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Assessment of student concept maps on environmental pollution subjects during the pandemic covid-19

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ABSTRACT

The ability to compile concept maps is strongly influenced by the knowledge possessed. This research aims to describe students' Concept Maps scores on environmental pollution during the Covid-19 pandemic. This research includes a quantitative descriptive using a survey method with a population of 210 high school students. Data collection uses a Google form that asks students to make Concept Maps at the end of learning environmental pollution material. The researcher then assesses and determines the score of each student. Student scores are then combined and an average is obtained. The results showed that the largest percentage was owned by a valid relationship component of 9.75%, followed by a hierarchical component with a percentage of 7.34% and a branching component with a percentage of 3.42%. The pattern component is the fourth component with a percentage of 1.31%, followed by an example component with a percentage of 1.30% and the last component is a crosslink with a percentage of 0%. Acquired student concept map scores can be used to assess student learning outcomes so it is hoped that this research can be an evaluation material for students and teachers.

Introduction

Concept Maps (CM) is a graphical organization for exploring knowledge and understanding (Hay et al., 2006), which is based on Ausubel's theory of meaningful learning in the classroom (Kharatmal & Nagarjuna, 2006). CM which functions as an assessment tool (King & Walker, 2002) is used to measure students' understanding through the complexity of concepts and relationships between concepts (Tan et al., 2017). The better understanding of students is marked by the existence of complex conceptual relationships and becomes one of the indicators of meaningful learning (A. Ghani et al., 2017) when students can connect old concepts with new concepts that students find (Novak, 2010). The complexity of the related concepts in CM is also used to measure higher-order thinking skills (Tan et al., 2017). Higher-order thinking skills based on Bloom's taxonomy are the ability to analyze, synthesize, and evaluate (Canas et al., 2017) and the third ability strongly supports the preparation of CM (Rosen & Tager, 2014).

CM structure consists of several components, namely: valid relationships, hierarchies, branching, crosslinks, patterns, and examples (Liu & Lee, 2013; Novak et al., 2012). A valid relationship is a connecting line between concepts. Concepts that are connected with valid relationships and form a meaning are called propositions (Chiou, 2008). Hierarchy is a structured level of concepts (Novak et al., 2012). Branching is a branching concept showing the degree of differentiation of a concept (Edmondson, 2005). Crosslinks are conceptual relationships with different paths and hierarchies (Wang, 2020) and can show creative relationships between knowledge domains (Erdimez et al., 2017; Novak et al., 2012). The pattern is the overall concept pattern consisting of a spoke, net, and chain (Hay et al., 2006). An example is a specific example of a concept (Novak et al., 2012). CM integrates conceptual relationships that make students learn in-depth to increase students' understanding of the concepts of learning materials (Schwendimann, 2015).

Environmental pollution learning materials are classified as socio-scientific issues with detailed concepts consisting of causes, effects, and countermeasures (Kim et al., 2020). Socioscientific issues material is classified as contextual material because it often occurs in students' lives. Contextual material helps students in writing examples because examples of pollution events can be seen by students for real. Contextual material is expected to make students' understanding more clearly visualized, namely the relationship of concepts previously understood by students in classroom learning with new concepts that students get in their respective living environments independently (De Morais et al., 2016).

Independent learning without face-to-face can be called online learning. Online learning in Indonesia which is currently taking place is mainly due to the Covid-19 pandemic. Online learning results in limited teacher interaction and supervision of students (Meilinda et al., 2021). Students are independently required to be able to express ideas or concepts in learning materials (De Morais et al., 2016) and CM can assist students in reflecting on the understanding that students have (Vanides et al., 2005) while at the same time accommodating students to study independently. Chiou (2008) but during a pandemic situation like now, students' independence in dealing with online learning has various effects such as psychological effects related to learning motivation (Shao, 2018) and the effectiveness of ongoing learning (Hikmat et al., 2020). Learning changes that occur indirectly have an impact on student learning outcomes, so the researcher asks students to make a CM at the end of the lesson to see student CM's scores which can also indirectly describe how student learning outcomes are during the online learning period.

Method

This research is quantitative and descriptive with a survey method. Data collection online using Google form which previously was given an image of a CM example with bacteria material to make an analogy for the construction of CM for students. Data was collected in June 2020 with the research population being class X high school students majoring in Mathematics and Natural Sciences. The sample selected was 71 students with a sampling technique in the form of clustered sampling, namely the population was divided into several separate groups, then the sample class was selected by the researcher.

