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# SCIENCE ADAPTIVE ASSESSMENT TOOL: KOLB'S LEARNING STYLE PROFILE AND STUDENT'S HIGHER ORDER THINKING SKILL LEVEL

**Zulfiani*[1], I. P. Suwarna[2], M. F. Sumantri[3]**

[1,2]UIN Syarif Hidayatullah Jakarta
[3]SMP Al Zahra Indonesia

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## ABSTRACT

This study aims to determine students' profiles of learning styles, levels of higher-order thinking skills, and the effect of differences in students' competence to various HOTS instruments using the Science Adaptive Assessment Tool application. In this study, researcher used the descriptive survey approach. The subjects of this study were 251 students of grade 8 (Al-Zahra Indonesia Secondary school and MTsN 1 South Tangerang (Islamic Secondary school) academic year of 2019/2020. The research instrument used was a test to measure 21st century skills (HOTS), which varied on the learning styles of students studying natural science (Biology and Physics). The instrument was validated by expert judgment and empirically tested in order to obtain instrument reliability of learning style with adequate to high category variations. The results show: (1) the profile of the most popular student learning styles is the assimilator (27,50%), while at least it is converger (20,71%); (2) Females tend to have assimilator learning style pattern, while males tend to have an accommodator learning style; (3) The higher-order thinking skills level in the Biology material was moderate (an average score of 39,69 from a maximum score of 70). The physics subject is in the lower category (an average score of 21,28 from a maximum score of 70); (4) The achievement of the HOTS score was influenced by the type of learning style and had average of a very small correlation, (5) There was significant difference incompetence across the Kolb's learning styles—divergers, assimilators, convergers, and accommodators with the use of various HOTS instruments.



Keywords: learning style; higher order-thinking skill; assessment tool

## INTRODUCTION

21st century learning cannot be divorced from innovative learning models, but it involves an assessment process for learning competency achievement. Several 21st century skills are the top priority in current learning outcomes. Measurement of learning outcomes requires alternative learning models and assessments. Meanwhile, students' potential can be developed by constructing a proper assessment (Bryan & Clegg, 2019; McNeill et al., 2012; Rustaman, 2004; Sambell et al., 2019).

Regarding the principle of assessment for learning, every student has opportunity to achieve complete mastery of competencies. The challenge of measuring 21st century skills, however, is the processes and outcomes that are measured (Laar et al., 2017; Qian & Clark, 2016; Wulan et al., 2018). Therefore, innovative learning models and assessments are needed to provide measurable and valid results (Griffin et al., 2014a; Zlatkin-Troitschanskaia & Pant, 2016) and accommodate the diversity of students (Griffin & Care, 2014b).

21st century skills include critical thinking and problem-solving, creativity and innovation, communication and collaboration, information literacy, media literacy, ICT literacy, life, and

***Correspondence Address**
E-mail: zulfiani@uinjkt.ac.id

career skills (flexible and adaptive, initiative and self-direction, social and cultural exchange skills, productivity and accountability; leadership and responsibility) (Chu et al., 2017; Saavedra & Opfer, 2012).

Several sophisticated skills dominate the context of 21st century skills. In a test, students should not be a subject of information gathering but should be able to find, evaluate, synthesize, use knowledge in new contexts, and arrange and solve non-routine problems. This requires students' competence in progressive thought processes, problem-solving, and design and communication skills (Darling-Hammond et al., 2010).

The existence of technology in learning is in line with the seven principles of smart teaching to build 21st century competencies, which include school climate, fundamental knowledge, knowledge, and organization, motivation factors, developing mastery, self-direct learners, and assessments (Ambrose et al., 2010). Assessment and learning are essential issues and are part of the current education reform (Darling-hammond et al., 2010; Kim, 2018).

The results of the CD and Android versions of ScEd-ALS Development as an adaptive delivery are still experiencing problems (Zulfiani et al., 2018). Constraints were found in the process of evaluating or measuring the competency of students, i.e. (1) the competency measuring instrument is still oriented to the low-level category, (2) the measuring instrument has not measured the competencies needed in the 21st century, (3) measurement of material mastery based on the students' potential is still not measured optimally, so the test results are also not optimal, (4) the questions are not contextual and integrated. The tendency of learning styles in thinking (Kolb) is not considered in the preparation of test questions, so it does not show the best competence of students.

