Jurnal Penelitian dan Pembelajaran IPA JPPI
Vol. 6, No. 2, 2020, p. 211-224 p-ISSN 2477-1422 e-ISSN 2477-2038

Designing an Innovative Assessment of HOTS in the Science Learning for the 21st Century

(Received 21 January 2019; Revised 3 November 2020; Accepted 3 November 2020)

Ilmi Zajuli Ichsan[1]*, Risky Hasanah[1], Rizhal Hendi Ristanto[1], Rusdi Rusdi[1], Michael Bobias Cahapay[2], Yeni Widiyawati[3], Md. Mehadi Rahman[4]

[1]Department of Biology Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta, Jakarta, Indonesia

[2]College of Education, Mindanao State University, General Santos City, Philippines

[3]Department of Science Education, Faculty of Science and Technology, Universitas Ivet, Semarang, Indonesia

[4]Institute of Education and Research, University of Dhaka, Dhaka, Bangladesh

Corresponding author: *IlmiZajuliIchsan_9908920004@mhs.unj.ac.id

DOI: 10.30870/jppi.v6i2.4765

Abstract

Science learning in the 21st century should develop the abilities of the students to find solutions to the problems. This task requires a set of skills called Higher Order Thinking Skills (HOTS) and innovative assessment should be designed to gauge the acquisition of these skills. Thus, this study aimed to create an innovative HOTS-based assessment tool in science learning. It entailed a method following the research and development model. It covered the topic of genetics and involved biology experts and junior high school students. The result initially showed that the assessment tool has high content validity. It further revealed that the items have a high-reliability index and they loaded on components based on the three HOTS intended for the test. Thus, this paper concludes that the HOTS-based assessment tool is a good classroom test to gauge the science learning of the students.

Keywords: HOTS, Science Education, Test Development, Assessment

INTRODUCTION

Education has a primary role to equip students with skills to be able to face future challenges, including the challenges of 21st-century learning. The 21st-century education entails various skills to help students maturely achieve global life. These skills include the HOTS as well as critical thinking, problem-solving, metacognition, communication, collaboration, information literacy, and creative innovation (Copley, 2013; Kane, Lear & Dube, 2014; Saido *et al.*, 2015; Akiba and Wilkinson, 2016; Baloche and Brody, 2017; Arthur *et al.*, 2019).

The term for the 21st-century skills stands for a broad set of knowledge, skills, behavior, and character traits that are crucial for students to survive the fast-changing world and lead an ideal life by shaping academic life and future career (Rahman, 2019). The target of achieving 21st-century skills can be done by renewing teaching quality. Student-centered teaching skills must be implemented in teaching in 21st-century learning. This is intended for project-based learning and problems to encourage collaboration and communication that will increase student involvement and motivation (Lemus *et al.*, 2014; Jewpanich and Piriyasurawong, 2015; Şener, Türk and Taş, 2015; Khan *et al.*, 2017; Khoiriyah and Husamah, 2018). However, there is a perennial challenge in developing the HOTS of the students in science learning (Nisa, Nadiroh & Siswono, 2018; Djamahar *et al.*, 2019; Sigit *et al.*, 2020). One of the reasons is that teachers mainly focus on teaching lower-order learning rather than higher-order thinking skills in their science teaching-learning (Rahman, 2018; Sultana & Rahman, 2018). Natural science learning covers various aspects ranging from biology, chemistry, physics, and the environment. Science learning presents many problems that need to be solved. This is aside from the fact that science serves as a primary launching pad for emerging competencies and contents that have social significance (Cahapay, 2020a; Cahapay, 2020b). The relevant topics such as damage to the urban environmental ecosystem, climate change, poor urban planning infrastructure, consumption of nutritious food, and the genetic influence of living things in biotechnology are some of the issues that need to be studied and resolved (Nugraini *et al.*, 2013; Kristyowati & Purwanto, 2019; Paristiowati *et al.*, 2019; Rahmayanti, Maulida & Kamayana, 2019; Rahmayanti, Oktaviani & Syani, 2020; Azwar *et al*, 2013; Intarti et al, 2014).

Learning biology emphasizes a kind of learning that prioritizes aspects of systematic and logical thinking. In 21st-century biology learning, the development of thinking should not only focus on the aspects of understanding various concepts but also on the aspects of critical thinking and analysis. Ideally, these aspects can be developed in all contents and materials of biology learning (Song, 2016; Tiruneh *et al.*, 2017).