The research sample has a balanced ability as evidenced by testing students' midterm exam scores using the paired F test (ANOVA test) with a sig value of > 0.05. Data analysis used Microsoft Excel by calculating the student's CM acquisition score which was assessed according to the expert CM procedure that had been made by the researcher. Student CM scores will be compared with scores on expert CM and calculated according to the rubric in Table 1.

Student scores are then combined and calculated for each CM component with the following equation (I).

$$\text{Percentage M on component X} = \frac{\text{students scores in component X}}{\text{the maximum value of CM for all students}} \times 100\% \quad \text{(I)}$$

Table 1. The rubric of expert CM

No	Component of CM	Score	Total	Percentage
1	Valid relationship	1	90 x 1 = 90	90/210 x 100 = 42.86%
2	Hierarki	5	6 x 5 = 30	30/210 x 100 = 14.29%
3	Branching			
	Level 1	1	1 x 1 = 1	16/210 x 100 = 7.62%
	Level 2	3	1 x 3 = 3	
	Level 3	3	1 x 3 = 3	
	Level 4	3	1 x 3 = 3	
	Level 5	3	1 x 3 = 3	
	Level 6	3	1 x 3 = 3	
			= 16	
4	Crosslink	10	2 x 10 = 20	20/210 x 100 = 9.52%
5	Example	1	49 x 1 = 49	49/210 x 100 = 23.33%
6	Pattern	5	5	5/210 x 100 = 2.38%
Total score		210		

Results and Discussion

The results of the study were students' CM point scores which were processed in the form of percentages. The percentage of students' CM scores classified according to the CM components presented in Table 2.

Table 2 shows that the valid relationship component is only 9.75% of the maximum scores. The hierarchical component scorscore4% and the branching component scored 3.42%. These two components can reach half of the maximum performance of the CM component. The next component is the crosslink component with scores of 0%. The example component has scores of 1.30% and the last component, namely the pattern, has scored 1.31%, reaching more than half of the maximum scores.

The CM component in the form of a valid relationship is a link in the concept. Concepts that are connected by connecting lines and certain labels form a meaning are called propositions (Yin & Shavelson, 2008). Relationships in propositions reflect the main idea of knowledge and become one of the important components of CM (Vanides et al., 2005). The percentage of valid relationship scores is only 9.75% of the maximum scores of 42.86%. Individual student scores are also low because the majority of students only achieve points in the range of 20-30 points and some students score even lower. The student's point gain is directly proportional to the scores his scores so the scores are also small. The majority of students did not write down the example component so the resulting valid relationship was much reduced because half of the concepts in the valid relationship contained the link to the example concept. The low scores of valid relationships because students skip concepts or write concepts incorrectly indicates that students do not understand the concept of the related material (Vanides et al., 2005).

The second component, namely the hierarchy. Hierarchy is the relationship of concepts from the general to the specific level (Chiou, 2008). Hierarchy makes CM more structured because there are superordinate subordinate parts (primary, tertiary, secondary) (Almulla & Alamri, 2021). The hierarchy of CM experts has 6 levels with a maximum of 30 points, the majority of students can construct a hierarchy up to the 3rd level, half of the maximum level of the hierarchy. This is proportional to the percentage of student scores, which is 7.34%, which only reaches half of the maximum scores of expert CM, indicating that students' analytical skills need to be improved again because students' analytical skills are needed to determine the level of hierarchy in each related concept (Juanengsih et al., 2017).

The third component is branching. Branching is a branch or concept fraction. Obtaining a branching score is in line with the acquisition of a hierarchical score because the concept of solving in branching is in the same hierarchy and is calculated according to the hierarchical level. Branching describes the differentiation of a concept (Edmondson, 2005). The percentage of scores of the branching component is 3.42%, it does not reach half of the maximum branching scores of 7.62%, indicating that many students do not understand the teaching material. Determination of branching requires students to be able to distinguish branches from related concepts and their differentiating factors so that a good understanding of the related material is needed (Borda et al., 2009).

The fourth component, namely crosslinks. Crosslinks is a link that connects different concepts of segments and hierarchies (Wang, 2020). Crosslinks describe creative relationships between related concepts (Canas & Novak, 2006). Crosslinks are also a reflection of the complexity of CM, the more crosslinks made by students, indicating the more complex the results of CM construction by students (West et al., 2000), but in the research conducted, none of the students made crosslinks so the scores of the Crosslink component was worth 0%. The low crosslink scores of students indicate that students do not understand the relationship between knowledge domains (West et al., 2000) and students' synthesis ability needs to be improved again because crosslinking in CM requires students' synthesizing abilities (Juanengsih et al., 2017).