Kolb's learning styles are classified into the following four: (1) Diverging, in which individuals like to see phenomena based on multiple perspectives; (2) Assimilating, in which individuals understand the overarching problem in order to conclude; (3) Converging, in which individuals like to look for practical sides of the theory; and (4) Accommodating, in which individuals prioritize the exploration of challenging experiences. Based on a combination of the four learning styles above, Kolb then divides it into four learning preferences that are applied in measurements using The Learning Style Inventory (LSI), which identifies four categories of learning preferences that are ipsative including conceptual orientation, experience orientation, action orientation, and reflection orientation (Alsa, 2010; Kolb, 2014).

For diverger learners with the dimensions of learning feelings and observations, accompanied by task preferences to generate ideas, then stimulus questions are developed with creative thinking skills problem type. Unlike the case with assimilator learners with the dimensions of learning to think and observe, of which they tend to be more theoretical and prefer to work with abstract ideas and concepts, then the stimulus questions are developed with the type of critical thinking problems.

Converger learners, with dimensions of thinking and doing, like learning when dealing with questions that have definite answers based on experiments, then stimulus questions are developed with the type of science process competence questions. Meanwhile, the accommodator learners with the dimensions of learning feelings and doing, like to apply the subject matter in a variety of new systems to solve a variety of real problems, the stimulus questions are developed with the problem-solving type (Kolb, 2014; Zulfiani & Suwarna, 2019)

Well-designed assessments can improve learning (Association for Educational Assessment, 2010), and this is still of low concern in Europe related to testing quality. The conceptual framework of digital assessment faces a challenge of the complexity of knowledge, capacity, skills that must be assessed, and innovative web-based assessment of innovation both in development, measurement process, and assessment. However, the Computer Adaptive Test (CAT), according to Ferrão & Prata (2014), can be the answer to this challenge. CAT, as a support system, enables the measurement of 21st century skills. Over the past 20 years, the use of CAT has increased and is used in educational assessments on a broad scale. CAT is different from conventional forms of testing. CAT is designed to test each level of the tester, and the item items can be chosen adaptively. CAT is the answer to adaptive tests, which in its development, can integrate the unique personalization of learning styles, cognitive styles, and student achievements (Dascalu et al., 2017; Siakas & Economides 2012). These are very urgent to develop (Truong, 2016), and they are currently online based (Castro & Tumibay, 2019).

Studies related to the use of adaptive assessment techniques have been widely reported. Saul & Wutke (2011) state the possibility of measuring HOTS with Adaptive Assessment System (AAS), which gives measurement opportunities more than factual knowledge, but problem-solving and reasoning strategies. AAS allows for individual student contexts, prior knowledge and personalize assessments. Efforts to integrate adaptive assessments are based on the need for the lack of historical data and statistical information, gender, education, ethnic and cultural levels that have not been integrated into the automation system. The results of previous studies indicate the above factors are very instrumental in determining learning styles (Bidabadi & Yamat, 2010; Omidvar & Tan, 2012; Özyurt et al., 2013; Özyurt et al., 2012). Yang et al. (2013) developed an adaptive learning system based on the cognitive learning model and Felder Silvermann's learning style. The results showed significantly better learning achievements for students who used adaptive learning systems than control group students. Thus, this adaptive system helps improve student learning performance.

Johar (2012) showed the success of Indonesian students in solving PISA questions depends on the evaluation system and the teacher's competence, and Indonesian students are more proficient at questions within the lower order thinking skills/LOTS than HOTS. In Indonesia, studies related to the profile of thinking skills have been widely reported, such as critical thinking skills (Fauzi & Sa'diyah, 2019; Rahmawati et al., 2018), Critical and metacognitive thinking (Fauzi & Sa'diyah, 2019; Palennari et al., 2018), Creative thinking (Madyani et al., 2019), gender-based higher-order thinking skills (Rahayuningsih & Jayanti, 2014). This research study related to the 21st century skills profile is fundamental research that provides the database needed by policymakers in education.

Zulfiani & Suwarna (2019) developed the Science Adaptive Assessment (SAA) —an adaptive assessment application tool—that accommodates the diversity of Kolb's Learning Styles by considering variations in the thought process and the potential career framework of students in the future. The development of SAA Tool in Integrated Science at SMP/MTs levels can measure higher order thinking skills. The SAA Tool can address the technical limitations of conventional assessments that do not reach the diversity of competencies and learning styles because not all students will have the same profession (Zulfiani & Suwarna, 2019). The Sc-Adaptive Assessment tool that will be designed in addition to adapting question items to the student's level of competence will also involve a new variable of 'Kolb's Learning Style,' so this tool has a predictive potential for students' career paths. Moreover, the research results of Yusuff & Idris (2018) show that students at late childhood and early adolescence are at sufficient age to recognize their career potential and interests in science.

