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# The implementation of NGSS-oriented learning at engineering skill programs in a vocational high school: analysis of students' cognitive and psychomotor profiles

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**Abstract.** Oriented learning NGSS developed to Increase the involvement of students in STEM learning, This study aimed to determine the profile of the student's ability in psychomotor and cognitive class X VHS1 and 7 Semarang. This class is a class that is used for implementation NGSS oriented learning chemistry. NGSS dimension is taken PS1B: Chemical Reaction (DCIS), Planning and Carrying Out Investigations; Using Mathematic and Computational Thinking (SEPS) as well as the System and System Models (CCs), This study was included in the descriptive quantitative research. The subjects of this study were 130 at the 10<sup>th</sup> class of State VHS 1 and 7 Semarang Engineering Skill Program of AE and ME. Data were Analyzed using Rasch models with IRT approach. Percentages of students' psychomotor abilities AE and ME reached the MCC (Minimum Criteria of Completeness) respectively 63% and 60%, whereas the results of students' cognitive AE and ME Reached the MCC respectively 6% and 52%. Reviews these based on the data it is concluded that the profile of students in the NGSS oriented learning of AE better in psychomotor aspects, while students ME better in cognitive aspects.

## 1. Introduction

Competence of the 21st century generation students need to have in order to live worthy of the 21st century in the world consisting of three main skills. Three main skills is used as a framework on learning 21st century, namely life and career skills, learning and innovation skills and information media and technology skills [1][2][3][4][5]. 21st century skills is a matter that must be implemented in the learning according to the curriculum in 2013. Application of the 21st century competencies is very influential in Vocational High School (VHS) [6]. Application of this 21st century competencies expected to equip learners VHS levels to face the problems and global competition [7]. The main objective in education VHS is building eight of competency, including problem Solving [8]. The students should be able to solve the problem and be able to adapt to changes that are dynamic [9].

Approach to education in the 21st century competence is the integration of STEM (Science Technology Engineering and Mathematic) [10]. STEM education is to prepare competencies in these multi-disciplines for students to meet the requirements for the 21st century workforce [11] STEM provide space for the development of critical thinking, creativity, innovation, and the ability of students to solve problems [1]. STEM-based science learning in the classroom is designed to provide opportunities for students to apply educational process on solving real problems in daily life or professional life [12]. STEM learning implementation in VHS necessary chemistry for chemistry as adaptive materials should be associated with the material productive employment.



Chemistry as a subject in VHS adaptive expected in line with the needs of productive material. Patterns of Science (chemistry) will be a learning experience relevant to the vocational fields if associated with productive material. One way to make learning chemistry is relevant is to present the STEM approach learning and NGSS oriented. Presentation of STEM learning approach must meet several aspects of the Scientific & Engineering Practice, also describe their crosscutting concept Concept or wedge between STEM knowledge. Curriculum providers are now experimenting with various methods of bolstering STEM education from the elementary to high school level [13][14]. Efforts to reform science education in the United States do with the preparation of a science learning standards known as the Next Generation Science Standards (NGSS). NGSS research has been conducted by [35][36][37][38][39].

NGSS developed to increase the involvement of students in STEM learning. NGSS has three main dimensions, namely Disciplinary Core Ideas (DCIS) (content), Science and Engineering Practices (SEPS) and Crosscutting Concepts (CCs) [15]. DCIS is the cognitive content of chemistry lessons [21]. SEPs address how scientific knowledge develops, with attention to the scientific habits of mind, reasoning skills, and methods of inquiry [16][17]. CCs to understand the similarity of thought from the perspective of different disciplines [18]. Students need opportunities to emphasize processes that incorporate three-dimensional learning NGSS through real-world experience in the classroom [19]. NGSS will dramatically change how students experience science by shifting the focus from the memorization of facts to greater student engagement in the processes of science [20]. Involving students actively in SEPS in the context of DCIS and CCs will appear when learning with NGSS framework [17].

This study was implemented on the student Program of Automotive Engineering (AE) and Mechanical Engineering (ME). Taken two of the Skills Program for NGSS provide the opportunity to include engineering (engineering) in science [15]. Skills Program AE and ME are both part of the engineering department. One among the challenges is to create a NGSS judgment in tasks that include the practice of science and engineering [22]. In which there are chemical subjects so that it can be implemented NGSS oriented learning. In January 2010, countries developed NGSS with the aim of preparing students for college and career readiness in science. Then internationally benchmarked (NGSS) in April 2013 [23]. A description of the best practices of NGSS has been carried out by [24]. [25] have also implemented NGSS crosscutting concepts, which are an opportunity for basic teacher contribution.