To achieve the 21st-century biology learning objectives, with a focus on genetic content and material in this paper, it is necessary to develop an assessment form based on HOTS. In addition to the aspects of systematic and logical thinking, aspects of critical and analytical thinking should also be reflected in the form of the HOTS assessment to be developed. Thus, this study aimed to develop a HOTS-based assessment tool for genetic topics for junior high school students.

METHOD

The research method used in this study followed the research and development model proposed by Gall, Gall, and Borg (2003) with modification. The study was conducted from 2018 to 2020. It followed the test development procedure consisting of 4 steps: (1) analyzing needs; (2) designing assessments; (3) developing assessment; and (4) conducting assessment validation.

First, content validation was conducted. The experts involved in this stage were three biology graduate students and two biology education school teachers. The content validity criteria were adapted based on Ratumanan & Laurens, (2006) which can be seen in Table 1.

Table 1. Validation criteria

Interval Category	Criteria
$3.25 < x \leq 4{,}00$	Very Valid
$2.50 \leq x \leq 3{,}25$	Valid
$1.75 < x < 2{,}50$	Less Valid
$1.00 < x < 1{,}75$	Not Valid

After content validation with the experts, the test items were further subjected to a reliability test. The test items were administered to 28 students in the Grade IX junior high school level. Reliability is the extent to which the same test scores would be obtained if the test were administered again. Test scores that yield reliability of 0.80 or higher are generally considered reliable (Gall et al., 1996).

Finally, the test items were subjected to factor analysis to determine their construct validity. A factor analysis utilizes student responses to determine groups of questions that are answered in a correlated manner by the respondents, indicating thinking skills that are related (Adams and Wieman 2010). A type of factor analysis used in this study is the principal component analysis to provide

an approximation to the required components. The items that load on one component above .30 are considered efficient factor loadings in this study.

All the tests were performed using the Statistical Package for the Social Sciences (SPSS).

RESULTS AND DISCUSSION

This paper is aimed to develop a HOTS-based assessment tool for junior high school students. This instrument is designed to measure HOTS in the form of essay questions. As seen in Table 2 and Table 3, the results of the developed assessment consisted of 12 items under two different subtopics. Each subtopic had 6 indicators that contained 1 test item. The subtopics were DNA as the first subtopic and biotechnology as the second.

Table 2. HOTS assessment grid

Sub Chapter 1. Structure of DNA and RNA Functions		
Aspect	Item	No item
C4 (Analyzing)	Students can analyze DNA functions as the inheritance	1
	Students can analyze the function of DNA and RNA based on their structure	2
C5 (Evaluating)	Students can provide an assessment of DNA locations in the cell nucleus	3
	Students can criticize a statement about DNA and RNA	4
C6 (Creating)	Students can make suppositions (hypotheses) against an inheritance-related event	5
	Students can design a simple research project about inheritance	6
Sub Chapter 2. Application of the Concept of Genetics		
Aspect	Item	No item
C4 (Analyzing)	Students can analyze genetic abnormalities	1
	Students can analyze the function of DNA in inheriting a characteristic disorder	2
C5 (Evaluating)	Students can provide an assessment of a genetically modified product	3
	Students can provide criticism of genetically modified products	4
C6 (Creating)	Students can make hypotheses about the effects of nuclear use on DNA and cells	5
	Students can design a simple research project on waste management through genetic engineering technology	6

Table 3. HOTS Assessment developed

Sub Chapter 1. Structure of DNA and RNA Functions	
No	Item
1	DNA is a very important thing for life. There are nowadays widespread cases involving DNA testing to determine a person's status in a family. Why do you think DNA can determine one's kinship? Explain and do analysis!
2	DNA and RNA are similar in structure. The difference is in the number of strands. Why is only one strand of RNA? What happens if DNA has only one strand? Do analysis!