For diverger learners with the dimensions of learning feelings and observations, accompanied by task preferences to generate ideas, then stimulus questions are developed with creative thinking skills problem type. Unlike the case with assimilator learners with the dimensions of learning to think and observe, of which they tend to be more theoretical and prefer to work with abstract ideas and concepts, then the stimulus questions are developed with the type of critical thinking problems.

Converger learners, with dimensions of thinking and doing, like learning when dealing with questions that have definite answers based on experiments, then stimulus questions are developed with the type of science process competence questions. Meanwhile, the accommodator learners with the dimensions of learning feelings and doing, like to apply the subject matter in a variety of new systems to solve a variety of real problems, the stimulus questions are developed with the problem- solving type (Kolb, 2014; Zulfiani & Suwarna, 2019)

The developed SAA Tool can summarize learners HOTS profiles while simultaneously recording students' HOTS results on the concepts of the motion system of the organism and simple machine. Since no research result automatically reports data to obtain comprehensive information, this article describes the profile of learning styles, high-level thinking levels of several Year 8 students in South Tangerang, and to perceive whether there are differences in the results of students' HOTS with the intervention of HOTS type variations based on learning styles. The results of this research also provide the initial foundation for the continued development of adaptive assessment research that is in line with the 21st century learning revolution. This revolution cannot be divorced from the involvement of technology in assessment and learning.

## METHODS

This research was conducted at Al-Zahra Indonesia Secondary school and MTsN 1 South Tangerang (Islamic Secondary School) in August – October 2019. The research method used was descriptive survey method. The subjects of this study were Year 8 students of SMP/MTsN who used the learning style-based Science Adaptive Assessment Tool application for Natural Sciences (Biology and Physics).

The study used test (SAA Tool) and non-test approach as instrument. The development of HOT science-based learning instruments test based on learning styles has included the stages of analysis, design, evaluation, and revision. The studied learning styles, according to Kolb. Kolb's Learning Style consists of diverger, assimilator, converger, and accommodator. At the analysis stage, a literature review of Kolb learning style classification was carried out referring to the Experiential Learning Theory and identification of essential competencies in the material systems of living things and simple machine according to the 2013 Curriculum. Next, the compiling questions related to the material to accommodate the material indicators based on the four learning styles of Kolb was conducted.

Based on the learning styles, four packages of questions were validated by a panel of expert, which consists of learning assessment experts and material experts. The instrument was then empirically tested. The value of the reliability of the questions was obtained with the construction of 14 questions, including seven questions concerning the motion systems and seven questions concerning the simple machine.

The reliability Crobach alpha scores of the item instrument for Biology was diverger = 0,639; assimilator = 0,6; converger = 0,67; accommodator = 0,678. However, the scores of item instrument for Physics questions were diverger = 0,650; assimilator = 0,665; converger = 0,565; accommodator = 0,674. SAA Tool used an Android-based CAT platform with MIT App Inventor software.

The results of the analysis of the four learning styles, according to the experts, then concluded four types of instruments that can measure higher order thinking skills. Creative thinking abilities characterize diverger learning styles, critical thinking skills characterize assimilator learning styles, converger learning styles are science process skills, and accommodator learning styles are problem-solving skills (Zulfiani & Suwarna, 2019).

The non-test instrument is in the form of an interview that aims to identify and confirm the profile of learning styles and the results of students' HOTS. The Natural Sciences'(Biology and Physics) question rubric made referred to the characteristics of Kolb's Learning Styles (Table 1 and Table 2).

**Table 1.** Examples of HOTS Question Rubric on Biology with the Material of Motion Systems

| Material | Types of Learning Styles | Competence | Item No. |
|---|---|---|---|
| Joints | Diverger | Proposing alternatives/other activities along with their reasons proving that the joints can move bones (creative thinking skills) | 1 |
| | Assimilator | Making hypotheses proving that joints can move bones but with limited movement (critical thinking) | 1 |
| | Converger | Summing up that joints play a role in the direction of movement (science process skills) | 1 |
| | Accomodator | Providing suggestions for the meeting of the two bones that make up the joint does not experience-collision (Problem-solving) | 1 |

Students worked on a learning style test before using the SAA Tool. Students are given a learning experience test based on Kolb's instruments to identify the right form of test. There are four forms of tests prepared for different learners' learning experiences, i.e., diverger, assimilator, converger, and accommodator.