Similar studies study of [26][27][28][29][30] has developed the assessment of performance-based STEM science literacy. The study equally analyzed using the approach of Item Response Theory (IRT). [31] suggested IRT is a theory which states that the test results can be predicted or explained by a series of factors called *trait*, *latent trait* or *abilities*, The higher level of ability *testee*, The greater the chance *testee* The answer really an item. Analysis of the test in this study using a model Rasch. Model of the parameters or model Rasch has several advantages that can reveal ability student views of grouping students between expertise and Inter-School Program.

## 2. Methods

This research is a quantitative descriptive research with the aim of knowing ability profile student in cognitive and psychomotor class 10<sup>th</sup> VHS 1 and 7 Semarang. The sampling technique used cluster sampling for engineering majors at VHS wide, but just taken a class X with Expertize Program AE and ME. The subjects of this study were 130 at the 10<sup>th</sup> class of State VHS 1 and 7 Semarang Engineering Skill Program of AE and ME. The instrument used in this study is the assessment of performance laboratory instrument redox material, a set of formative standardized test instruments and instruments a 15-point response of learners towards learning chemistry NGSS oriented. Data collection techniques through documentation, questionnaires and observation sheets. Data were analyzed by descriptive quantitative Rasch model through the program Winstep 3.73.

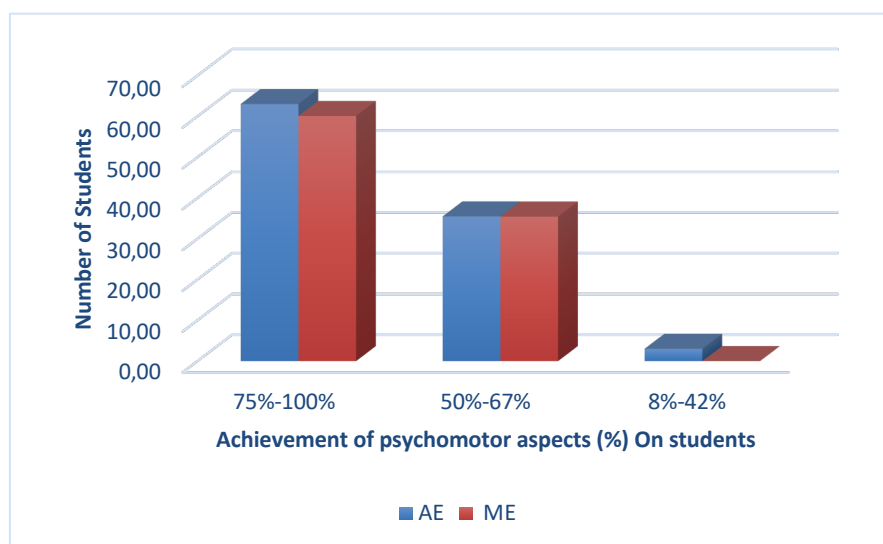
### 3. Results and Discussion

NGSS dimension is taken PS1B: Chemical Reaction implemented because the material is a redox reaction and nomenclature of chemical compounds. SEPS is taken *Planning and Carrying Out Investigations* because there is a lab that investigates how to blow the balloon through redox reactions. Students create and innovate in menggunakan tools and materials that have been provided in order to blow the balloon through a redox reaction to the fullest. In addition, the dimensions of which are also taken SEPS Mathematic and Using Computational Thinking for students also calculate the oxidation numbers and determine a reductant and oxidant after the practicum. CCs in this study took the System and Model System for the original redox reaction is only a theory, this research is modeled through practicum and is associated with the material productively Engineering Program. After the lab work and tests, the following will be presented abilities students on psychomotor and cognitive aspects:

#### 3.1 Psychomotor Aspects Students

Psychomotor observed consists of four aspects: the use of equipment / materials; observation of qualitative and quantitative; record the results; create and present their interpretation of the results. Every aspect has a maximum score of 3. In addition there are aspects psychomotor observation sheet in the form of practical activities, the instrument is also equipped with an assessment rubric to be more objective assessment. Rubric assessment clearly presented. Examples of aspects noted the results revealed to be sub aspects: note the observation is accurate, true and detailed: (1) calculate the time for Sn react, (2) Observing changes in Sn and NaOH from the presence and absence of bubbles, (3) Observing the changes Sn and NaOH from blowed (large/small) bubble, (4) Record equation for the case. Criterion scores are as follows: Score 1 indicate do only one point. Score 2 indicate perform three points. Score 3 indicate perform four points from four sub aspects above.

