Assessment of Malaysia School Student's Cognitive Ability Towards the Knowledge and Understanding of pH of Human Skin Through Online STEM Activity

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Abstract
Cognitive ability of students can be measured by level of questions through bloom taxonomy. This study is to assess secondary school student's cognitive ability towards the knowledge and understanding of pH of human skin through STEM activity, entitle "pH of Human Skin: Acid or Base?" by asking them to answer 10 items online questionnaires by using Google Form after demonstrated them a mini experiment via Google Meet. 200 students around Malaysia involved in this activity; 49 lower form students, 49 Form 4 students and 122 Form 5 students. Level of item questions based on bloom taxonomy are 50% is remembering (C1), 20% is understanding (C2) and 30% is applying (C3). Based on the results, most of the students which is the lower form, form 4 and form 5 mastering on C1 rather than C2 and C3. They have knowledge and understanding about the pH, acid and base definition since they had study in Form 2. We can conclude that the students can't relate the theory that studied in the class because of the lack of knowledge and understanding about the application of pH, acid and base in daily life.

Keywords: Cognitive Ability, pH of Human Skin, Online STEM Activity

Introduction

Cognitive ability is an individual thinking process that includes simple intellectual abilities and complex intellectual abilities (Sari, Usodo & Subanti, 2017). Cognitive ability also associated with intrapersonal intelligence. This is because intrapersonal intelligence is intelligence that lies in someone who is characterized by the ability to understand themselves (Armstrong, 2009). This good understanding of self helps individuals to be able to control themselves in responding to various situations, including solving problems. Individuals who have strong intrapersonal intelligence include being independent, having an attitude of confidence, and being able to make important decisions for themselves (Gangadevi & Ravi, 2014). Individuals who have average intrapersonal intelligence know their strengths and weaknesses, but they have not been able to maximize their strengths and have not been able to minimize the shortcomings. Habeeb & Fatema (2016) explained that individuals with weak intrapersonal intelligence have not been able to reflect on their own shortcomings in solving a problem.

Bloom's Taxonomy was originally developed by educational psychologist Benjamin Bloom in 1956 and revised by researchers Lorin Anderson and David Krathwohl in 2001. Bloom's taxonomy was initially meant to be a technique of measuring competency by classifying a student's knowledge into one of six levels. According to Bloom's taxonomy revision (Krathwol, 2002) cognitive domains are classified into six levels, namely: remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6). The major usefulness of Bloom's taxonomy is its adaptability as a tool in a variety of domains of learning. Its broad reach provides a valuable framework for organizing and planning learning experiences that are intended to encompass a wide variety of cognitive capacities while being non-prescriptive (Norova *et. al*. 2022).

Malaysian Education Blueprint 2013-2025 aspires to develop Malaysian students who are able to master HOTS including critical thinking, reasoning, creative thinking, and innovation. Efforts to promote and develop thinking skills should begin at the primary school level because this level is considered as the best time to cultivate the basic foundation for further education (Mohamad & Nasruddin, 2008). The challenges were in the aspects of teachers, teaching and learning preparations and processes, and in the aspects of pupils. To overcome these challenges, teachers need more knowledge, the general pedagogical knowledge, and pedagogical content knowledge. Therefore, teachers need to master various fields; become skilled and competent in teaching and learning; understand the development of pupils, teaching psychology, and counselling skills (Nor Hayati & Kamarolzaman, 2015).

The success in the modern era is determined by how students strive to have certain skills. This can be achieved by students through the development of cognitive domain, because it is considered as the ability to master subject matter with regard to thinking ability in addition to learning. The skills required in the 21st century include not only knowledge in school subjects but also all-around knowledge and skills of human development (Spadaro *et. al*., 2017). These skills include critical thinking, communication, creativity, and collaboration (Gonzalez-salamanca *et. al*. 2020). These are required skills to make students effective workers. Skills such as creativity, critical thinking, collaboration, computer thinking, and problem-solving (Lambrechts, 2019) are for learning that is focused on helping students develop their mental processes (Seema *et. al*., 2020). Literacy skills such as reading and writing also include understanding of digital usage with skills such as information literacy, technology literacy, consuming information, and life skills such as leadership, productivity, flexibility, and social skills. These competencies and skills can be achieved by engaging students in Science, Technology, Engineering, and Mathematics (STEM) learning activities.

STEM education has two outstanding characteristics: first, it emphasizes the integration of science, technology, engineering and mathematics; and, secondly transforms traditional teaching models to a student-centre model such as project-based learning, design-based learning, inquiry-based learning and so on, to cultivate students' ability and improve their achievement (Zeng *et. al.* 2018). Zeng *et. al*. (2018) and Firdaus & Rayahu (2019), found that STEM education is conducive to improving students'

higher-order thinking and cognitive ability levels. The results indicate that teaching methods and student experiences in STEM education have a positive effect on student learning. For example, in project-based learning, students have opportunity to obtain hands-on experiences and from that it can help student gain meaningful learning, and help students improve their cognitive abilities. By using an interactive learning environment such as using various digital tools, including PowerPoint presentations, videos, online simulations, interactive quizzes, and innovative games as teaching aids, it can ensure students' engagement, retention and participation (Azza *et. al*., 2021).