**Table 2.** Examples of HOTS Question Rubric on Physics with the Material of Simple Machine

| Material | Types of Learning Styles | Competence | Item No. |
|---|---|---|---|
| 1st Category Level | Diverger | Finding/making other ways (creative thinking skills) | 1 |
| | Assimilator | Correct answers or statements (critical thinking) | 1 |
| | Converger | Predicting a variable or an event in different circumstances based on known data/variable (science process skills) | 1 |
| | Accomodator | Finding solutions based on the same variable with different circumstances (problem-solving) | 1 |

After students know their own learning experiences, students can choose the questions that suit their learning style. Students who have already taken the test will get their grades directly. Identification of students and the flow of the use of the SAA Tool according to the explanation above, is explained through the scheme presented in Figure 1.

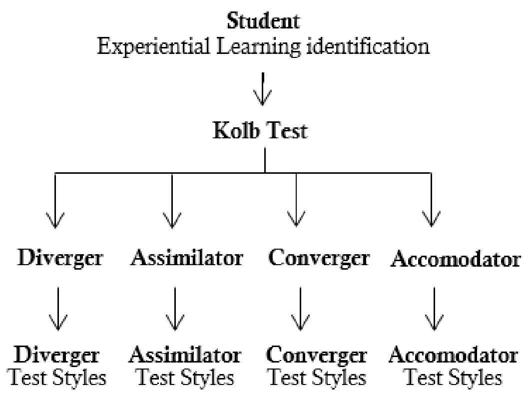


**Figure 1**. Identification of Sudents and the Flow of Using the SAA Tool

The following statistical models are applied: (1) One-Way ANOVA which aims to determine the level of students' higher-order thinking skills; (2) Pearson correlation which aims to determine the relationship of HOTS scores and students' learning styles, and (3) Tukey Test which aims to identify the differences in learning styles with HOTS variations.

Calculation of criteria for higher-order thinking skills refers to the rubric from Yee et al. (2015). The HOTS category is presented in Table 3.

**Table 3.** Categories of Higher-Order Thinking Skills (HOTS)

| HOTS Category | |
|---|---|
| **Mean Score** | **Category** |
| 0,00 – 23,33 | Low |
| 23,34 – 46,67 | Medium |
| 46,68 – 70,00 | High |

The relationship between Kolb's Learning Style and HOTS was analyzed using Pearson correlation. The calculation of the score level of correlation of higher-order thinking skills with learning styles refers to the rubric from Cohen (1992). The degree of HOTS correlation is presented in Table 4.

**Table 4.** HOTS Correlation Level

| Correlation Coefficient | Correlation Level |
|---|---|
| 0,1– 0,3 | Small |
| 0,3 – 0,5 | Medium |
| >0,5 | Large |

The interview results are described in a parallel narrative according to the characteristics of students in the high or low category. Triangulation was done by verifying quantitative data, findings from interviews, and theories.

## RESULTS AND DISCUSSIONS

### Students' Learning Style Profile

Students' learning style profile can be identified based on the results of Kolb's Experiential Learning test. Kolb's Learning Style identification was performed on 251 Year 8 students of SMP/MTs. The pattern of students Kolb's Learning Style is shown in Table 5.

The data in Table 5 shows that the highest learning style pattern is assimilator, with a percentage of 27,50%, while the lowest learning style pattern is converger with a percentage of 20,71%. Meanwhile, for the learning style patterns based on gender, females are dominated by the assimilator learning style, while the accommodator learning styles dominate males.

These results are in line with Bhat's research (2018) conducted on 598 high school Year, 10 students. The results showed that the most dominant learning styles were assimilators and the least convergers. This data shows that in one class, students have a variety of ways of thinking. Teachers have never facilitated this diversity of ways of thinking (during the learning process, or when providing evaluation tests). The learning process and the form of evaluation given to students, tend to use only one way of thinking (the way of thinking owned by the teacher, not those of students).

However, the research results may be varied, for example, the results of a study on Turkish nursing students (Shirazi & Heidari, 2019) and students in Iran (Vizeshfar & Torabizadeh, 2018) were dominated by diverger learning style. Other studies also mention that diverger and accommodator learning styles were dominant for nursing students (Mohammadi et al., 2013). Tulbure's (2012) research results show that learning styles were dominated by assimilators and convergers (Orhun, 2012).