Sub Chapter 1. Structure of DNA and RNA Functions	
No	Item
3	DNA in animal and plant cells is located in the cell nucleus, whereas DNA in bacteria is located in the cytoplasm. Give an opinion and evaluation of excellence obtained by the position of DNA inside the cell nucleus?
4	"DNA is an important substance in life. All living things and their environment have DNA. So that living things and the environment can also inherit their nature " Give critic and correction to the statement above!
5	A tree has a red flower. It is then crossed with the same tree species and produces a tree with green flowers. How can this phenomenon occur? Make a hypothesis about this.
6	Make a research plan about genetics with the following tools and materials: - 3 red rose trees - 2 pink rose trees - 2 Pots - a knife - A guidebook for crossing plants - water - manure - compost
Sub Chapter 2. Application of the Genetics Concept	
No	Item
1	Hemophilia and color blindness are abnormalities caused by genetic factors. If a person's parents experience a genetic disorder, is it going to be passed down? Explain based on your analysis!
2	Someone who has Turner syndrome loses one chromosome in his body. In your opinion, will the chromosome lose one chromosome at the time of cell division, or does it have a complete chromosome? Explain and do the analysis
3	Seedless watermelon is a product of genetic modification. The watermelon is more in demand in the market than seeded watermelons. Give your opinion and evaluation of the consumption of seedless watermelons for health!
4	The use of genetic modification to make fruit without seeds is beneficial but also had a negative impact. This is not too much concern for the industry by planting fruit from genetic modification. What should be done by various parties to overcome this? Try giving a critic of this event!
5	Someone was found to have a DNA mutation because he worked for 5 years in the hospital especially in x-ray rooms that use X-rays. While his other colleagues who were in the administration room did not experience mutations. Make a hypothesis as to why this happened?
6	Bacteria A can digest odor-causing chemicals. Meanwhile, it can only live on the ground. While bacteria B can live in water. Make a design research project that you can do to eliminate the waste and odor that exists in the river using the principle of modern genetics!

Table 4. Validation results of experts' assessment

No	Expert	Score	Category
1	User 1	3.08	Valid
2	User 2	3.58	Very Valid
3	User 3	3.66	Very Valid
4	User 4	3.66	Very Valid
5	User 5	3.66	Very Valid

Table 5. Reliability index of the test items

No Item	Sub Chapter	Chronbach Alpha if Item Deleted
Item 1	Sub Chapter 1	.843
Item 2	Sub Chapter 1	.848
Item 3	Sub Chapter 1	.849
Item 4	Sub Chapter 1	.836
Item 5	Sub Chapter 1	.854
Item 6	Sub Chapter 1	.839
Item 7	Sub Chapter 2	.836
Item 8	Sub Chapter 2	.835
Item 9	Sub Chapter 2	.843
Item 10	Sub Chapter 2	.841
Item 11	Sub Chapter 2	.839
Item 12	Sub Chapter 2	.854
Overall Chronbach Alpha		.855

Table 6. Factor analysis of the test items

Item	Component 1	Item	Component 2	Item	Component 3
1	.692	3	.154	5	.847
2	.223	4	.387	6	.619
7	.903	9	.708	11	.466
8	.587	10	.645	12	.003

The items of the HOTS-based assessment tool were initially content validated by the experts. As seen in Table 4, the experts rated the tool as valid and very valid. It suggests that it has technical adequacy for instructional use. The experts provided the best assessment for the aspect of the communicative language used and followed by the ability of the developed assessment to foster the power of student analysis. The comments generated from the validators focused on the making of more varied assessments by adding images.

Then, the items were subjected to a reliability test to determine their dependability. As shown in Table 5, the overall result showed a Chronbach alpha of .855 indicating high reliability. It implies that the instrument is a dependable classroom test. It can be also noted that the overall reliability index of the test did not improve if an item is deleted. Overall, the instrument is a reliable test to measure the HOTS of the students in natural science.

The test further underwent a factor analysis to confirm its construct validity. The preliminary statistics of factor analysis showed the Kaiser Meyer Olkin value at .662 and Bartlett Test of Sphericity was significant at .000 level, indicating that the sampling is adequate. The result also showed a total of 12 components with initial eigenvalues of 0.1 and higher of which three factors satisfied accounting for 39.79%, 15.76%, and 10.28% of the variability. As shown in Table 6, the rotated component matrix revealed the factor loadings for each

item. The items were subjected to principal component analysis to approximate the required components corresponding to the three HOTS in which the test items were intentionally designed. It was noted that all 12 items cross-loaded in more than one component, but most had a minimum factor loading of 0.30, thus considered acceptable. The analysis of the test items revealed the characteristics of the items common for each of the three components. The items that loaded under Component 1 are those items that required the students to analyze; Component 2 to evaluate, and Component 3 to create.