Virtual learning simulation is an example of ICT-based teaching material. A few advantages of virtual learning simulation are cost-effective and time consuming. Furthermore, simulations make it possible for students to grapple with realistic scenarios that may not be possible to experience in real life because they may be too dangerous or only occur rarely (Wang *et. al*., 2014). Based on the findings by Malene Thisgaard & Guido Makransky (2017), they indicate that virtual learning simulations may be a useful tool in enhancing student's interest in and goals toward STEM related careers.

Firdaus & Rahayu (2019) suggested the introduction of a variety of STEM-based learning teaching materials especially in forms of ICT-based teaching materials. Hence, the online STEM activity is implemented by MiCoST in order to enhance the student's interest to STEM Programme. The aim of this study is to assess Malaysia school student's cognitive ability towards the knowledge and understanding of pH on skin through online STEM activity. Students undergo synchronous learning with online demonstration experiment. Students are given online questionnaires in order to evaluate their knowledge regarding the STEM activity. The results of the questionnaires are sorted based on students form level.

Methodology

An online STEM activity titled "pH of Human Skin: Acid or Base?" was conducted with secondary school students from various schools in Malaysia. A total of 49 lower form students, 49 form 4 students and 122 form 5 students participated in the activity. The session began with an explanation of pH, acids, bases, the pH scale, and the pH range of human skin in different conditions by the facilitator.

The students were also shown a mini experiment related to pH, acids, and bases, which was conducted by Diploma in Pharmacy students from MiCoST. The experiment involved determining the pH of substances that come into contact with human skin in daily life such as rain water, lotion, hand sanitizer, tap water, perfume, soap, detergent, household cleaner, bleach and more. The pH of each substance was determined using the natural indicator 'Red Cabbage'.

Following the activity, the students were given 10 minutes to complete an online questionnaire via Google Form. The link to the Google Form was provided by the facilitator through the Google Meet chat. The questionnaire consisted of 10 items designed to assess Malaysia school student's cognitive ability towards the knowledge and

understanding of the pH of human skin in various conditions. The results of the survey were analyzed and discussed.

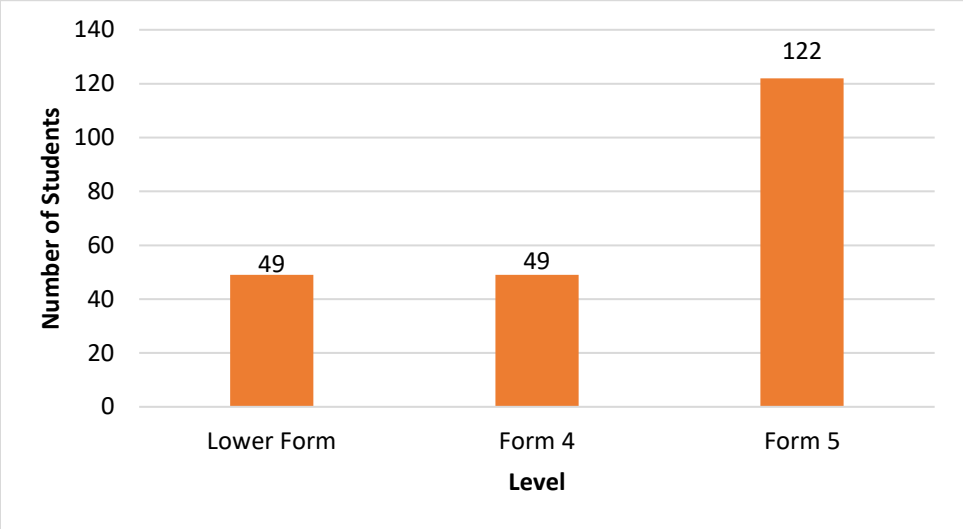

Figure 1: Number of Respondents based on Form Level

The number of students that involved in the STEM activity was more than 200 students. Based on bar graph in Figure 1, there were 49 lower form students, 49 form 4 students and 122 form 5 students that answered the STEM activity questionnaires.

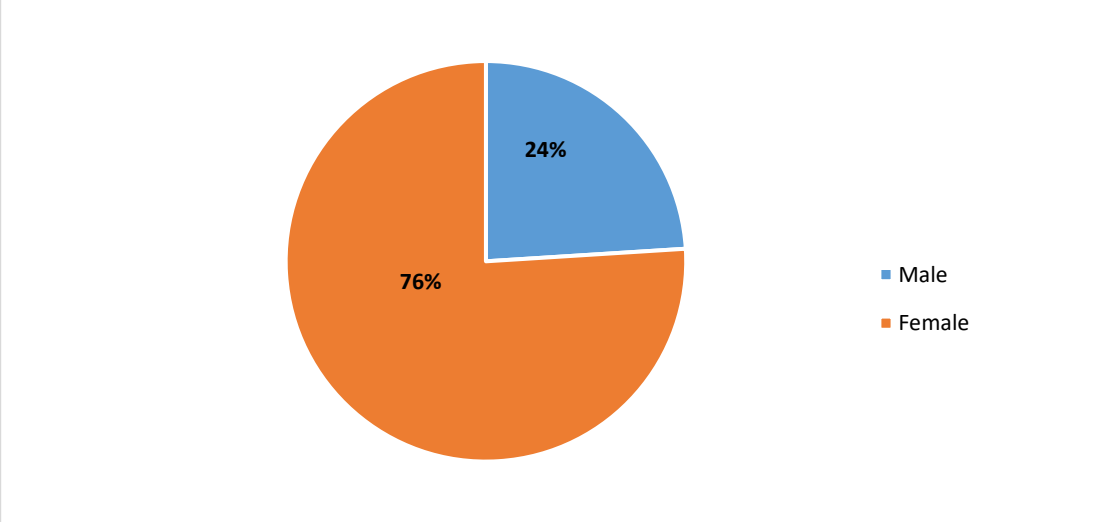

Figure 2: Percentage of Male and Female of Lower Form Students

Based on pie chart in Figure 2, the percentage of male and female of lower form students involved in the STEM activity were 24% and 76% respectively.