The fifth component, namely example. An example is a specific object in the last concept link that is used to help clarify the meaning of the statement in each concept (Zubaidah & Pangestuti, 2016). The percentage of example scores only reached 1.30% of the maximum scores of 23.33%. The scores of the example component are quite low. The low scores of the example component are because many students do not write down the example at all so it is worth 0 points. The low scores of examples indicate that students' analytical skills still need to be improved because the example is the most specific concept at the hierarchical level so determining examples requires good analytical skills (Juanengsih et al., 2017).

The sixth component is a pattern. The pattern is the shape or pattern of the diagram in CM (Novak et al., 2012) which forms a typology structure and can be used to analyze CM which shows different patterns of understanding (Hay et al., 2006). The overall pattern is worth 5 points. The percentage of pattern scores of 1.31% is more than half of the pattern's maximum scores of 2.38%. The pattern in pattern consists of a spoke, net, and chain (Hay et al., 2006). The spoke pattern has a single hierarchy. Chain pattern has a lot of hierarchy without branching and net pattern has a hierarchy also branches (Kinchin et al., 2010). The majority of students make CM with a spoke pattern. An example of a student's CM pattern can be seen in Figure 1.

The spoke pattern is the simplest pattern, unlike other patterns, namely net and chain. The chain pattern has many hierarchies but does not have branching while the net pattern is the most complex because there are many hierarchical levels, a lot of branching and there are crosslinks (Hay et al., 2006). The spoke pattern is a single-level pattern with 1 central concept. Addition and subtraction of concepts can be done easily as long as it does not damage the core concept. The spoke pattern is a simple pattern with a simple concept meaning (Kinchin et al., 2010).

Overall, the data shows that the scores of the CM component of students are unsatisfactory because the highest scores only reach half of the maximum scores. Low student scores can be influenced by less meaningful learning by teachers. Environmental pollution material is material that requires contextual knowledge but the learning that takes place is online learning so students only see pictures presented by the teacher. Online learning is virtual learning using technology (Mulyani & Asmendri, 2021). The technologies that students generally use in online learning are gadgets and laptops. The use of gadgets and laptops for too long can cause physical complaints for students, for example, eyes are tired as a result of screen radiation and the body feels sore because during learning activities students just stay silent and focus on learning in front of devices and laptops. Other physical disturbances that students feel are headaches and drowsiness when online learning takes place (Mustakim, 2020).

Table 2. Students' CM scores

The Component of CM	Valid Relationship	Hierarchy	Branching	Crosslink	Example	Pattern
Students' scores (%)	9.75	7.34	3.42	0	1.30	1.31
Maximum scores (%)	42.86	14.29	7.62	9.25	23.33	2.38

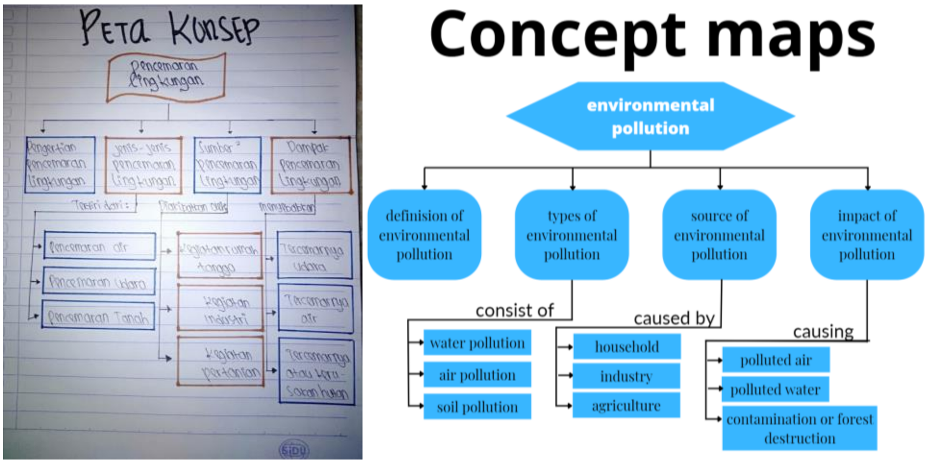

Figure 1. Example of student CM with a spoke pattern (left), translation version (right)

Online learning also requires a stable internet connection but the internet services that students get are inadequate so it interferes with the learning process. During online learning, students are also required to study independently and this results in pressure for students (Maatuk et al., 2022). According to Mustakim (2020), online learning also causes students to feel bored, anxious, and worried. Students also find it difficult to concentrate and lack the motivation to learn (Fatimah & Mahmudah, 2020). Limitations on online learning make the student learning process not optimal (Mulyani & Asmendri, 2021) so it affects students' understanding of the material.