Data from pshycomotor aspects analyzed using the program Winstep Measure Output Table 17. Person. Graph the percentage of psychomotor on redox-oriented practicum NGSS presented in Figure 1.



**Figure 1.** Percentages of students' abilities in psychomotor aspects.

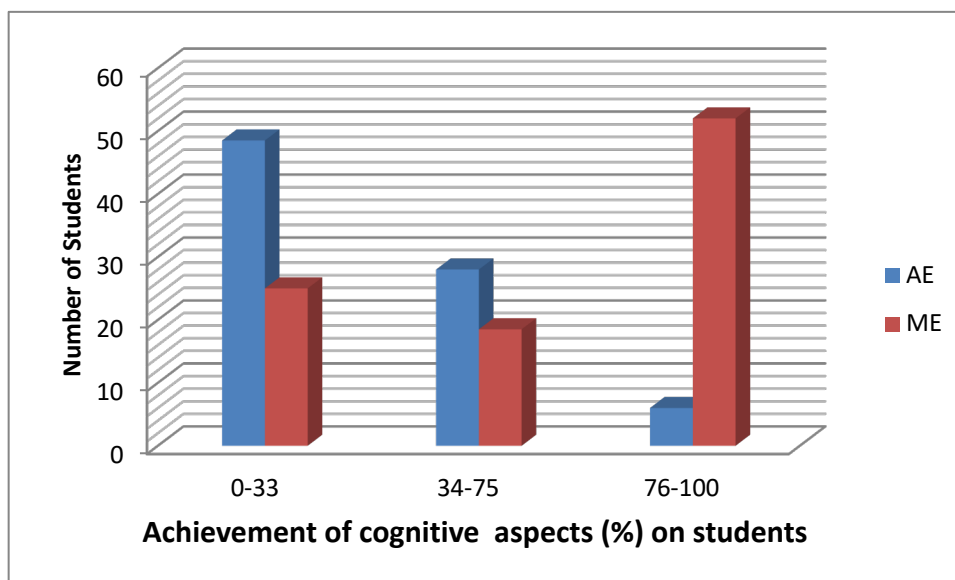
The percentage with a range of 75% -100% in Figure 1 is the percentage of completed or exceeded the value of the MCC. Students with Expertize Program AE gets way more superior than the students with the Program of ME although the difference was not significant (the difference is only 3%). This was in line with the curriculum studied in pogram Expertize AE demanding students to have more skills, such as subjects Image Engineering, Electrical Maintenance Vehicle Light, Maintenance Chassis and Power Shifters Light Vehicles as well as other productive subjects[32].

### 3.2 Cognitive Aspects Students

One of the challenges is to create a NGSS judgment in tasks that incorporate the practice, science and engineering [23]. Prior to the test, there are practical about redox. That practicum is to identify the redox reaction occurs between the cans reacted with NaOH solution. Once the lab is complete, students were asked to write down the redox reactions that occur and calculate the oxidation state of each element / compound. Interest enter the practice, science and engineering is to improve the aspects of knowledge, techniques and technologies by integrating engineering design in the learning process of science. Engineering design in this lab find a solution on the unused cans and NaOH to blow the balloon through redox reactions[33].The next meeting after the practicum is the implementation of formative tests (cognitive). Test item in accordance with the current task-oriented chemistry lab NGSS and associated with the Program of AE and ME according to the studied subject.

The cognitive aspect is assessed through a set of chemical tests NGSS oriented. Before assessing the students' cognitive aspects, firstly researchers developed the test through a series of trials, namely self-assessment, test one to one, small class test, and test large classes. Data from the trial were analyzed to know the quality of instruments that includes the validity and reliability. Final stages of development tests standardized test result amounted to 15 items. Each item consists of three dimensions, namely cognitive dimensions / DCIS, the dimensions of the achievement that must be possessed of learners in the learning / SEPS and linkage chemistry with various disciplines / CCs [16]. Some fourteen (14) out of nineteen (19) NGSS dimension is taken, which is 3 DCIS, 7 SEPS, and 4 CCs.

A total of 15 items were standardized analyzed by Rasch models for known abilitas students' cognitive aspects. The output can be seen in Table 17 (Winstep 3.73). Person Output Output Table 30 (Winstep 3.73). Measure and DIF. Percentages of students ability on cognitive aspects presented in Figure 2.



