
Analysis of Junior High School Students' Misconceptions About the Human Excretion Using a Four-Tier Diagnostic Test

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Abstract.

This study aimed to measure middle school students' conceptions and misconceptions related to human excretion using a four-tiered diagnostic test. Using a cross-sectional survey design, responses of 113 eighth-grade students, convenience sampled from two schools in Bandung were collected. A four-tiered instrument was developed specifically for the focus of this study and the data analyzed below consists of test results and interviews with teachers. The findings indicate that students' conceptions of the human excretory system fall into several categories: scientific knowledge (SK) at 46.90%, false positive (FP) at 13.09%, false negative (FN) at 6.13%, misconception (M) at 20.45%, and lack of knowledge (LK) at 13.43%. The most common misconceptions relate to diseases and disorders (38%) and sweating and body thermoregulation (31%). These misconceptions may arise due to factors such as students' lack of enthusiasm for learning and limited engagement during the learning process. Consequently, there is a need for improved teaching approaches to address misconceptions associated with human excretion and to foster a more comprehensive scientific understanding among students.

Keywords: Four-tier Test, Students' Conception, Human Excretion, Misconception

Introduction

Misconceptions refer to students' conceptions that are different with scientific understanding accepted by experts in the field (Maryanti et al., 2022). Misconceptions can occur in any field, but it is well studied in the natural sciences, including biology. Natural phenomena and has abstract and diverse concepts that make it difficult for students.

Students build concepts in their mind from their experiences in school education or daily activities that give them with certain ideas about science, knowingly or unknowingly, that they bring to the classroom (Gurel et al., 2015; Yan & Subramaniam, 2018). Since students have different experiences, there can be many concepts held in the classroom that are different from scientific conceptions (Kaniawati et al., 2019).

Identifying and investigating misconceptions is a critical challenge in educational research (Caleon & Subramaniam, 2010). Kiray & Simsek (2021) evaluated several diagnostic and measurement tools that have been used to identify student misconceptions. Interviews offer insights into students' cognitive circumstances, but very time consuming. Conversely multiple choice-tests (MCTs) are efficient for collecting data from a large group, but they don't give an in-depth analysis of responses (Kaltakci-Gurel et al., 2017). Multi-tiered tests, that is a test instrument with several levels or tiers, can provide more insights. This type of diagnostic test provides information on students' conceptions as well as the

confidence of their understanding (Caleon & Subramaniam, 2010; Sreenivasulu & Subramaniam, 2013).

Multi-tiered instruments have already been used to identify students' misconceptions about the human excretory system, such as two-tiered and three-tiered tests among junior high school students (Mardiani et al., 2020; Dahlina et al., 2019), and three-tiered and four-tiered tests among senior high school students (Aprilanti et al., 2016; Wilantika et al., 2018). A four-tiered diagnostic test includes a content/answer tier, a confidence tier, a reason tier and a second confidence tier related to the reason chosen (Caleon & Subramaniam, 2010). Research by Gurel et al. (2015) compared several diagnostic tests for misconceptions, and found that a four-tiered diagnostic test was more accurate in identifying misconceptions than other tests.

The current study aimed to develop a four-tier diagnostic test to analyse grade 8th students' conceptions and misconceptions about the human excretory system. Since there is no research yet in merdeka curriculum, student's conceptions and misconceptions was measured using a new instrument developed according to research need, that through preliminary study, expert judgement and pilot study.

Methods

A cross-sectional survey design (Fraenkel et al., 2011) was used to collect responses from 113 eighth-grade students. Convenience sampling was used to collect data from two local schools. The criteria for the participants were that they were eighth-graders junior high school students who had studied the topic of human excretion using the Merdeka Curriculum. The four-tier diagnostic test instrument in this research was developed from a preliminary study, validation and reliability stages with input from expert judges and a pilot study. The final instrument consisted of 13 questions covering four concepts in human excretion. The distribution of the questions across concepts is given in Table 1.

Table 1. Question distribution across concepts in the test instrument

Sub-Topic	Concept	Item Number	Number of Questions
	The organs of excretory system	Q1,Q2,Q3	3
Structure and Function of Human Excretory System	Sweating for body regulation	Q4,Q5,Q6,Q7,Q8	5
	The structure and function of skin	Q9,Q10,Q11	3
Diseases and Disorders of the Human Excretory System	Diseases and disorders of the kidneys	Q12,Q13	2
Total			13

The research instrument was distributed to students through a google form. The test data collection was conducted over a span of two days, carried out within each classroom under the direct supervision of the researcher. Subsequent interviews with teachers and selected students took place. The collected data was analysed using Microsoft Excel.

