 | 37 | 40,40 | 89.78 |
| Amount | 205 | 204 | 193 | 204 | 194 | 200 | 90.91 |
| % | 93.18 | 92.73 | 87.73 | 92.73 | 88.18 | **90.91** | **Very Valid** |

Based on the table above is known that the average percentage score validation on all component by all validator as big as 90.91% with category very valid.

Validation results used as material evaluation based teaching materials of suggestions and improvements from the validator. Aspect appropriateness fill with results validation 91.00% and suggestions for improvement that is repair to objective learning Because not yet meet the ABCD objective format (*Audiance, Behavior, Condition and Degree*). Aspect appropriateness presentation with results validation 91.08% and suggestions for improvement that is necessity addition explanation related base and the approach used in develop teaching materials (tetrahedral representation and ethnoscience). As for the results repair to aspect appropriateness presentation presented in Table 5 following.

**Table 5: Improvement results aspect appropriateness presentation**

| Ethnoscience | Tetrahedral Representation |
|---|---|
|  |  |

Aspect appropriateness Language with results validation is 91.60% aspect with evaluation highest, however Still There is repair related some typo words. Whereas the media aspect is aspect with results lowest validation namely 89.78% because there is repair on the videos used, on previous teaching materials video revision no Can enlarged so that make student difficulty in see in detail the visuals presented in the video. Researcher repair matter This with replace *software* used in make teaching materials. Improvement results making teaching materials more video views practical Because can enlarged and more makes it easier student in watching the video. As for the results repair aspect media suitability is presented in Table 6 as following.

**Table 6: Before and after revision media aspect**

| Before Revision | After Revision |
|---|---|
|  |  |

Based on the explanation above, the teaching materials developed are valid for implemented in learning kinetics reaction chemistry. If reviewed from facet aspect; all aspect evaluation teaching materials are in the valid category. Some suggestions for improvement of the validator used as material evaluation and revision teaching materials before enter stages implementation.

In terms of aspect presentation is one of consideration in selection of learning media because of learning media must can interesting interest and attention participant educate or prospective teachers/ students so the media has to served with structured and organized (Prayuda & Miftahurrizqi, 2018). Apart from that, the presentation also serves components in teaching materials for makes it easier teachers and students in operate or utilise developed teaching materials.

This matter in line with results study Rusmansyah & Almubarak (2020) that strategy learning that contains representation chemistry can help participant educate for understand material chemistry in a way deep. Tetrahedral representation This is supporter presentation main in e- module development Because material in serve to in four form representation chemistry, so that participant educate control draft material in a way comprehensive. Addition results explanation related tetrahedral representation and learning ethnoscience on aspects appropriateness presentation presented appropriateness language is aspect containing assessment rule language Which used in teaching materials, straightforwardness, characteristics sentence Which communicative as well as suitability use sentence with development participant educate. Indicators used for aspect language is as following (Sugianto *et al.*, 2018): 1). Straightforward, that is characteristics sentences that are standard, effective and accuracy structure. 2). Suitability with development participant educate, is indicator evaluation to language used relevant with development intellectual and emotional participant educate. 3). Communicative, namely indicator evaluation to sentence the easy one legible, communicative as well as nature motivating participant educate. 4). Suitability with rule linguistics, is accuracy use Language as well as suitability with spelling Language Indonesia right. As for the results evaluation.

Aspect appropriateness language for all indicator evaluation presented on Image below This.
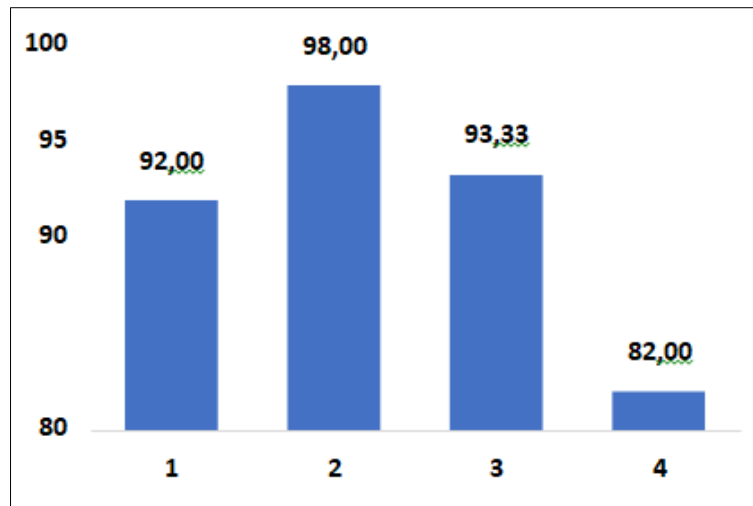
**Figure 2: Results validity aspect appropriateness language**

Based on the picture above show that all indicator evaluation in aspect appropriateness language is in the very category valid, except indicator Which to 4 or suitability with rule language Which is at on category valid with number evaluation as big as 82.00. Matter This caused Because there is use say Which No standard in teaching materials as well Still Lots there is error writing the word No in accordance with EYD or Improved Spelling , as in example following this : Di page 12 from teaching materials are available say " *shit* " Which is tradition from Bali, the writing of the word in teaching materials No italics , On page 13 there is error use sign read that is sign point typed twice ( *double* ), On page 17 there is the word no standard namely "risk". Should "risk", On page 18 there are sentences that don't structured that is exists conjunction "with" at the beginning sentence. Suggestions the become material repair for researcher to aspect language. Aspect language which used on media learning is component main which need noticed because language very tightly connection with understanding participant educate (Amin, 2019). This result strengthened with research by Khairunnisa *et al.,* (2018), that created teaching materials must use good and Correct Language Indonesia, so that in understand material teach No happen error.

Appropriateness media is aspect evaluation e-module from facet appearance media which load evaluation related visual, audio, videos, letter, system location as well as all which relate with appearance product. There is three indicator evaluation to aspect media that is as following (Primary *et al.*, 2021) (Luthfi *et al.*, 2021): Size module, is indicator evaluation to size material aajar appropriate with standard Appearance content, load evaluation to all content which are contained in material ajarl, like images, graphics, videos, proportion letters, colors and aspect appearance other. Characteristics, assessment to Power pull even teach too convenience media use. This matter relates with aspect capable media assessment interesting interest student For

Study related learned content Good from facet both visual and arrangement sentence.

Aspect evaluation media in development very teaching material crucial because influence appearance And Power pull. Matter This in accordance with research by Fadhilah *et al.,* (2020) which states that use of fonts, proper layout, illustrations make teaching materials used more interesting for be read. Additionally, aspects media assessment influences clarity content Which served and proportional visual, videos, text, color and appropriate distance with standard media development (Luthfi *et al.*, 2021). This matter shows that indicator evaluation to aspect media is at on category very valid. Indicator evaluation aspect media with evaluation most low is appearance content with evaluation as big as 86.87. Although in category valid, however need repair to appearance content based on suggestions and comments from that validator the video media container used too small as well as proposition letter and pictures need adjustment. Repair to media done on media videos which used, on teaching materials before revision videos No Can enlarged so that make student difficulty in see in a way details visual Which served in videos. Researcher repair matter this with replace *software* which used in make teaching materials. Results repair teaching materials make more video views practitioner Because can enlarged and more makes it easier in watch the video as well help For Can Study in a way independent. Phase learning independent very important in increase quality learning, p This in line with results findings research by Winarti *et al,* (2021), show that activity learning dialogic just No Enough make student understand draft in a way effective. Therefore that, they must left through phase learning independent And deep.

**B.    Practicality Teaching Materials**
Another must criteria fulfilled in determine quality product development learning is product development learning must practical. Media learning must can with easy accessed and easy studied although

limited will tool supporter learning so that possible student Study with Good. By Because That, before applied in the learning process, product developed learning must practicality test was carried out moreover formerly for now level convenience use product (Annisa *et al*., 2020).

In development this teaching material done test practicality which consists on a number of component assessment, including, questionnaires readability, responsiveness students and responses teacher as well as through sheet observation ability teacher use teaching materials and observations implementation learning. Rating result practicality Teaching materials are presented in table 6 below This.

**Table 6: Practical results teaching materials**

| Component | Mark (%) | Information |
|---|---|---|
| Legibility | 91.40 | Very Practical |
| Response student | 91.73 | Very Practical |
| Response teacher | 92.05 | Very Practical |
| Ability teacher use teaching materials | 91.78 | Very Practical |
| Implement ability learning | 87.88 | Very Practical |
| **Average** | **90.97** | **Very Practical** |

Based on the table and image above show that in a way whole the teaching materials developed were very practical (90.97%) to use in learning chemistry material learning kinetics reaction. This matter in accordance with response interested studentsStudy chemistry use based teaching materials tetrahedral representation with approach ethnoscience, to they Study in a way comprehensive from the complex until simple with use approach Which contextual that is ethnoscience. Apart from that, the teaching materials developed are also easy used Because only with share just. Student can use it in a way easy and practical so that support For Study in a way comprehensive and deep. This matter caused Because in teaching materials are available source or material varied learning and not limited to textual only, but in form phenomena, science info, visuals (images), and videos.

By Overall, the data above show that developed teaching materials effective because load capable tetrahedral representation that maximizes teaching chemistry because load four representation chemistry that is element man, macroscopic, symbolic and symbolic. Representations which are contained in teaching materials will construct knowledge student from the general to the specific. As explained by Ananda & Aini (2022) that learning with chemical tetrahedral representation aim for sharpen understanding student about four levels of thinking. With I see, students can make connection in level submicroscopic for explain matter which are actually occurs in the macroscopic world. This matter relate with characteristics material chemistry which mentioned by Langitsari *et al.,* (2021) that is nature abstract, concrete, contextual, and tiered.

Abstract nature chemistry in material learning kinetics reaction there is in molecular collision and influence a number of factor to rate reaction. Explanation draft abstract material This give rise to error understanding by student, So that can understand learning chemistry in a way intact, then required a

learning media that includes aspect macroscopic, microscopic and symbolic (Anitasari *et al.*, 2019). Additionally, nature concrete can reviewed from representation macroscopic Because material in this level can sensed by students. A number of characteristics chemistry This need explained in a way tiered for form understanding student from Which simple until complex, in matter This assisted by representation symbolic form explanation theoretical and mathematical representation base, improvements literacy science students too influenced by approach ethnoscience Which used in learning. This matter caused Because stages learning Which used use draft learning ethnoscience Which consists from a number of step learning that is *reviews, tasks, solutions, evaluation* and *reflection* (Subali, 2015). Learning with stages ethnoscience This will makes it easier student in understand material, because learning started with orientation combined materials with tetrahedral representation i.e. material learning kinetics reaction in four representations. Additionally, in stages learning carried out there is assignment to be practice ability solution problem student for finish problem scientific.

## CONCLUSION

Reaction kinetics learning teaching materials based tetrahedral representation with approach ethnoscience for increase ability think critical and literacy science student stated: a). Very valid with score 90.91% validity was assessed from aspect content, presentation, language and media. b). Very practical with score practicality 90.97%, rated from a number of components that is questionnaire readability, questionnaire response students, questionnaire response teacher, sheet observation ability teacher use teaching materials and sheets observation implementation learning.

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