**Table 5.** Kolb's Learning Style Patterns for Students

| Learning style | No. of students | Percentage (%) |
|---|---|---|
| Diverger | 66 | 26,30 |
| Assimilator | 69 | 27,50 |
| Converger | 52 | 20,71 |
| Accommodator | 64 | 25,49 |
| Total | 251 | 100 |

**Distribution of Students' Learning Style Patterns**

| | Diverger | Assimilator | Converger | Accommodator |
|---|---|---|---|---|
| Female | 37 | 55 | 23 | 19 |
| Male | 29 | 14 | 29 | 45 |
| Total (Percentage) | 66 (26,30%) | 69 (27,50%) | 52 (20,71%) | 64 (25,49%) |

Shirazi & Heidari (2019) stated that there was no significant relationship between learning styles and age and education level. According to them, this variation reflects differences in educational settings and teaching methods. Slightly different from the results of Shirazi & Heidari (2019), Atlasi et al. (2017) stated that learning styles were influenced by learning experiences, gender (Lee et al., 2016). Kolb states that the learning style is a combination of cognitive, affective, and psychological elements. Knowledge related to students' learning styles tends to increase their knowledge, which can significantly achieve their academic success. Therefore, if an individual's learning strategy is in accordance with their learning style, it is expected to improve their performance (Panahi et al., 2012).

The results of Yee et al. (2015) indicate that the identification of learning styles serves as an initial guide in developing a learning environment conducive to improve higher order thinking skills. Learning style and higher order thinking skills are essential aspects in teaching and learning, especially in higher education institutions.

Based on some research above, several factors influence student learning styles. Factors that can influence the emergence of individual learning styles in students are hereditary factors from their parents, the dominance of learning conditioning in the family environment (surrounding community and school environment). Conditioning was formed earlier and longer before new learning conditions were discovered (Alkooheji & Al-Hattami, 2018; Kopsovich, 2001; Roa, 2013).

For example, assimilator students can understand and respond to various information offers and can summarize them in a logical, concise, and clear format. Students of this type are more theoretical, preferring to work with abstract ideas and concepts, rather than working with people. They are more interested in science and mathematics. One or both parents may have nature or work related to science. The family environment discusses more information in ways such as a scientist or expert in thinking (Farooq & Regnier, 2011; Kolb, 2014).

Converger students prefer challenges in solving problems through adventure. They have the desire to find the right answer through the activities of trying (trial and error). Students like this in the family environment are more involved in the activities carried out by both parents. They were asked to help with the work done by their parents. This learning style will grow well if the learning environment of students in school develops learning based on laboratory or more practical activities (Akram et al., 2013; Farooq & Regnier 2011; Kolb, 2014).

Thus, profiling learning style may act as initial diagnosis that different characteristics of learner becomes critical for the instructor in managing their learning in creative manner and directing the learning process to variation of information processing among students.

**Levels of Higher Order Thinking Skills**

Levels of higher-order thinking skills can be identified based on the results of students' tests when working on higher-order thinking skills (HOTS), which are adjusted to Kolb's Theory on Natural Sciences material (Table 6).

The maximum score of higher order thinking skills in Biology and Physics are 70. The data in Table 6 shows that the level of higher-order thinking skills of Biology on average, is dominated by the **medium** category with a mean score of 39,69. In comparison, the level of higher-order thinking skills of Physics on average is dominated in the **low** category with a mean score of 21,28.

The lower thinking skills of Diverger students as compared to other learning styles is more unsuitable treatment by teacher. The teacher did not provide positive stimulation for students in learning. In theory, these students can imagine concrete situations with different points of view to make generalization. Unfortunately, this skill cannot be optimized while learning. Other studies show similar result where the divers students faced difficulty in learning Biology on environment in the class of 10th (Azrai et al.,2017). Researchers saw that students with this learning style will face difficulty in learning science. This is a challenge for the teacher to find the right way to teach this student.

In addition to tests, the HOTS profile of students may also be perceived based on the interview results. Interviews were conducted on 16 high, medium, and low skill category in each learning style as obtained based on HOTS test results. The followings are excerpted from the interviews of three students representing three ability categories (high, medium, and low)

"Biology was easier than physics since most biology materials had been taught. Physics is harder since I did not really comprehend the subject" [NAS, Higher skill student].

"The tested materials were difficult especially physics. The questions were hard and were not direct questions since we have to use reasoning" [NA, Medium skill student].

"The tested materials were different from those had been taught in the class and also different from those of daily tests. The problems were harder since they are abstract in nature and requires lots of formulas [AN, Lower skill student].

Based on the interview result, one of the reasons for lower level of HOTS physics was that the physics questions were different to the usual questions as given while learning. Some students did not understand the material and could not recall the formulas while working on problems.