Each item of the developed assessment represented open-ended responses so that students had to construct their responses according to the questions. Constructed response assessment can be utilized to reveal students' reasoning and analytical thinking skills (Ku, 2009; Widiyawati, Nurwahidah & Sari, 2019). Students as a test taker perform HOTS better in constructed response than multiple-choice due to the less of guessing factor (Sangwin & Jones, 2017; Scully, 2017).

The assessment's main objective was to judge the skill-based learning outcome of students as well as enhance the quality of teaching-learning. Assessment is an essential process that influences students' knowledge, skills, attitudes, and beliefs more than teaching Sultana & Rahman, 2018). Assessment is developed following the 21st-century biology learning that applies the scientific approach. This assessment aims to prepare students' thinking power in facing the global era. HOTS is a students' thinking level whose achievements are characterized by problem-solving that applies evaluating and creative ways of thinking (Anderson *et al.*, 2001; Jensen *et al.*, 2014; Widiana and Jampel, 2016; Ritter and Mostert, 2017; Miller, 2018). Students' HOTS performance will guide them to be able to connect and describe natural facts, concepts as well as manipulate them in relevant conditions (Rashika & Salleh, 2019).

In 21st-century learning teacher's role optimization is important in providing students 4C skills (Communication, Collaboration, Critical thinking, and Creative innovation). In addition to good process skills by the teacher, 21st-century learning can also be realized from the student-centered learning process. So it is expected that the ability to solve problems by utilizing critical thinking skills for students can be trained (Tyabaev, Sedelnikova & Voytovich, 2015; David, 2017; Motallebzadeh, Ahmadi and Hosseinnia, 2018).

Science teaching and learning develop students' scientific attitudes and also nurtures students' scientific inquiry skills. Students will be able to achieve 21st-century skills, only if they can foster problem-solving with their observation and critical thinking skills in science classes. Therefore, teachers need to create diverse assessment tools that will engage students in a HOTS-based learning process (Hafiz & Rahman, 2019).

The 21st-century biology learning, besides being seen from the learning process, can also be seen through the assessment tool. The HOTS-based assessment, in its application, can train critical and analytical thinking for students. This way of thinking induces students to be one step ahead in acquiring 4C skills in 21st-century learning. Therefore, the development of the HOTS assessment is needed in developing critical thinking skills for students (Lile and Bran, 2014; Charoencha, Phuseeorn and Phengsawat, 2015; Aziz and Yusoff, 2016; Kinay and Bagceci, 2016).

The developed assessment provides HOTS of revised Bloom's taxonomy in Biology topics. The test takers were given 12 items in 3 levels of HOTS, namely: analyzing, evaluating, and creating. For example, in item number 1 in the sub-chapter of Structure of DNA and RNA function students had to analyze DNA functions as an inheritance. Students must be able to explain their arguments on DNA functions to determine one's kinship. They had to connect the concept of DNA function, the fact of kinship, and connect it into a real condition of relatives phenotype, as observable characteristic (Deznabi *et al.*, 2018; Perego *et al.*, 2019). Create a connection between facts, concepts, or theory to solve the problem will improve students' HOTS.

The HOTS-based assessment tool, which has now been integrated into the National Examination Assessment, has not yet been made a part of the practices for training junior high school and elementary school students. In reality, the HOTS-based assessment still indicates low results, which implies that junior high school students' analytical thinking level is still low. This is because junior high school students have not been intensively accustomed to working on assessments that require such critical and analytical thinking. In the HOTS-based assessment trials that have been developed, the maximum results obtained for junior high school students utilize their thinking critical abilities (Gündüz *et al.*, 2016; Santos, 2017; van der Veen and van Oers, 2017).

The HOTS-based assessment can be designed in the different subjects, especially in biology subjects, that use a

scientific approach in learning. The HOTS-based assessment can also be applied to all levels of school. The secondary school level is ideal for applying HOTS-based assessment tools and requires more intense than the elementary school level. Particularly for junior high school students, it is useful to develop analytical thinking ability that could be improved as they go through higher education (Vijayaratnam, 2012; Camacho and Legare, 2015; Koh *et al.*, 2015; Sahronih, Purwanto and Sumantri, 2019).

The use of learning devices to support HOTS-based learning must also be developed in elementary school to support students in the future. The learning that take place should not only work on assessment but must also be complemented with appropriate learning media. Learning media have an important role in delivering important material, including, in this case, HOTS-based material. Teachers should be able to take advantage of this developed assessment by also applying web-based learning media. There are pieces of evidence that web-based learning media are very helpful in learning (Nugraini *et al.*, 2013; Baris, 2015; Fatih, 2016; Alomyan, 2017; Jiang *et al.*, 2017; Alsadoon, 2018)

CONCLUSION

Science learning in the 21st century should develop the ability of students to solve problems through HOTS. This task demands for the development of an innovative assessment to gauge the acquisition of these skills. Thus, this study aimed to design a HOTS-based assessment tool on the topic on genetics for junior high school students. This paper found out that the HOTS-based assessment tool has high content validity, a good reliability index, and acceptable construct validity. Thus, it offers evidence that the HOTS-based assessment tool is a suitable test for use in teaching and learning.

REFERENCES

Adams, W. K. and Wieman, CE 2010. 'Development and Validation of Instruments to Measure Learning of Expert-like Thinking' *International Journal of Science Education, vol. 33* no. 9, pp. 1289-312. doi:10.1080/09500693.2010.512369

Akiba, M. and Wilkinson, B 2016, 'Adopting an International Innovation for Teacher Professional Development: State and District Approaches to Lesson Study in Florida', *Journal of Teacher Education*, vol. 67 no.1, pp. 74–93. doi: 10.1177/0022487115593603.

Alomyan, H 2017, 'A Conceptual Framework for Web-Based Learning Design', in *International Conference e-Learning*, pp. 191–195.

Alsadoon, E 2018, 'Motivating Factors for Faculty to Use Web Applications in Education', *TOJET: The Turkish Online*

Journal of Educational Technology, vol. 17 no. 3, pp. 73–90.

Anderson, L. W. *et al* 2001, *A taxonomy for learning, teaching and assessing: A revision of Bloom's taxonomy of educational outcomes: complete edition*. New York: Longman.

Arthur, R. *et al* 2019, 'Plumbing work competence instrument in the field of civil engineering', *Journal of Physics: Conference Series*, vol. 1402 no. 2, p. 022019. doi: 10.1088/1742-6596/1402/2/022019.

Aziz, M. N. bin abdul and Yusoff, N. M 2016, 'Improving Process Writing with the Use Authentic Assessment', *International Journal of Evaluation and Research in Education*, vol. 5, no. 3, pp. 200–4.

Azwar, S. A.; Suganda, E; Tjiptoherijanto, P; Rahmayanti, H 2013, 'Model of Sustainable Urban Infrastructure at Coastal Reclamation of North Jakarta', *Procedia Environmental Sciences*, vol. 17, pp. 452-61. doi: 10.1016/j.proenv.2013.02.059

Baloche, L. and Brody, C. M 2017, 'Cooperative learning: exploring challenges, crafting innovations', *Journal of Education for Teaching*, vol. 43 no. 3, pp. 274–83. doi: 10.1080/02607476.2017.1319513.

Baris, M. F 2015, 'European Teachers' Technological Pedagogical Content Knowledge (TPCK) and Educational Use of Web Technologies', *European Journal of Educational Research*, vol. 4 no. 4, pp. 149–55. doi: 10.12973/eu-jer.4.4.149.

Cahapay, M. B 2020a, 'Delphi technique in the development of emerging contents in high school science curriculum'. *International Journal of Curriculum Development and Learning Measurement, vol. 1* no. 2, pp. 1-9. doi: 10.4018/ijcdlm.2020070101

Cahapay, M. B. 2020b, 'Development of preparedness competencies in basic education science curriculum: An insight from the COVID-19 global outbreak'. *European Journal of Environment and Public Health*, vol. 5 no. 1, pp. em0063. doi: 10.29333/ejeph/8578

Camacho, D. J. and Legare, J. M 2015, 'Opportunities to Create Active Learning Techniques in the Classroom', *Journal of Instructional Research*, vol. 4, pp. 38–45.