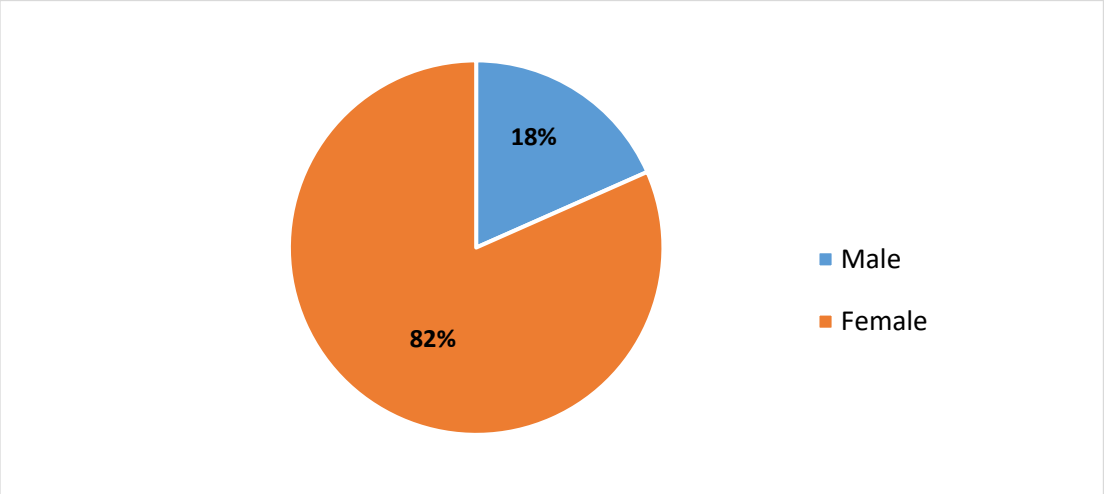

Figure 3: Percentage of Male and Female of Form 4 Students

Based on pie chart in Figure 3, the percentage of male and female of form 4 students involved in the STEM activity were 18% and 82% respectively.

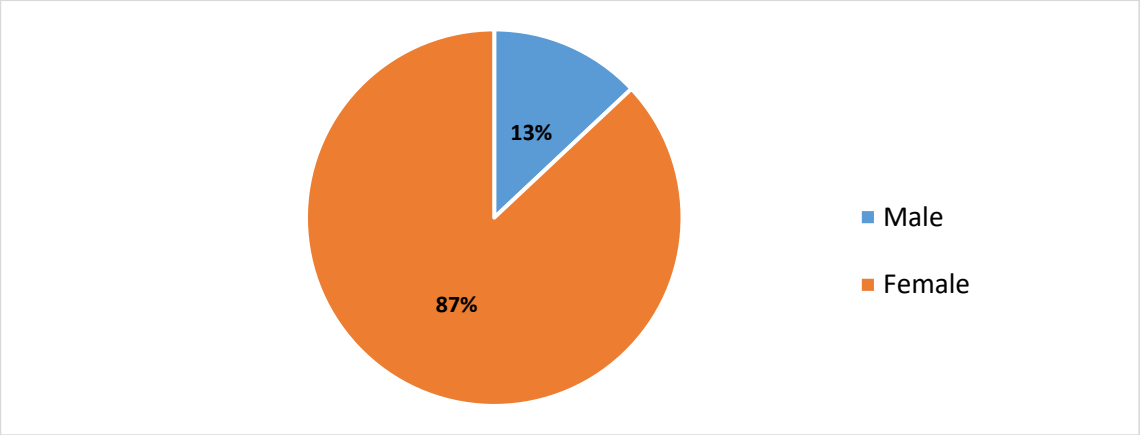

Figure 4: Percentage of Male and Female of Form 5 Students

Based on pie chart in Figure 4, the percentage of male and female of form 5 students involved in the STEM activity were 13% and 87% respectively.

Table 1: Bloom Taxonomy Level Based on Questionnaires Items

Questions	Description	Bloom Taxonomy Level
Q1	I know the meaning of pH I know the meaning of pH.	C1
Q2	I can describe the definition of acid and base.	C2
Q3	I know the pH scale of acid and base.	C1
Q4	I can identify the properties of acid and base.	C1
Q5	I can describe the suitable indicators to test the pH of acid and base.	C2
Q6	I know the pH of the clean skin.	C1
Q7	I know the pH of the dirty skin.	C1
Q8	I can interpret the changes of pH based on the human skin condition.	C3
Q9	I am able to explain the pH when microbes present on the human skin.	C2
Q10	Overall, I can interpret the condition and pH of human skin with or without microbes.	C3

Table 1 shows the bloom taxonomy level based on questionnaires items. For Q1, Q3, Q4, Q6 and Q7, the level of bloom taxonomy is C1 (remember). Then, for Q2, Q5 and Q9, the level of bloom taxonomy is C2 (understand) meanwhile, for Q8 and Q10 is C3 (apply).

Results/Discussion

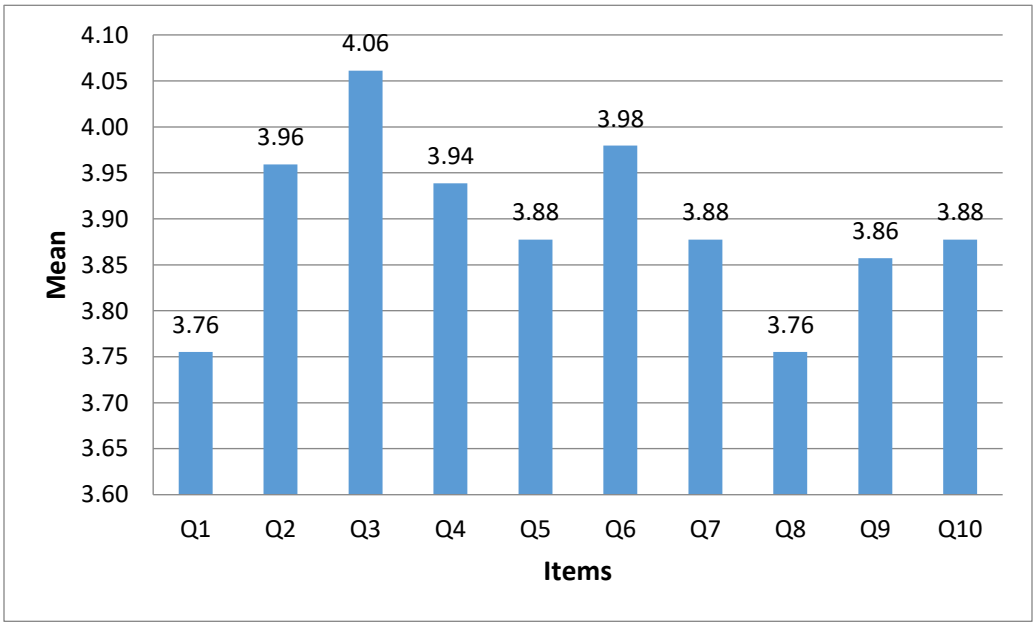

Figure 5: Knowledge and Understanding of Lower Form Students Towards pH of Human Skin

Based on bar graph at Figure 5, the means for respective questions are Q1 is 3.76, Q2 is 3.96, Q3 is 4.06, Q4 is 3.94, Q5 is 3.88, Q6 is 3.98, Q7 is 3.88, Q8 is 3.76, Q9 is 3.86 and Q10 is 3.88. The majority of Lower Secondary students know the pH scale of acid and base because they already studied during Form Two in the subject Science, Chapter Acid and Base. However, least students know the meaning of pH and cannot relate the changes of pH based on the human skin condition. It is because based on the syllabus of subject Science Form Two, they did not expose the meaning of pH in Chapter Acid and Base.

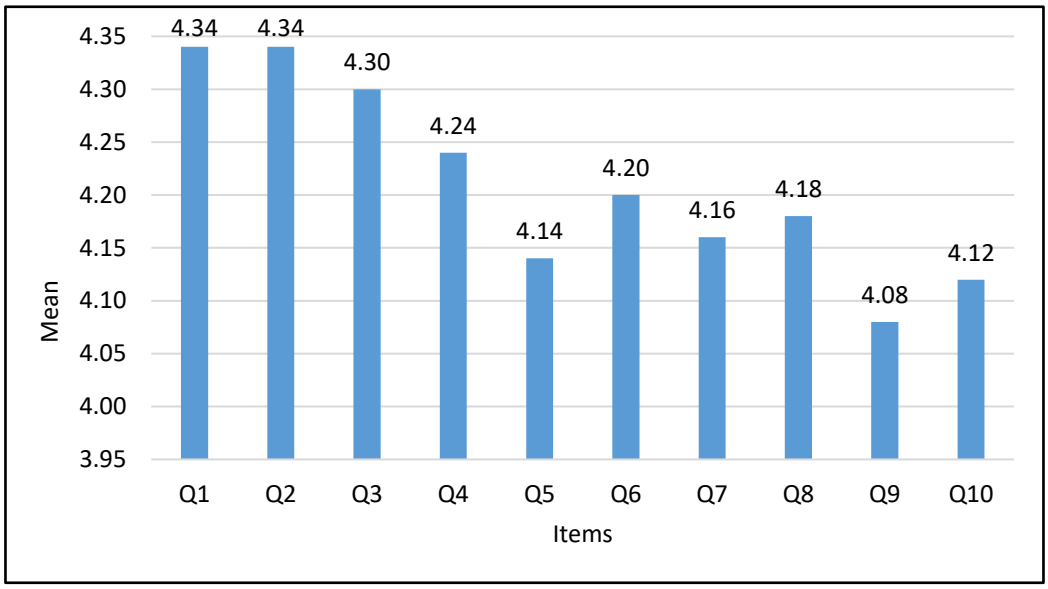

Figure 6: Knowledge and Understanding of Form 4 Students Towards pH of Human Skin

Figure 6 shows the graph of knowledge and understanding of form 4 students towards pH of human skin. Based on the graph, the mean of Q1 and Q2 is 4.34, Q3 is 4.30, Q4 is 4.24, Q5 is 4.14, Q6 is 4.20, Q7 is 4.16, Q8 is 4.18, Q9 is 4.08, as well as Q10 is 4.12.

The graph shows that the items that have the highest meaning is Q1 and Q2 meanwhile, the item that has a lowest mean is Q9. These results show that, most of the form 4 students have knowledge and understanding about the pH, acid, and base definition. However, most students have little knowledge and understanding to explain the pH condition during the presence of microbes on human skin. This is because the students already have the knowledge and understanding about the pH, acid and base since their study in Form 2. But they lack of knowledge and understanding about the application of pH, acid and base in their daily life. The students can't relate the theory that studied in the class with the application in their daily life.

In addition, the lowest meaning of item shows that the students need a lot of time to study something new especially about the application of pH, acid and base. During the programme, the students got new knowledge regarding the application in a short time. Some of the students can follow the situation, some of them are not. Hence, this affects the mean value of the application items in the survey.

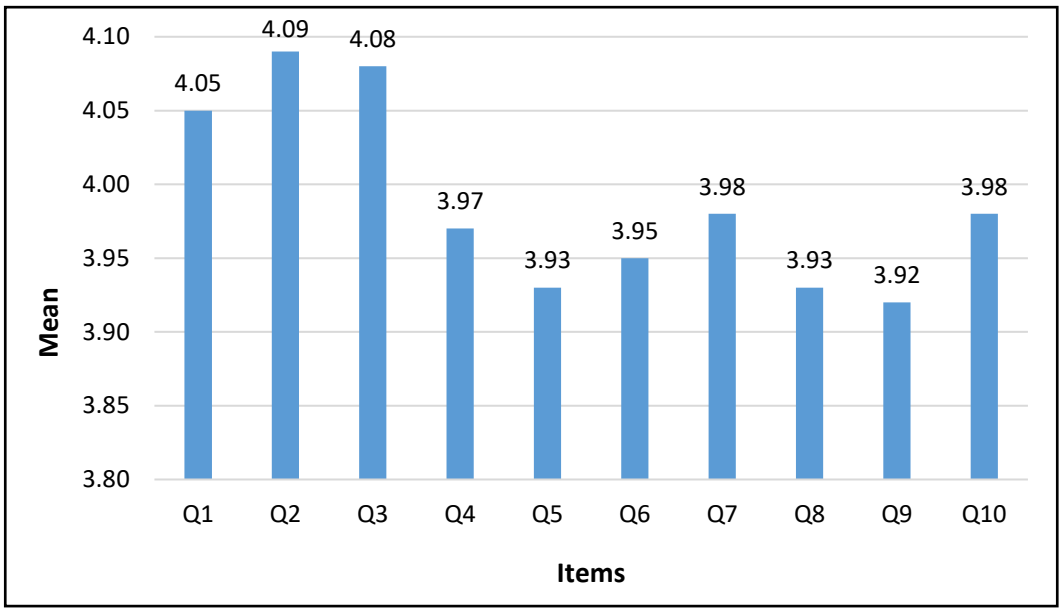

Figure 7: Knowledge and Understanding of Form 5 Students Towards pH of Human Skin

Figure 7 shows the graph of knowledge and understanding of form 5 students towards pH of human skin. Based on the graph, the mean of Q1 is 4.05, Q2 is 4.09, Q3 is 4.08, Q4 is 3.97, Q5 is 3.93, Q6 is 3.95, Q7 is 3.98, Q8 is 3.93, Q9 is 3.92, as well as, Q10 is 3.98.

The graph shows that the items that have a highest mean is Q2 meanwhile, the item that has a lowest mean is Q9. These results show that, most of the form 5 students have knowledge and understanding about the acid and base definition. However, most of students have little knowledge and understanding to explain the pH condition during the presence of microbes on human skin. This is because the students already have the knowledge and understanding about the pH, acid and base since their study in Form 2. But they lack of knowledge and understanding about the application of pH, acid and base in their daily life. The students can't relate the theory that studied in the class with the surrounding situation.

In addition, the lowest mean of item shows that the students need a lot of time to study the something new especially about the application of pH, acid and base. During the programme, the students got the new knowledge regarding the application in a short

time. Some of the students can follow the situation, some of them are not. Hence, this affects the mean value of the application items in the survey.

As a conclusion, the knowledge and understanding towards pH of Human Skin between groups of secondary school students shows the different mean values. The group of students that achieves the highest knowledge and understanding is Form 4 students, meanwhile, the lowest is Lower Form students. This shows that the Form 4 students gave more attention during the programme because of their awareness on skin care and maturity compare to Lower Form students.

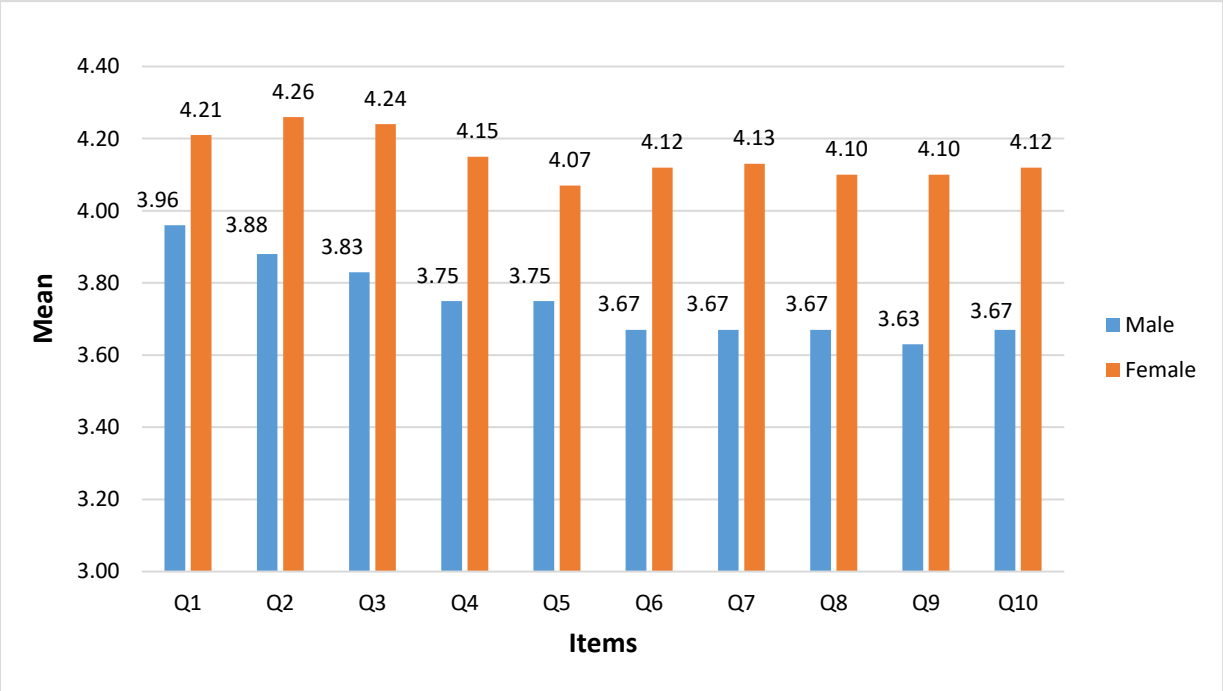

Figure 8: Comparison between Knowledge and Understanding of Male and Female Students Towards pH of Human Skin

Figure 8 shows the graph of comparison between knowledge and understanding of male and female students towards pH of human skin. Based on the graph, for the male students, the mean of Q1 is 3.96, Q2 is 3.88, Q3 is 3.83, Q4 is 3.75, Q5 is 3.75, Q6 is 3.67, Q7 is 3.67, Q8 is 3.67, Q9 is 3.63, as well as Q10 is 3.67. Meanwhile, for the female students, the mean of Q1 is 4.21, Q2 is 4.26, Q3 is 4.24, Q4 is 4.15, Q5 is 4.07, Q6 is 4.12, Q7 is 4.13, Q8 is 4.10, Q9 is 4.10, as well as Q10 is 4.12.

Based on the data obtained, the female students have higher knowledge and understanding towards pH of human skin compared to the male students. This shows that the female students have a good perception towards STEM activities implemented compared to the male students. The female students gave full attention and shows their interested during the activities because it was related to their skincare routine. As a result, the female students gained the higher knowledge and understanding towards pH of human skin compared to the male students.

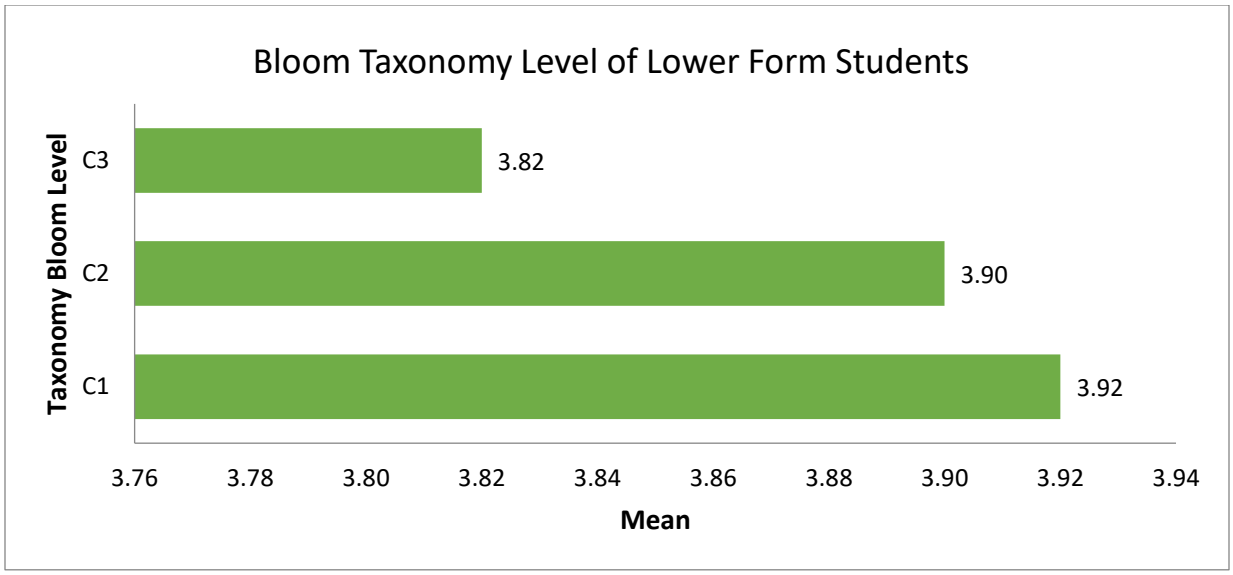

Figure 9: Bloom Taxonomy Level of Lower Form Students

Figure 9 shows the graph of bloom taxonomy level of lower form students towards pH of human skin. Based on the graph, the mean of C1 is 3.92, C2 is 3.90 and C3 is 3.82. This shows that the highest bloom taxonomy of lower form students is C1.

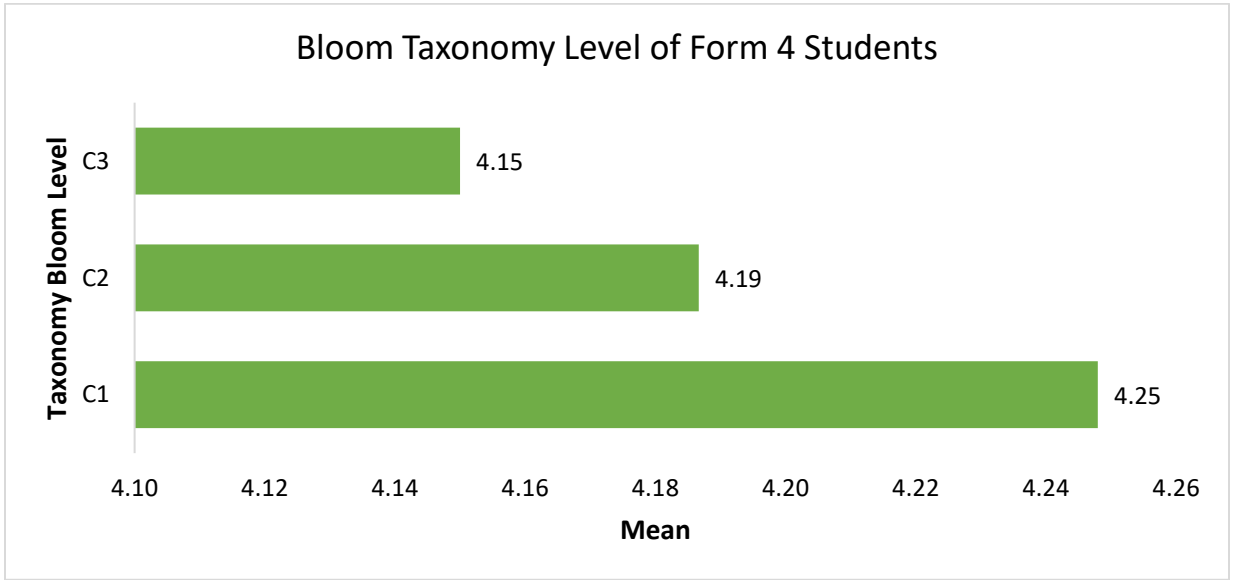

Figure 10: Bloom Taxonomy Level of Form 4 Students

Figure 10 shows the graph of bloom taxonomy level of form 4 students towards pH of human skin. Based on the graph, the mean of C1 is 4.25, C2 is 4.19 and C3 is 4.15. This shows that the highest bloom taxonomy of form 4 students is C1.

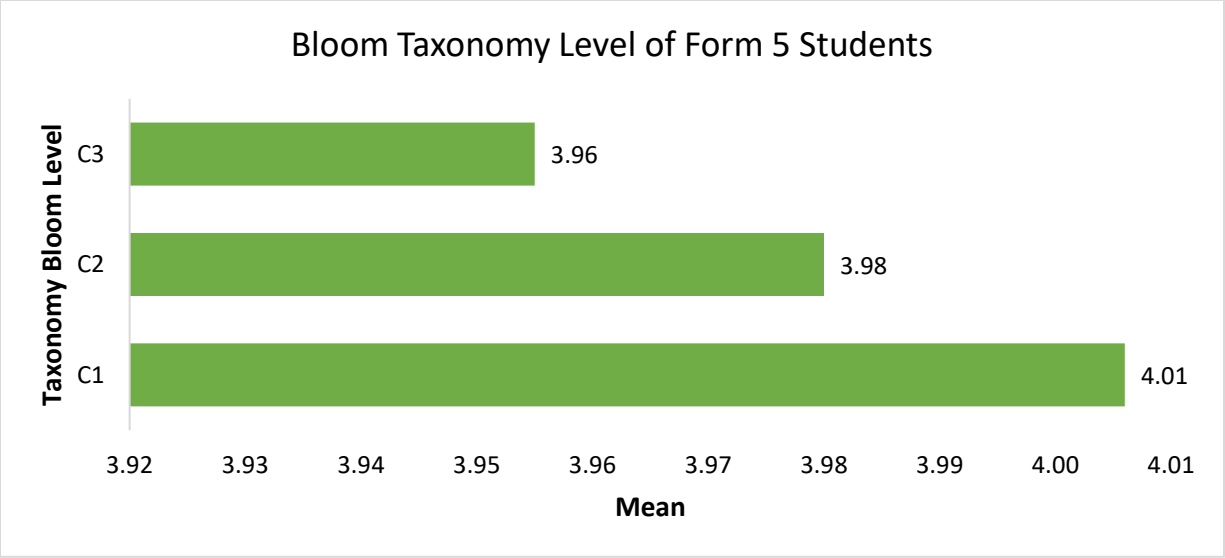

Figure 11: Bloom Taxonomy Level of Form 5 Students

Figure 11 shows the graph of bloom taxonomy level of form 5 students towards pH of human skin. Based on the graph, the mean of C1 is 4.01, C2 is 3.98 and C3 is 3.96. This shows that the highest bloom taxonomy of form 5 students is C1.

Conclusion

As a conclusion, the highest bloom taxonomy for all of the secondary school student level is C1. Most of the students able to enhance their knowledge about pH of human skin, acid and base during the online STEM activity. The purpose of this research was to assess school student's cognitive ability towards the knowledge and understanding of pH of human skin through online STEM activity. Based on the findings, it can be concluded that, most of the students were mastering on C1 rather than C2 and C3. They have knowledge and understanding about the pH, acid and base definition since they had study in Form 2, but they lack of knowledge and understanding about the application of pH, acid and base in their daily life. This finding will be able to give an idea for teachers to make a variety of STEM activity through application based on their Science syllabus in order to ensure the students understand the theory and concept very well and relate them with their daily life. STEM education is known for promoting higher-order thinking and cognitive skills in students. Hence, engaging in online STEM activities can help students enhance their cognitive abilities.

References

Anderson, L. W and Krathwohl, D. R., eds. (2001). A taxonomy for learning, teaching, and assessing: *A revision of Bloom's taxonomy of educational objectives*. Allyn and Bacon.

Armstrong, T. (2009). Multiple Intelligences in the Classroom. USA: Alexandria.

Azza, A., Rana, M. A., Jolly, B., Malavika, S., Zubair, A. and Noora, J.A.-T. (2021). A Distinctive Method of Online Interactive Learning in *STEM Education: Sustainability.*

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H. and Krathwohl, D. R. (1956). Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain. New York: David McKay Company.

Firdaus, A. R. and Rahayu, G. D. (2019). Effect of STEM-based Learning on the Cognitive Skills Improvement. Mimbar Sekolah Dasar, 6(2), 198-207. doi:10.17509/mimbar-sd.v6i2.1756

Gangadevi, S. and Ravi (2014) Multiple Intelligence Based Curriculum to Enhance Inclusive Education to Bring Out Human Potential. *International Journal of Advanced Research,* Vol. 2, pp. 619-626.

González-salamanca, J.C., Agudelo, O.L. and Salinas, J. (2020) Key Competences, Education for Sustainable Development and Strategies for the Development of 21st Century Skills. *A Systematic Literature Review. Sustainability*, 12, 10366.

Habeeb, K. T. and Fatema, M. (2016). Effect of Intrapersonal and Interpersonal Awareness Dimensions of Emotional Intelligence on Stress Management of Adolescents. *International Journal of Applied Research*,2,589-592.

Ikhsan, O. and Norlia, M.S (2005). Kurikulum dan pengajaran sekolah rendah, aspek-aspek yang berkaitan (curriculum and primary school teaching, relevant aspects). Tanjong Malim, Perak: Quantum Books.

Krathwol, D. R. (2002). A Revision of Bloom's Taxonomy: An Overview. Theory Into Practice,41,212-218

Lambrechts,W. (2019). 21St Century Skills, Individual Competences, Personal Capabilities and Mind-Sets Related To Sustainability: *A Management and Education Perspective. Cent. Eur. Rev. Econ. Manag.* 3, 7–17.

Mohamad, M.M.S. and Nasruddin, Y. (2008). Halangan-halangan kepada usaha memupuk kreativiti di kalangan pelajar (Obstacles in Developing Creativity Among Students). Melaka: *Prosiding Seminar Kemahiran Insaniah dan Kesejahteraan Sosial (SKIKS).* pp: 89–150.

Nor Hayati, I. and Kamarolzaman, M.J. (2015). Effectiveness of teaching and learning science in HOTS 21st century: A review of literature. Batam: *Proceedings of the 1st International Conference on Character Education.* pp: 54-64

Norova, M., Alimardanova, N. and Rasulova, Z. (2022). Applying Bloom's Taxonomy In Teaching Effectively. Innovative Development In The Global Science. https://doi.org/10.5281/zenodo.6974790

Sari, D. P., Usodo, B. and Subanti, S. (2017) Metacognitive experience of mathematics education students in open start problem solving based on intrapersonal intelligence. *Journal of Physics: Conference Series.*

Seema, S., Gupta, M. and Sharma, R.K. (2020) Century Skills and Sustainability. *Int. J. Adv. Sci. Technol.,* 28, 507–513.

Spadaro, G.S.; Curiel, M.G.T. and Rodríguez Melchor, V.Z. (2017). Education as a Strategy for Sustainability in the 21st Century: Teachers as Creators of Educational Change. *Eur. J. Educ. Sci.,* 4, 57–68.

Thisgaard, M. and Makransky, G. (2017). Virtual Learning Simulations in High School: Effects on Cognitive and Non-cognitive Outcomes and Implications on the Development of STEM Academic and Career Choice. Frontiers in Psychology.

Wang, C. Y., Wu, H. K., Lee, S. W. Y., Hwang, F. K., Chang, H. Y. and Wu, Y. T. (2014). A review of research on technology-assisted school science laboratories. *Educ. Technol. Soc.* 17, 307–320.

Zeng, Z., Yao, J., Gu, H. and Przybylski, R. (2018). A Meta-Analysis on the Effects of STEM: Education on Students' Abilities. *Sci Insigt Edu.*