In Natural Sciences, the converger learning style score with HOTS type skills-based process achieved the highest score, compared to other learning style scores. Converger students have good capabilities in Physics and Biology in this study. These students are able to combine thinking and doing (Abstract Conceptualization (AC) with Reflective Observation (RO). These students have also good capability in responding to various opportunities, enjoys challenges, and are willing to learn through trial and error.

However, the lowest score of Biology was in the assimilator learning style, and Physics was in the diverger learning style. The results above indicate that the HOTS level is influenced by the characteristics of the content/subject material. Biology content for the motion system of organism concept was dominated by concrete concepts with factual and conceptual dimensions. However, Physics content for simple machine concepts was dominated by abstract concepts with dimensions of conceptual knowledge, procedural, and mathematical calculations. Procedural knowledge requires students to carry out an investigation using several skills, techniques, and methods that make it difficult for students to work on question items (Krathwohl & Anderson, 2001).

For follow-up action, students should be trained to work on questions that measure the ability to think at a higher level in order to think critically. Educators are expected to present learning sourced from problem analysis.

**Table 6.** Levels of Students' Higher Order Thinking Skills (HOTS) based on Learning Styles

| **Levels of Higher Order Thinking—Biology** | | | | |
|---|---|---|---|---|
| **Learning Style** | **Type of HOTS** | **Mean score** | **SD** | **Category** |
| Diverger | Creative thinking | 37,88 | 9,92 | Medium |
| Assimilator | Critical thinking | 32,89 | 10,11 | Medium |
| Converger | Science process competence | 53,46 | 15,21 | High |
| Accommodator | Problem-solving | 38,39 | 15,93 | Medium |
| Mean | | 39,69 | 14,63 | Medium |
| **Levels of Higher Order Thinking—Physics** | | | | |
| **Learning Style** | **Type of HOTS** | **Mean score** | **SD** | **Category** |
| Diverger | Creative thinking | 10,55 | 12,422 | Low |
| Assimilator | Critical thinking | 24,52 | 14,796 | Medium |
| Converger | Science process competence | 26,54 | 12,944 | Medium |
| Accommodator | Problem-solving | 24,85 | 14,816 | Medium |
| Mean | | 21,28 | 15,145 | Low |

The results of other studies state that the difficulty of the content/subject material, especially content that demands analysis, evaluation, and creation, can affect the HOTS level of students. Difficult content/subject material can be quickly answered by students with moderate HOTS level, while students with low HOTS level are not able to answer it. Medium HOTS level students can do complete, systematic, and theoretical answers to several questions. In contrast, low HOTS level students are not able to work on problems with complete, systematic, and theoretical steps (Kurniati et al., 2016). The low level of HOTS is also caused by students lacking understanding of basic concepts so that it is challenging to work on question items, especially those that require mathematical calculations (Maulani & Subali, 2019).

The adaptive assessment approach that integrates learning styles shows positive gains. This is evidenced by the acquisition of HOTS Natural Sciences scores for converger, assimilator, and accommodator learning styles at high and medium HOTS category levels, except for diverger learning styles at the low category. This instrument is still limited to 1 question indicator per higher order thinking skills question item if the representation of each of these thinking skills is increasing; the score for each learning style score may be increasing. This fact is a finding that recommends the need to develop indicators of thinking skills on each SAA Tool assessment instrument with HOTS question construction that effectively measures student competence.

Students with a converger learning style get the most learning suitability compared to other learning styles, especially in biology science subjects. The process of learning biology is mostly done by teachers with practical activities and provides challenges to solve problems. Learning this condition is not found in physics science lessons. Learning conducted in more monotonous physics lessons cannot stimulate student learning styles to get optimal learning results (Abungu et al., 2014; Cimer, 2012; Ibe, 2015; Toplis, 2012; Wesonga & Aurah, 2019).

## HOTS Correlation with Learning Styles

The relationship between Kolb's Learning Styles and HOTS types is shown in Table 7. Table 7 shows that average Kolb's Learning Style's relationship with HOTS is very small. Problem-solving HOTS category in Biology shows significant results compared to other HOTS; creative thinking, critical thinking, and science process competence. Learning styles-based HOTS style construction is proven to have a correlation, where the achievement of HOTS scores has a contribution from the learning style, although it is low.