Charoencha, C., Phuseeorn, S. and Phengsawat, W 2015, 'Teachers development model to authentic assessment by empowerment evaluation approach', *Educational Research and Reviews*, vol. 10 no. 17, pp. 2524–30.

Copley, P 2013, 'The Need to Deliver Higher-Order Skills in the Context of Marketing in SMEs', *Industry and Higher Education*, vol. 27 no. 6, pp. 465–76. doi: 10.5367/ihe.2013.0181.

David, A. A 2017, 'A student-centered framework for teaching undergraduate parasitology', *Trends in Parasitology*. vol. 33 no. 6, pp. 420–23. doi: 10.1016/j.pt.2017.01.010.

Deznabi, I. *et al* 2018, 'An Inference Attack on Genomic Data Using Kinship , Complex Correlations , and Phenotype Information', *IEEE/ACM Transactions on*

Computational Biology and Bioinformatics. IEEE, vol. 15 no. 4, pp. 1333–43. doi: 10.1109/TCBB.2017.2709740.

Djamahar, R. *et al* 2019, 'Empowering Student's Metacognitive Skill Through Cirsa Learning', *Journal of Physics: Conference Series*, 1227, p. 012034. doi: 10.1088/1742-6596/1227/1/012034.

Fatih, M. T. 2016, 'Design process for online websites created for teaching Turkish as a foreign language in web based environments', *Educational Research and Reviews*, vol. 11 no. 8, pp. 642–55. doi: 10.5897/ERR2015.2511.

Gall, M. D., Gall, J. P. and Borg, W. R. (2003) *Educational Research An Introduction*. San Fransisco: Pearson Education.

Gündüz, A. Y. *et al* 2016, 'Design of a problem-based online learning environment and evaluation of its effectiveness', *The Turkish Online Journal of Educational Technology*, vol. 15 no. 3, pp. 49–57. doi: 10.1017/CBO9781107415324.004.

Hafiz, L., & Rahman, M. M 2019, 'Investigating the effects of bangladesh and global studies (bgs) assessment of secondary school certificate (ssc) examination on students learning'. *British Journal of Education, vol. 7* no. 2, pp. 33-57. doi:10.37745/bje.2013

Intarti, Y. R et al 2014, 'Development of Minangkabau Women's Roles as an Effort to Reduce Risk in Disaster-prone Cities in Indonesia A Case Study of Western District of Padang, Padang City, West Sumatra, Indonesia', International Journal of Disaster Recovery and Business Continuity, vol. 5, pp.29-42. doi: 10.14257/ijdrbc.2014.5.03

Jensen, J. L. *et al* 2014, 'Teaching to the Test or Testing to Teach: Exams Requiring Higher Order Thinking Skills Encourage Greater Conceptual Understanding', *Educational Psychology Review*, vol. 26 no. 2, pp. 307–29. doi: 10.1007/s10648-013-9248-9.

Jewpanich, C. and Piriyasurawong, P 2015, 'Project-based learning using discussion and lesson-learned methods via social media model for enhancing problem solving skills', *International Education Studies*, vol. 8 no. 6, pp. 24–31. doi: 10.5539/ies.v8n6p24.

Jiang, B. *et al* 2017, 'Internet cross-media retrieval based on deep learning', *Journal of Visual Communication and Image Representation*. Elsevier Inc., vol. 48, pp. 356–66. doi: 10.1016/j.jvcir.2017.02.011.

Kane, S., Lear, M. and Dube, C. M 2014, 'Reflections on the role of metacognition in student reading and learning at higher education level', *Africa Education Review*, vol. 11 no. 4, pp. 512–25. doi: 10.1080/18146627.2014.935001.

Khan, A. *et al* 2017, 'Communication Skills of a Teacher and Its Role in the Development of the Students' Academic Success', *Journal of Education and Practice*, vol. 8 no. 1, pp. 18–21.

Khoiriyah, A. J. and Husamah, H 2018, 'Problem-based learning: Creative thinking skills, problem-solving skills, and learning outcome of seventh grade students', *JPBI (Jurnal Pendidikan Biologi*

Indonesia), vol. 4 no. 2, pp. 151–60. doi: 10.22219/jpbi.v4i2.5804.

Kinay, I. and Bagceci, B 2016, 'The Investigation of the Effects of Authentic Assessment Approach on Prospective Teachers' Problem-Solving Skills', *International Education Studies*, vol. 9 no. 8, pp. 51–9. doi: 10.5539/ies.v9n8p51.