The low scores of students at the same time show that students still need to learn a lot to better understand the learning material so that it can improve student learning outcomes. But the research only covers 1 material, namely environmental pollution and further research needs to be done to find out student learning outcomes in other materials so that student learning outcomes can be described in more detail. This research contributes that students need to be equipped with knowledge related to concept maps and the ability to classify various information obtained. So that it can be compiled into an informative concept map.

Conclusion

The conclusion of the research is students' CM components are unsatisfactory because the highest percentage only reaches half of the maximum percentage. The low percentage of students at the same time shows that students still need to learn a lot to better understand the learning material so that it can improve student learning outcomes, especially on environmental pollution material. students' ability to process information needs to be improved to support CM abilities.

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References

A. Ghani, I. B., Ibrahim, N. H., Yahaya, N. A., & Surif, J. (2017). Enhancing students' HOTS in laboratory educational activity by using concept map as an alternative assessment tool. *Chemistry Education Research and Practice*, *18*(4), 849-874. https://doi.org/10.1039/c7rp00120g

Almulla, M. A., & Alamri, M. M. (2021). Using conceptual mapping for learning to affect students' motivation and academic achievement. *Sustainability*, *13*(7). https://doi.org/10.3390/su13074029

Borda, E. J., Burgess, D. J., Plog, C. J., DeKalb, N. C., & Luce, M. M. (2009). Concept maps as tools for assessing students' epistemologies of science. *Electronic Journal of Science Education*, *13*(2), 160-185. https://cedar.wwu.edu/cgi

Canas, A. J., & Novak, J. D. (2006). Re-examining the foundations for effective use of concept maps. *Conference: Concept Maps: Theory, Methodology, Technology, Proceedings of the Second International Conference on Concept Mapping, 1.* https://maaz.ihmc.us

Canas, A. J., Reiska, P., & Möllits, A. (2017). Developing higher-order thinking skills with concept mapping: A case of pedagogic frailty. *Knowledge Management & E-Learning: An International Journal*, 348-365. https://doi.org/10.34105/j.kmel.2017.09.021

Chiou, C. C. (2008). The effect of concept mapping on students' learning achievements and interests. *Innovations in Education and Teaching International*, *45*(4), 375-387. https://doi.org/10.1080/14703290802377240

De Morais, M. A., Hirano, F. W., de Araujo, T., & de Nery, G. (2016). Use of concept maps as a strategy for teaching-learning and assessment tool in geography lessons. *Congresso Regional Sobre Tecnologias na Educacao*, 139-146.

Edmondson, K. M. (2005). Assessing science understanding through concept maps. *Elsevier.* https://doi.org/10.1016/B978-012498365-6/50004-4

Erdimez, Ö., Tan, S., & Zimmermann, R. (2017). The use of concept maps as a tool to measure higher level thinking skills in elementary school science classes. *Journal for the Education of Gifted Young Scientists*, *5*(2), 1-20. https://doi.org/10.17478/jegys.2017.60

Fatimah, S., & Mahmudah, U. (2020). How e-learning affects students' mental health during covid-19 pandemic: an empirical study. *DWIJA CENDEKIA: Jurnal Riset Pedagogik*, *4*(1). https://doi.org/10.20961/jdc.v4i1.41991

Hay, D. B., Sadler-Smith, E., & Kinchin, I. M. (2006). Using concept maps to reveal conceptual typologies. *Education + Training*, *48*(2/3), 127-142. https://doi.org/10.1108/00400910610651764

Hikmat, H., Hermawan, E., Aldim, A., & Irwandi, I. (2020). *Efektivitas pembelajaran daring selama masa pandemi Covid-19: Sebuah survey online*. LP2M UIN Sunan Gunung Djati Bandung. http://digilib.uinsgd.ac.id/30625/1/FISIP%20Kelompok%207.pdf

Juanengsih, N., Ramadhani, D. P., & Mardiati, Y. (2017). Analysis of critical thinking skill of students on the concept of human movement system using concept map. *Edusains*, *9*(2). https://doi.org/10.15408/es.v9i2.5407

Kharatmal, M., & Nagarjuna, G. (2006). A proposal to refine concept mapping for effective science learning. In concept maps: theory, methodology, technology. *Proceedings of the second international conference on concept mapping*.