**Table 7.** Relationship between Kolb's Learning Style with HOTS

| **The Relationship of Kolb's Learning Styles with Biology HOTS** | | | | | |
|---|---|---|---|---|---|
| **Type of HOTS** | **Mean** | **SD** | **P** | **Pearson** | **Correlation** |
| Creative thinking | 37,88 | 9,92 | 0,61 | -0,09 | Negative Correlation |
| Critical thinking | 32,89 | 10,11 | 0,29 | 0,17 | Small |
| Science process competence | 53,46 | 15,21 | 0,64 | -0,09 | Negative Correlation |
| Problem-solving | 38,39 | 15,93 | 0,007 | 0,474 | Medium |
| **The Relationship of Kolb's Learning Styles with Physics HOTS** | | | | | |
| **Type of HOTS** | **Mean** | **SD** | **P** | **Pearson** | **Correlation** |
| Creative thinking | 5,27 | 6,21 | 0,053 | 0,339 | Medium |
| Critical thinking | 12,42 | 7,94 | 0,073 | 0,327 | Medium |
| Science process competence | 13,27 | 6,47 | 0,348 | 0,192 | Small |
| Problem-solving | 12,42 | 7,40 | 0,429 | 0,142 | Small |

The results obtained are in line with the research of Heong et al. (2011), which used Cramer V correlation analysis, showing that there is a shallow relationship between Kolb's Learning Style with 13 levels of Marzano's HOTS. Analysis using MANOVA shows that only HOTS types of deductive thinking and problem analysis obtained a significant correlation. These results indicate that HOTS of students is more influenced by how the teacher conducts the teaching. The suitability of teacher style with the student learning styles, especially in teaching the ability to analyze, evaluate, and create. If skills were not developed, the results will remain low. Problem-solving instrument for Biology subject is sufficient to be used by Accommodator students. While for physics subject, creative thinking instruments are more suitable to be used by Diverger students. HOTS measurement instruments for other learning styles needs to be further developed to achieve good adaptive tests.

Other studies conducted by Heong et al. (2017) based on Cramer V Analysis, show that there is no relationship between students' learning styles and Marzano's eight HOTS levels. There is no significant difference between Kolb's Learning Style and Marzano's HOTS level. This shows that regardless of the learning styles possessed by engineering students, i.e., Doer (accommodator), Watcher (converger), Thinker (assimilator), or Feeler (diverger), the HOTS level of all students is the same.

Further action, it was concluded that each student has a different learning style, but they all have the same opportunity and ability to learn and master HOTS.

The achievement in HOTS skill may be formulated as appropriate learning formula and assessment. Educators are increasingly challenged to design a learning strategy based on HOTS, thereby the students gain learning experiences that will develop the HOTS.

**Effect of Learning Style with HOTS Variations**

The obtained results for One-Way Anova test shows a significant influence on the difference between Kolb's Learning Style versus HOTS HOTS variations in Biology and Physics subjects. This may be seen from thesignificance value of (p (0.000) <0,05) (Table 8).

**Table 8.** One-Way Anova Test Results on the Differences in Kolb's Learning Styles against HOTS

| | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| **Kolb's Learning Styles—Biology** | | | | | |
| Between Groups | 6846,590 | 3 | 2282,197 | 13,912 | ,000 |
| Within Groups | 20340,910 | 124 | 164,040 | | |
| Total | 27187,500 | 127 | | | |
| **Kolb's Learning Styles—Physics** | | | | | |
| Between Groups | 5266,413 | 3 | 1755,471 | 9,195 | ,000 |
| Within Groups | 22718,628 | 119 | 190,913 | | |
| Total | 27985,041 | 122 | | | |

Tukey's Post Hoc Tests results show that there are differences in the whole Kolb's Learning Styles—diverger, assimilator, converger, and accommodator—with various HOTS instruments in Natural Sciences (Tables 9 and 10).

The data in Table 9 and Table 10 show that there are significant differences in the entire Kolb's Learning Style—diverger, assimilator, converger, and accommodator with HOTS variations on the Natural Sciences. This means that there is a difference in the HOTS score that matches the learning style. This also shows that the HOTS question item instruments that have been prepared were following with the characteristics of Kolb's Learning Style.

**Table 9.** Post Hoc Tukey Tests—Biology

| (I) Learning style | (J) Learning style | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| Diverger | Assimilator | 4,984 | 3,048 | ,363 | -2,95 | 12,92 |
| | Converger | -15,583* | 3,359 | ,000 | -24,33 | -6,84 |
| | Accommodator | -,508 | 3,204 | ,999 | -8,85 | 7,83 |
| Assimilator | Diverger | -4,984 | 3,048 | ,363 | -12,92 | 2,95 |
| | Converger | -20,567* | 3,260 | ,000 | -29,06 | -12,08 |
| | Accommodator | -5,492 | 3,100 | ,292 | -13,56 | 2,58 |
| Converger | Diverger | 15,583* | 3,359 | ,000 | 6,84 | 24,33 |
| | Assimilator | 20,567* | 3,260 | ,000 | 12,08 | 29,06 |
| | Accommodator | 15,074* | 3,406 | ,000 | 6,20 | 23,94 |
| Accommodator | Diverger | ,508 | 3,204 | ,999 | -7,83 | 8,85 |
| | Assimilator | 5,492 | 3,100 | ,292 | -2,58 | 13,56 |
| | Converger | -15,074* | 3,406 | ,000 | -23,94 | -6,20 |

The assessment approach used in this study is an adaptive approach, in which the learning style element is an important factor to be developed in the HOTS question instrument. Given that each student has a unique learning style preference, there is this assumption that the stimulus test that suits their learning style will allow students to achieve mastery learning. Heong et al. (2017) stated that the identification of learning styles is needed to help students learn thinking skills more effectively and improve academic performance.

**Table 10.** Post Hoc Tukey Tests—Physics

| (I) Learning style | (J) Learning style | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval Lower Bound | 95% Confidence Interval Upper Bound |
|---|---|---|---|---|---|---|
| Diverger | Assimilator | -13,971* | 3,456 | ,001 | -22,98 | -4,97 |
| | Converger | -15,993* | 3,623 | ,000 | -25,43 | -6,55 |
| | Accommodator | -14,303* | 3,402 | ,000 | -23,17 | -5,44 |
| Assimilator | Diverger | 13,971* | 3,456 | ,001 | 4,97 | 22,98 |
| | Converger | -2,022 | 3,674 | ,946 | -11,60 | 7,55 |
| | Accommodator | -,332 | 3,456 | 1,000 | -9,34 | 8,67 |
| Converger | Diverger | 15,993* | 3,623 | ,000 | 6,55 | 25,43 |
| | Assimilator | 2,022 | 3,674 | ,946 | -7,55 | 11,60 |
| | Accommodator | 1,690 | 3,623 | ,966 | -7,75 | 11,13 |
| Accommodator | Diverger | 14,303* | 3,402 | ,000 | 5,44 | 23,17 |
| | Assimilator | ,332 | 3,456 | 1,000 | -8,67 | 9,34 |
| | Converger | -1,690 | 3,623 | ,966 | -11,13 | 7,75 |

Thus, adaptive-formative and summative tests that integrate technology in its development provide opportunities so that future educational experiences obtain satisfying feedback (Louhab et al., 2018; Spector et al., 2016). Significant opportunities obtained include the following: obtained assessment data to be more accurate, relevant, and useful in providing information in making curriculum decisions. Furthermore, formative assessments can bridge the gap between assessment and learning; specifically, the database on the adaptive test system can increase the level of student ability.

Research in the integration of learning styles shows positive results. Its application can be seen in various fields such as adaptive learning systems, adaptive learning content, learning strategies, smart tutorial systems, adaptive media, assessment, and educational games (Marković, 2015). Educational game and assessment applications require further exploration and development. At least the integration of learning styles in an adaptive assessment provides insights as well as opportunities for the development of more integrative adaptive assessments.

## CONCLUSION

The most popular student learning styles is the assimilator (27,50%), and at least it is converger (20,71%). As for the learning style patterns based on gender, females are dominated by the assimilator learning style, while accommodator learning styles dominate males. The level of Biology higher order thinking skills on average is dominated in the medium category with a mean score of 39,69. In contrast, the level of Physics highe order thinking skills on average is dominated in the low category with a mean score of 21,28.

The results showed that the achievement of the HOTS score was influenced by the type of learning styles, even though it had averaged a very small correlation. There are significant differences throughout the Kolb's learning styles—diverger, assimilator, converger, and accommodator, with HOTS variations on the Biology and Physics material.

This study provides a fundamental framework for the importance of adaptive assessment which able to accommodate student's characteristics. In this case, the SAA Tool accommodates variations in the KOLB learning style of students, allowing them to achieve scientific competence through tests that are in line with thinking preferences which are strongly influenced by genetic and environmental factors. Thus, further research may be conducted by synergizing with learning by following the student learning style model. Through a good adaptive test pattern the student's potential may be developed optimally which results in accomplished experts in their respective fields. This prevent unsuitable placement in the future professional world. The right man for the right job prevail.

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