Koh, J. H. L. *et al* 2015, 'Design Thinking and 21st Century Skills', in *Design Thinking for Education: Conceptions and Applications in Teaching and Learning*, pp. 1–131. doi: 10.1007/978-981-287-444-3.

Kristyowati, R. and Purwanto, A 2019, 'Pembelajaran Literasi Sains Melalui Pemanfaatan Lingkungan', *Scholaria: Jurnal Pendidikan dan Kebudayaan*, vol. 9 no. 2, pp. 183–91.

Ku, K. Y. L 2009, 'Assessing students ' critical thinking performance : Urging for measurements using multi-response format', vol. 4, pp. 70–76. doi: 10.1016/j.tsc.2009.02.001.

Lemus, J. D. *et al* 2014, 'Infusing traditional knowledge and ways of knowing into science communication courses at the university of hawai'i', *Journal of Geoscience Education*, vol. 62 no. 1, pp. 5–10. doi: 10.5408/12-416.1.

Lile, R. and Bran, C 2014, 'The Assessment of Learning Outcomes', *Procedia - Social and Behavioral Sciences*. Elsevier B.V., vol. 163, pp. 125–131. doi: 10.1016/j.sbspro.2014.12.297.

Miller, A. L 2018, 'The Role of Creative Coursework in Skill Development for University Seniors', *Global Education Review*, vol. 5 no. 1, pp. 88–107.

Motallebzadeh, K., Ahmadi, F. and Hosseinnia, M 2018, 'Relationship between 21st century skills, speaking and writing skills: A structural equation modelling approach', *International Journal of Instruction*, vol. 11 no. 3, pp. 265–276. doi: 10.12973/iji.2018.11319a.

Nisa, N. C., Nadiroh, N. and Siswono, E 2018, 'Kemampuan Berpikir Tingkat Tinggi (Hots) Tentang Lingkungan Berdasarkan Latar Belakang Akademik Siswa', *Jurnal Pendidikan Lingkungan dan Pembangunan*, vol. 19 no. 2, pp. 1–14. doi: 10.21009/plpb.192.01.

Nugraini, S. H. *et al* 2013, 'Students' feedback of e-av biology website and the learning impact towards biology', *Procedia - Social and Behavioral Sciences*. Elsevier B.V., vol. 103, pp. 860–69. doi: 10.1016/j.sbspro.2013.10.408.

Paristiowati, M. *et al* 2019, 'Analysis of students' scientific literacy in contextual-flipped classroom learning on acid-base topic', *Journal of Physics: Conference Series*, vol. 1156 no. 1, p. 012026. doi: 10.1088/1742-6596/1156/1/012026.

Perego, U. A. *et al* 2019, 'Forensic Science International : Genetics Resolving a 150-year-old paternity case in Mormon history using DTC autosomal DNA testing of distant relatives', *Forensic Science International: Genetics*, vol. 42, pp. 1–7. doi: 10.1016/j.fsigen.2019.05.007.

Rahman, M. M 2019, '21st Century Skill "Problem Solving": Defining the Concept. *Asian Journal of*

Interdisciplinary Research, vol. 2 no. 1, 64-74. doi:10.34256/ajir1917

Rahman, M. M 2018, 'Exploring Teachers Practices of Classroom Assessment in Secondary Science Classes in Bangladesh. *Journal of Education and Learning, vol. 7* no. 4, 274-83. doi:10.5539/jel.v7n4p274

Rahmayanti, H., Maulida, E. and Kamayana, E 2019, 'The role of sustainable urban building in industry 4.0', *Journal of Physics: Conference Series*, vol. 1387 no. 1, p. 012050. doi: 10.1088/1742-6596/1387/1/012050.

Rahmayanti, H., Oktaviani, V. and Syani, Y 2020, 'Development of sorting waste game android based for early childhood in environmental education', *Journal of Physics: Conference Series*, vol. 1434 no. 1, p. 012029. doi: 10.1088/1742-6596/1434/1/012029.

Rashika, H. and Salleh, M 2019, 'Promoting hots through thinking maps', *International journal of Education, Psychology and Counseling*, vol. 4 no. 26, pp. 104–112.

Ratumanan, T. . and Laurens, T 2006, *Evaluasi hasil belajar yang relevan dengan kurikulum berbasis kompetensi*. Surabaya: Unesa University Press.

Ritter, S. M. and Mostert, N 2017, 'Enhancement of creative thinking skills using a cognitive-based creativity training', *Journal of Cognitive Enhancement*. Journal of Cognitive Enhancement, vol. 1 no. 3, pp. 243–53. doi: 10.1007/s41465-016-0002-3.

Sahronih, S., Purwanto, A. and Sumantri, M. S 2019, 'The effect of interactive learning media on students' science learning outcomes', *ACM International Conference Proceeding Series*, pp. 20–24. doi: 10.1145/3323771.3323797.

Saido, G. M. *et al* 2015 'Higher order thinking skills among secondary school students in science learning', *The Malaysian Online Journal of Educational Science*, vol. 3 no. 3, pp. 13–20.

Sangwin, C. J. and Jones, I 2017, 'Asymmetry in student achievement on multiple-choice and constructed-response items in reversible mathematics processes', *Educational Studies in Mathematics*. Educational Studies in Mathematics, pp. 205–22. doi: 10.1007/s10649-016-9725-4.

Santos, L. F 2017, 'The Role of Critical Thinking in Science Education', *Journal of Education and Practice*, vol. 8 no. 20, pp. 158–73.

Scully, D 2017, 'Constructing Multiple-Choice Items to Measure Higher-Order Constructing Multiple-Choice Items to Measure Higher-Order Thinking', *Practical Assessment, Research & Evaluation*, vol. 22, pp. 1–13.

Şener, N., Türk, C. and Taş, E 2015, 'Improving science attitude and creative thinking through science education project: a design, implementation and assessment', *Journal of Education and Training Studies*, vol. 3 no. 4, pp. 57–67. doi: 10.11114/jets.v3i4.771.

Sigit, D. V. *et al* 2020, 'EECN: Analysis, potency, benefit for students knowledge and attitude to conserve mangroves and coral reefs', *International Journal of Instruction*, vol. 13 no. 1, pp. 125–38. doi: 10.29333/iji.2020.1318a.

Song, X 2016, 'Critical Thinking and Pedagogical Implications for Higher Education', *East Asia*, vol. 33 no. 1, pp. 25–40. doi: 10.1007/s12140-015-9250-6.

Sultana, P., & Rahman, M. M 2018, 'Exploring General Science Questions of Secondary School Certificate (SSC) Examination: Assessment Effects on Students Learning', *Journal of Education and Practice, vol. 9* no. 26, 60-73. doi:10.7176/JEP/9-26-5

Tiruneh, D. T. *et al* 2017, 'Measuring Critical Thinking in Physics: Development and Validation of a Critical Thinking Test in Electricity and Magnetism', *International Journal of Science and Mathematics Education*, vol. 15 no. 4, pp. 663–82. doi: 10.1007/s10763-016-9723-0.

Tyabaev, A. E., Sedelnikova, S. F. and Voytovich, A. V 2015, 'Student-Centered Learning: The Experience of Teaching International Students in Russian Universities', *Procedia - Social and Behavioral Sciences*. Elsevier B.V., vol. 215, pp. 84–9. doi: 10.1016/j.sbspro.2015.11.578.

van der Veen, C. and van Oers, B 2017, 'Advances in research on classroom dialogue: learning outcomes and assessments', *Learning and Instruction*, vol. 48, pp. 1–4. doi: 10.1016/j.learninstruc.2017.04.002.

Vijayaratnam, P 2012, 'Developing Higher Order Thinking Skills and Team Commitment via Group Problem Solving : A Bridge to the Real World'. The Authors, vol 66, pp. 53–63. doi: 10.1016/j.sbspro.2012.11.247.

Widiana, I. W. and Jampel, I. N 2016, 'Improving Students' Creative Thinking and Achievement through The Implementation of Multiple Intelligence Approach with Mind Mapping', *International Journal of Evaluation and Research in Education (IJERE)*, vol. 5 no. 3, pp. 246–54.

Widiyawati, Y., Nurwahidah, I. and Sari, D. S 2019, 'Pengembangan instrumen integrated science test tipe pilihan ganda beralasan untuk mengukur HOTS peserta didik', *Saintifika*, vol. 21 no. 2, pp. 1–14.