Results and Discussion

The categories of students' conceptions are scientific knowledge (SK), false positive (FP), false negative (FN), misconception (M), and lack of knowledge (LK) (Kiray & Simsek, 2021). Figure 1 shows the overall student conceptions in this study

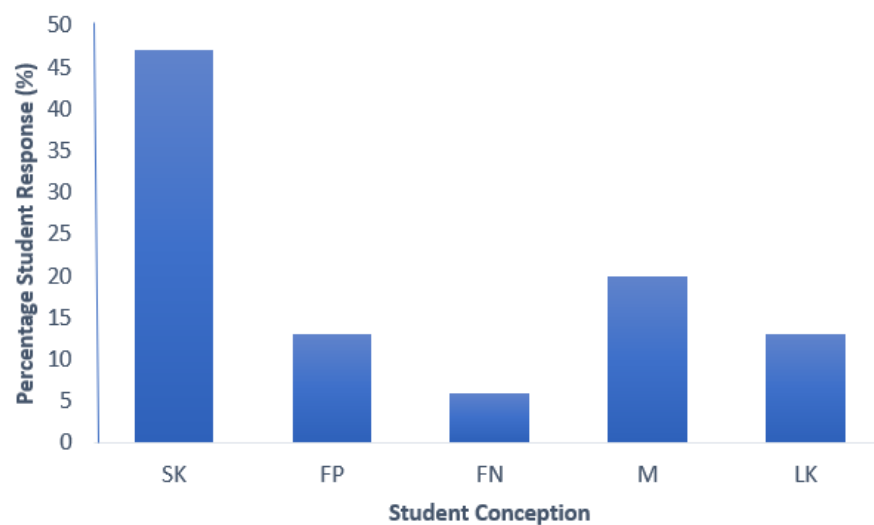


Figure 1. The Percentages of Students' Conceptions about Human Excretion from All Questions Investigated

From the data above, it is evident that scientific understanding of the concepts is observed in almost 50% of the responses. This indicates that the students in these classes have not yet mastered the concepts related to human excretion. Over 20% of the student responses indicated misconceptions. Misconceptions are considered significant when over 10% of the students choose incorrect first and third tier answers with confidence. In other words, two out of ten students had incorrect conceptions about human excretion which they considered as valid. The third observation to make is that LK is also high at over 13% of responses. In these cases, regardless of whether students answered the main question and the reasoning question correctly or incorrectly, they displayed uncertainty regarding their answers. As a result, some students might choose the correct answer by chance or guesswork, but they lack confidence in their response due to a lack of solid understanding about the topic.

FP levels are relatively high. Students who have a false positive conception fail to explain the specific reason behind their correct answer. They understand the concept, but they are unable to provide a right reasoning for the correct answer (Muryani et al., 2022; Taslidere, 2016).

In order to gain a clearer view of students' conceptions, further analysis was conducted by examining the four specific concepts covered by the test instrument. The analysis of the results can be seen in the graph below.

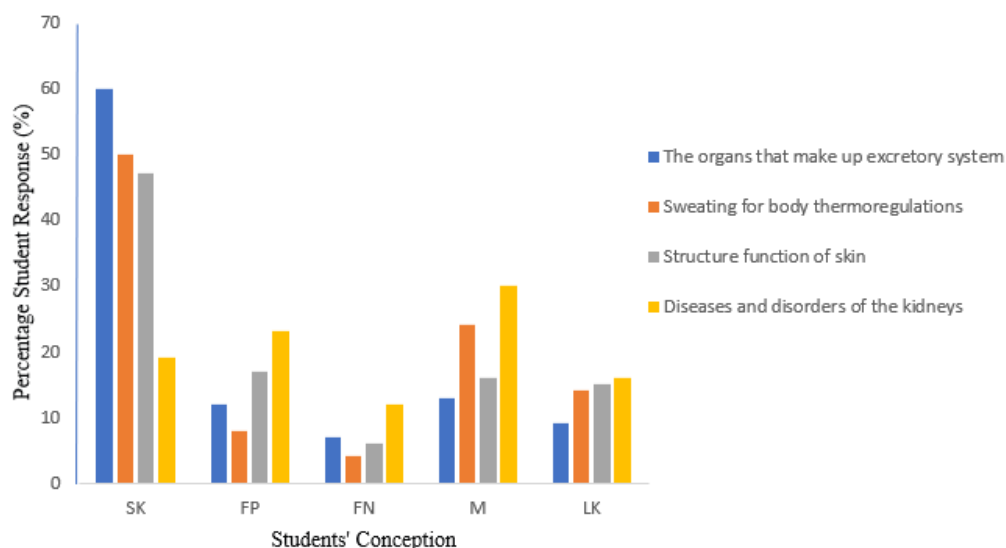


Figure 2. The Average Percentages of Students' Conceptions about Human Excretion from each Concept Investigated

The main observations from this data is that misconceptions are relatively high for the sweating for thermoregulation concept and very high for the questions covering disease and disorders of the kidneys.

The research findings are in line with previous research which found students held misconceptions about human excretion (Dahlina et al., 2019). In that research, completed with a three-tier diagnostic test, the highest misconceptions were related to sweating for body thermoregulation, while the second highest misconceptions related to kidney disease. But the present research contradicts Ritonga et al. (2017) who found few misconceptions kidneys diseases in their study.

Another interesting finding from graph above are the high false positive (FP) observed in the structure and function of the skin as well as the diseases and disorders concepts, and relatively high false negative (FN) encountered with the diseases and disorders concept. Hestenes & Halloun (1995) suggested that the occurrence of false negatives should be less than 10%, but may be higher due to carelessness of students in answering questions. A false positive has a 20% chance of occurrence in multiple-choice questions if students are just guessing. Also a strong distractor will give rise to false positives in students (Istiyani et al., 2018).

Based on the interviews with the science teachers, some students did not pay attention to the content when teacher explained it, a general lack of scientific literacy and a lack of interest in reading all worked together to reduce the likelihood of students seeking more information about the content. