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A model of scientific attitudes assessment by observation in physics learning based scientific approach: case study of dynamic fluid topic in high school

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Abstract. This study aimed to produce a model of scientific attitude assessment in terms of the observations for physics learning based scientific approach (case study of dynamic fluid topic in high school). Development of instruments in this study adaptation of the Plomp model, the procedure includes the initial investigation, design, construction, testing, evaluation and revision. The test is done in Surakarta, so that the data obtained are analyzed using Aiken formula to determine the validity of the content of the instrument, Cronbach's alpha to determine the reliability of the instrument, and construct validity using confirmatory factor analysis with LISREL 8.50 program. The results of this research were conceptual models, instruments and guidelines on scientific attitudes assessment by observation. The construct assessment instruments include components of curiosity, objectivity, suspended judgment, open-mindedness, honesty and perseverance. The construct validity of instruments has been qualified (rated load factor > 0.3). The reliability of the model is quite good with the Alpha value 0.899 (> 0.7). The test showed that the model fits the theoretical models are supported by empirical data, namely p-value 0.315 (≥ 0.05), RMSEA 0.027 (≤ 0.08)

1. Introduction

Physics is a branch of science that is obtained through scientific methods to unravel the mysteries of matter and its interactions with other objects in the universe. For teaching physics, scientific activity is a learning activity that can restore the spirit of the application of scientific methods to find concepts, laws, principles, theories and other physical products. On the other hand, there are some topics in physics that physics teacher assumed as an abstract matter, because the teacher presents difficulties for scientific activity in the topic. One of them, the topic of dynamic fluid on learning physics in high school. To organize scientific activities through experiments, preparation for carrying out scientific activities quite time-consuming, in addition to the school laboratory facilities are often considered inadequate. For example in the scientific activities with the aim to apply the principles of Bernoulli, the teacher can not perform using venturi meter as in figure 1, because the tool is not owned by the school.

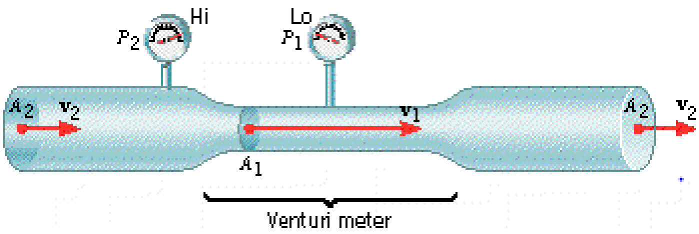

Figure 1. Venturi meter [1]

Based on interviews with teachers, materials related to the application of Bernoulli's principle is rarely taught using trial, more likely is presented in the form of lectures and discussions were accompanied by exercises, individual work or group work. On the other hand, teachers found to meet the assumptions: the flow is steady and laminar, the fluid is incompressible, and the viscosity is small enough to be ignoring [1], rather difficult met. Consequently, the results of data collection, data analysis and conclusions practicum students often do not correspond to the Bernoulli principle.

The situation is causing high order thinking skills and scientific attitude of students is not well developed. To overcome these problems, a teacher must prepare more creative learning by making simple tools and apply a scientific approach. One model of learning that applies scientific approach is Guided Inquiry Learning Laboratory (GIL). The model is in accordance with the teaching of physics to students in high school, because it can improve scientific thinking skills or develop a scientific attitude. GIL is one of the activities the students to identify problems based on phenomena such as formulating problems and hypotheses, designing an experiment with the guidance of teachers, conduct experiments, draw conclusions trial, presented the results of observations of the experiment and work on the problems associated with materials such trials, teachers comment that the ongoing investigation[2]. GIL consists of 5 stages of learning, namely: observation, manipulation, generalization, verification and application[3]. These stages are very relevant to the steps of the scientific method.

The application of scientific approaches assumed to be used as an attempt to develop a scientific attitude of students. Scientific attitude becomes important to be developed, because without scientific attitude the students will lose spirit in the study of physics, especially in high school. Baumel & Berger in his research report provides some suggestions:

- the scientific attitude needs to be examined for all levels of ability,
- science teacher (physics) not only evaluate the ability of knowledge, but the development of scientific attitude of students as well,
- Teachers should provide guidance to students that the scientific attitude is an integrated part of the behavior / habits of learners in everyday life, which includes: intelectual honesty, willingness to admit error, listening to others' ideas, and dealing with facts in an unbiased way makes a favorable and lasting impression upon the pupils [4].

Scientific attitude is a different meaning to the attitude towards science and the ability to carry out scientific procedures. Gardner referred to 'attitudes towards science' (including aspects such as attitudes towards scientists and interest in science) and 'scientific attitudes' (such as openmindedness, Scepticism etc) [5]. Attitudes have emotional content and vary in intensity and generality according to the range of objects or situations over they've apply. Mostly attitude to learn are difficult, extinguishing from affective attributes of personality such as interest, appreciation, likes, Opinion values, ideals and character traits [4]. In further examining this latter construct Gauld and Hukins concluded that 'the components of the scientific attitude Mentioned in the literature seem to fall into three broad groups'. Reviews these groups are:

- general attitude towards ideas and information, such as curiosity, openmindedness, Scepticism;

- attitudes related to the evaluation of ideas and information, Generally labeled as critical mindedness and containing such things as Objectivity, intellectual honesty and caution in drawing Conclusions and making decisions; and
- a commitment to a particular scientific beliefs such as loyalty to truth, cause and effect relationships, etc [6].

The habit of thought associated with scientific thinking deserved more careful consideration. To be scientific mean that one has such attitudes as curiosity, rationality, willingness to suspend judgment, open mindedness, critical mindedness, objectivity, honesty and humility etc. attitude regulate behavior that is directed towards or away from some object or situation group of objects or situations [7]. In other hand, Jones & Butts developing scales for measuring measuring students' scientific attitudes along four dimensions, concern for new evidence relating to currently held ideas, belief in causation, honesty in reporting and scepticism (involving suspension of judgement, concern for evidence and use of many sources of information) [8].

The presence of scientific attitude assessment instruments become part needs to be prepared by the teacher, to monitor the progress of scientific attitude of students. Emphasis on the development of the scientific attitudes was pointed out by Heiss [9] who stated that the development of the scientific attitudes and the ability to use the methods of science are major goals of science instruction. It was further pointed out that considerable attention has been given to ways of teaching the scientific method, whereas less attention has been given to the development of scientific attitudes. In his suggestions for developing the scientific attitudes, Heiss asserted that the main handicap in this area was the lack of an appropriate instrument for measuring these attitudes. There are several forms of assessment instruments that can be used to determine the scientific attitude of students, and assessment instruments in the form of observation is a model that assumed matches assessment for the scientific approach, especially with models Guided Inquiry Laboratory. The results of the Kozlow & Nay provided the inspiration to develop forms of assessment is not only using the techniques of inventory. In line with the development of educational measurement, has so far not been found studies that develop assessment instruments scientific attitude in learning high school physics which use techniques other than inventory, such as the valuation techniques of observation and assessment colleagues [10].

Based on the above issues, this study was focused on the preparation of the models of scientific attitude assessment for teaching physics in high school. The valuation model is expected to help teachers to foster the development of a scientific attitude of students in the organization of learning physics that apply scientific approach, with case studies on the topic of dynamic fluid.

2. Method

This study uses a model of research and development of Plomp which uses five phases, namely the preliminary investigation phase, design phase, realization/construction phase, test, evaluation, revision phase, and implementation phase [11]. This research was conducted in Surakarta, using schools representing of high, medium and low achievements in 2016. The determination used these schools using purposive sampling technique. The schools name were SMA N 1 Surakarta, Batik 2 Surakarta SMA and SMA Al Islam Surakarta, with the number of subjects was 122 students. Data related to school achievement accessed from the new admissions system online in Surakarta on http://www.ppdbsolo.net. These schools have laboratory facilities and supporting scientific activities in teaching physics.

The quantitative data obtained from observation sheet with rating scale and semi-questionare with likert scale. Qualitative data obtained from focus group discussions, interviews, and observations. Data analysis technique performed quantitatively and qualitatively. Analysis of quantitative data used to obtain evidence of the validity of the content by using a formula Aiken [12]. Analysis to obtain evidence that a valid instrument construct's, using confirmatory factor analysis of order 2^{nd} by using a version of the lisrel 8.50 program, while for reliability using Cronbach Alpha formula. Qualitative data analysis is used to describe the comments of validator and students to the developed product.

3. Result and Discussion

The instruments developed in this study to assess the attitudes of students, with the scientific observation by teachers in teaching physics. Scientific activity is a prerequisite assessment and trials carried out on the topic Fluid Dynamic. In the study, scientific activities carried out by the scientific approach, especially with models Guided Inquiry Laboratory (GIL). Components scientific attitude assumed to be observed in every phase of the learning model GIL, with a guide in Table 1. Teachers can use in the assessment of these guidelines, but it may be possible scientific attitude to be expected in the indicator is not according to the guidelines.

Table 2. Syntax of GIL and Observed Components of Scientific Attitude

GIL Phase	Student Activity	Scientific Attitudes Observed
Phase 1 *Observation*	Students observe natural phenomena that exist. Students describe in detail what they saw. Questions in the beginning used to help students in the process of discovery.	Curiousity,
Phase 2 *Manipulation*	Students provide suggestions and ideas for the investigation of finding answers to the problems. Students design and conduct experimental procedure designed	Curiousity, Open-mindedness
Phase 3 *Generalization*	Students make observations on the results of the experiment, collect data and establish principles or rules of appropriate data. Students discuss the results of observations logically based on data findings	Objectivity, honesty
Phase 4 *Verification*	Students present findings that other groups interested in his findings as well as to prove the results of experiments on each group.	Objectivity, Open-mindedness
Phase 5 *Application*	Students conclude the findings. Students are guided to solve the problem of applications in everyday life by administering a matter or issue	Willingness to suspend judgment, Perseverence

In GIL learning model, each student is grouped with each group consists of a maximum of 5 students. One sheet of assessment instruments used to assess the scientific attitude of the group. The instrument contains statements related to student activities should be observed, selection assessment score that consists of the numbers 1, 2, 3, 4, 5 and rubric to help teachers in providing assessment scores. Table 2 presented the examples of instruments and sections.

Tabel 2. Sample Instrument of Scientific Attitudes Assessment

No	Observed activity	Student Name:			
		1	2	3	4
1	Before starting eksperimen activity, teacher ask to student for learning the task sheet and student disposed as				

Instructions for giving a score:
Score 1: quite
Score 2: reading the task sheet, but lean quite
Score 3: reading the task sheet, and ask to her / his friend
Score 4: reading the task sheet, and ask to her / his teacher

Instruments model of scientific attitude assessment in this study was observations form, which include grilles, observation sheets (instrument), assessment guidelines and scoring rubric. Constructs instruments of scientific attitude assessment developed, consists of 6 components and 13 indicators. Item 2 for indicator 2 was bad items that eliminated, so the result of development of instruments received 12 indicators with 12 items, each item is represented by two items. In Table 3 are presented the components and indicators are reported as a result of research.

Table 3. Component and Indicator of Scientific Attitude Assessment in Physics Learning at High School

Component of Scientific Attitudes	Indicator	Item Code	No Item
Curiousity	1.1. Prioritize asked to face the new situation	CR 1	1
	1.2. Having a desire to update knowledge	CR 2	2
Objectivity	2.1. Observing and recording the facts without the influence of personal pride	OB 1	3
	2.2. In interpreting the results of observations are not influenced by others	OB 2	4
Wilingness to Suspend Judgment	3.1. Do not rush to draw conclusions before enough evidence collected	SS 1	5
	3.2. Willingness to accept the facts as supported by convincing evidence	SS 2	6
Open-mindedness	4.1. Willingness to renew their opinions and conclusions	OP 1	7
	4.2. Not necessarily reject the opinions of others	OP 2	8
Honesty	5.1. Report the observing result despite contradict with hypotesis	HN 1	9
	5.2. Assume all available information/data when establish conclusion	HN 2	10
Peserverence	6.1. Complete all scientific activities until end	PS 1	11
	6.2. Not giving up when doing practicum	PS2	12

Results of reliability analysis indicate that the instrument has been qualified reliability with Cronbach Alpha coefficient is 0.899 (≥ 0.70). CFA 2nd order analysis results show the proposed empirical measurement model has a good model fit. Figure 2 shows the fulfillment of criteria, ie, p-value 0.315 (≥ 0:05), RMSEA = 0.027 (≤ 0:08). Rated load factor standard of all indicators in the model of instruments of scientific attitude assessment have met the requirements in the moderate category (> 0.3).

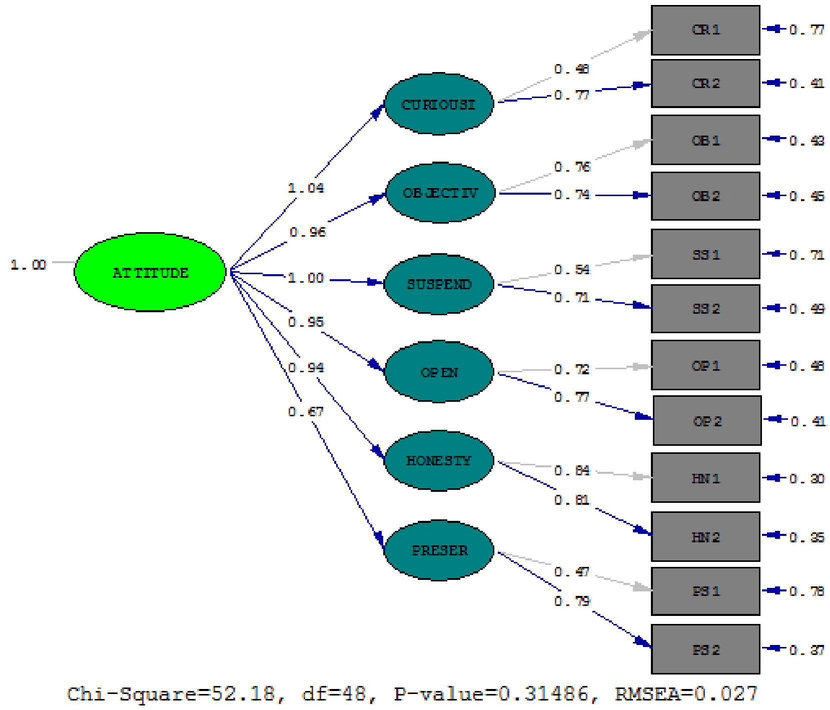

Figure 2. Empiric Model of Instrumen of Assessment Scientific by 2nd order CFA

Decisions of analysis result related goodness of fit, by comparing the index with a cut-off criteria[13] which is presented in Table 4.

Tabel 4. The result of goodness of fit analysis the model of instrumen of scientific attitude assessment

No	Goodness of Fit Index Criteria	Cut of value	Result	Conclusion
1	*p-value*	$>$ 0.05	0.31486	Good fit
2	RMSEA	$\leq$ 0.08	0.027	Good fit
3	RMR	$<$ 0.05	0.025	Good fit
4	NFI	$\geq$ 0.90	0.97	Good fit
5	NNFI	$\geq$ 0.90	0.99	Good fit
6	CFI	$\geq$ 0.90	1.00	Good fit
7	IFI	$\geq$ 0.90	1.00	Good fit
8	RFI	$\geq$ 0.90	0.95	Good fit
9	GFI	$\geq$ 0.90	0.93	Good fit
10	AGFI	$\geq$ 0.90	0.90	Good fit

Empirically, instruments of scientific attitude assessment can be declared to have content validity, construct validity and reliability that meet the criteria. In addition, valuation models with this observation allow teachers to monitor the progress of scientific attitude of students. In general, three components of scientific attitude that needs more attention, namely perseverance, honesty and objectct. Based on observations with qualitative approach, records obtained during the learning physics model GIL, namely:

- Students were motivated to complete scientific activity will decrease as students in other groups have completed the task group. There are some students who gave up or did not complete the task when the hour lesson ends.
- The data collected is not objective, because students must assume as a theory in a book or observations of students in other groups.
- Some students did not write the data to be honest, because students were afraid the results of observations are not consistent with the theory.

Scientific attitude identified the weak, due to some students' mistakes in the process of scientific activity. For example, in an experiment to find the continuity equation, the students make mistakes:

- drafting tool trial (with a hand pump) which does not support the flow of fluid to move with constant
- do not perform step experiments made steady fluid flow, tend to be less serious conduct experiments
- fluid flow is unstable resulting in students not getting proper continuity equation. But students still report what their findings, although aberrant theory
- on tools that use tap water as a source of fluid, the fluid flow is relatively stable, but the water that comes out of the faucet is colorless, so that students have difficulty determining the beginning and end position when measuring time.

Consequently, the results of the experiment the students are not in accordance with the principles continuity. In the example of a table on the observation and analysis of data obtained by the students in figure 3, and figure 4, it can be shown that the experimental results deviate from theory students, but the students made their conclusion in accordance with the theory (shown in figure 5)

The Observation Table Continuity of Principles

No	Hose 1: d_1 = 1,5 . 10^{-2} m; A_1 = 1,766 . 10^{-4} m^2				Hose 2: d_2 = 0,7 . 10^{-2} m; A_2 = 0,385 . 10^{-4} m^2			
	s_1 (m)	t_1 (s)	v_1 (m/s)	$A_1 v_1$	s_2 (m)	t_2 (s)	v_2 (m/s)	$A_2 v_2$
1	0,7	3	2,1	3,7086 . 10^{-4}	0,7	4	2,8	1,078 . 10^{-4}
2	0,7	3	2,1	3,7086 . 10^{-4}	0,7	5	3,5	1,3475 . 10^{-4}
3	0,7	5	3,5	6,1810 . 10^{-4}	0,7	5	3,5	1,3475 . 10^{-4}
4	0,7	4	2,8	4,9448 . 10^{-4}	0,7	5	4,2	1,617 . 10^{-4}
5	0,7	3	2,1	3,7086 . 10^{-4}	0,7	5	3,5	1,3475 . 10^{-4}

Figure 3. Sample of Student's Observation Table

Data Analysis

Based on the observation table Principle of Continuity, value $A_1 v_1$ ....>.......... $A_2 v_2$

(fill in the blank with <, = or >)

Figure 4. Sample of Student's Data Analysis

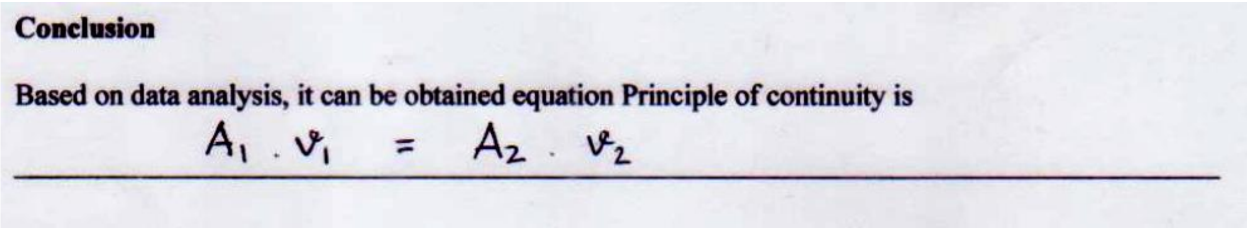

Figure 5. Sample of Student's Conclusion

In this case, the student does not use the data as a source of information in formulating conclusions. Students indicated making conclusions related to the principle of continuity as written in the reference book.

Overall, the model assessment conducted scientific attitude in learning physics, especially with models GIL for dinamics fluid topic, can foster positive scientific attitude. Students looked eager to follow the teaching of physics. On the other hand, teachers can guide students to discover the physics concepts with the scientific method

4. Conclusion

Model scientific attitude assessment in learning physics that has been generated, it used to improve the quality of learning physics-based scientific approach. One of them was implemented through the learning model GIL. Assessment will not be obtained by optimal when learning of physics do not organize scientific activities. Not all components of the scientific attitude can be observed in teaching physics in high school. Components scientific attitude can be assessed using instruments developed in this study, namely: curiousity, objectively, willingness to suspended judgment, open-mindedness, honesty and preserverence. That component, is important component of scientific attitude to be developed and can be observed relative ease in learning physics in high school.

This research has produced the instruments of scientific attitude assessment that meet both criteria, and match the learning model GIL. In addition, the instrument fit for use by teachers in teaching physics in high school, especially on the topic of dynamic fluid.

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