**Figure 2.** Percentages of student ability on cognitive aspect.

Figure 2 can be explained through the receiving range of 76-100 values or values above the MCC that is as much as 52% can be achieved by students ME and AE students can only reach 6% in the value range. The lowest value is in the range 0-33 made up 48.5% of the students AE, and as much as 25% of students ME. Value of two different VHS show students tend to be more nice ME seen from the cognitive aspect. Causes of ME students better cognitive aspect because tests are tested relating to the calculation. This is suitable with curriculum on ME that the competence concept places emphasis

on the practical use of mathematics and seems therefore to be particularly suitable for the mathematical education of engineers [34]. After that, ME is more often associated with mathematics (calculations) and science thus causing the cognitive abilities of students ME nice.

When compared between VHS A and B in Figure 2, the ability testee better on VHS B. The reason is based on interviews with teachers at VHS A, that learners less importance chemical subjects. One class consists of 36 learners, only 5-10 children seemed enthusiastic when learning. The observations during the learning-oriented chemistry NGSS also shows learners on VHS B seemed enthusiastic when NGSS practical presentation by asking questions and objections, while VHS A look passively at the time of presentation NGSS practicum. A VHS learners only deliver presentations, nobody asked the question.

In this study, there are two groups of testee and 2 groups of Expertize Program. Both Skills Program can be analyzed by DIF that can be seen in which the combination of item bias on a specific group of Expertize Program. The percentage of students abilitas cognitive aspect is strengthened with DIF analyzes are presented in Figure 3.

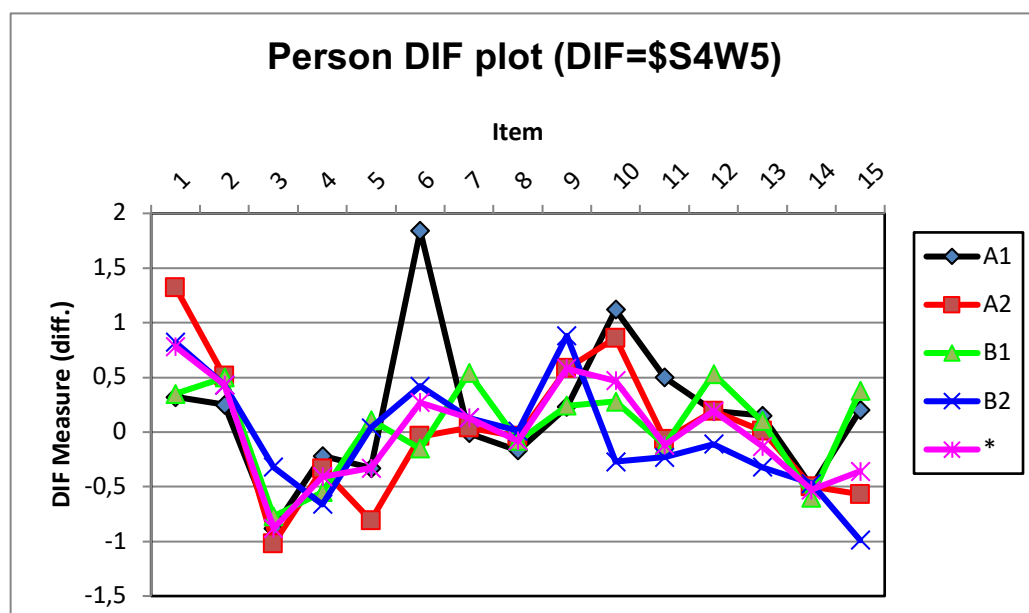


Figure 3. Plots Biased Existence Detection Group.

Figures on the DIF Measure shows the smaller the number, the more is considered difficult by students who work on the item number. Item 6 students hard coded A1 assume that item by level of difficulty indicates the number 1.9. Students with regard B2 code is item number 10 to 15. Thus the student code of B2 (ME Skills Program) considers the easy point 10-15, but to the student code of A1 and A2 (Skills Program AE of SMK N 1 and 7 Semarang ) considers the difficult items. Measure evidenced by the DIF values are getting closer to the top. Results showed students ME Skills Program has better ability to do item number AE 10-15 while students have a weak capacity for item numbers 10-15 are still considered difficult.

#### 4. Conclusion

AE student profile better in psychomotor aspects, although the difference was not significant (the difference is only 3%). The reason is the structure of the curriculum at the Skills Program AE demanding more skills, while students ME better in cognitive aspect because ME Skills Program is

more often associated with mathematics (calculations) and science thus causing the cognitive abilities of students ME nice.

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