Kim, G., Mun, K., & Lee, H. (2020). Exploration of middle school students' ideas of fine dust issues using issue concept maps. *Asia-Pacific Science Education*, *6*(2), 564-583. https://doi.org/10.1163/23641177-bja10014

Kinchin, I. M., Streatfield, D., & Hay, D. B. (2010). Using concept mapping to enhance the research interview. *International Journal of Qualitative Methods*, *9*(1), 52-68. https://doi.org/10.1177/160940691000900106

King, P., & Walker, J. (2002). *Concept mapping as a form of student assesment and instruction*. Annual Conference. https://doi.org/10.18260/1-2--10185

Liu, S.-H., & Lee, G.-G. (2013). Using a concept map knowledge management system to enhance the learning of biology. *Computers & Education*, *68*, 105-116. https://doi.org/10.1016/j.compedu.2013.05.007

Maatuk, A. M., Elberkawi, E. K., Aljawarneh, S., Rashaideh, H., & Alharbi, H. (2022). The COVID-19 pandemic and E-learning: challenges and opportunities from the perspective of students and instructors. *J Comput High Educ*, *34*(1), 21-38. https://doi.org/10.1007/s12528-021-09274-2

Meilinda, M., Nazip, K., Susanti, R., Riyanto, R., & Anwar, Y. (2021). Pelatihan strategi assesment dan pembelajaran daring di masa covid untuk guru-guru SMA Srijaya Negara. *Jurnal Pengabdian Dharma Wacana*, *2*(2), 20-26. https://doi.org/10.37295/jpdw.v2i1.94

Mulyani, M., & Asmendri, M. (2021). Model ASSURE dan media infografis pada desain pembelajaran sosiologi di masa pandemi covid-19. *JIRA: Jurnal Inovasi dan Riset Akademik*, *2*(8), 1189-1200. https://doi.org/10.47387/jira.v2i8.201

Mustakim, M. (2020). Efektivitas pembelajaran daring menggunakan media online selama pandemi Covid-19 pada mata pelajaran Matematika. *Al asma : Journal of Islamic Education*, *2*(1), 1-12. https://doi.org/10.24252/asma.v2i1.13646

Novak, J. D. (2010). *Learning, creating, and using knowledge*. Rotledge.

Novak, J. D., Gowin, D. B., & Kahle, J. B. (2012). *Learning how to learn*. https://doi.org/10.1017/cbo9781139173469

Rosen, Y., & Tager, M. (2014). Making student thinking visible through a concept map in computer-based assessment of critical thinking. *Journal of Educational Computing Research*, *50*(2), 249-270. https://doi.org/10.2190/EC.50.2.f

Schwendimann, B. A. (2015). Concept maps as versatile tools to integrate complex ideas: From kindergarten to higher and professional education. *Knowledge Management & E–Learning: An International Journal*, 73-99. https://doi.org/10.34105/j.kmel.2015.07.006

Shao, Z. (2018). Examining the impact mechanism of social psychological motivations on individuals' continuance intention of MOOCs. *Internet Research*, *28*(1), 232-250. https://doi.org/10.1108/IntR-11-2016-0335

Tan, S., Erdimez, O., & Zimmerman, R. (2017). Concept mapping as a tool to develop and measure students' understanding in science. *Acta Didactica Napocensia*, *10*(2), 109-122. https://doi.org/10.24193/adn.10.2.9

Vanides, J., Yin, Y., Tomita, M., & Ruiz-Primo, M. A. (2005). Using concept maps in the science classroom. *Science Scope*, *8*(28), 27-31. https://eric.ed.gov/?id=EJ722780

Wang, S. H. (2020). Instruction design and strategy of concept mapping. *Proceedings of the 5th International Conference on Economics, Management, Law and Education*, *10*, 1195-1198. https://doi.org/https://doi.org/10.2991/aebmr.k.191225.236

West, D. C., Pomeroy, J. R., Park, J. K., Gerstenberger, E. A., & Sandoval, J. (2000). Critical thinking in graduate medical education: A role for concept mapping assessment? *JAMA*, *284*(9), 1105-1110. https://doi.org/10.1001/jama.284.9.1105

Yin, Y., & Shavelson, R. J. (2008). Application of generalizability theory to concept map assessment research. *Applied Measurement in Education*, *21*(3), 273-291. https://doi.org/10.1080/08957340802161840

Zubaidah, S., & Pangestuti, A., A. (2016). Peta konsep sebagai alat evaluasi pada pembelajaran biologi. *Proceeding Biology Education Conference*, *13*(1), 164-168. https://jurnal.uns.ac.id/prosbi/article/view/5684/5052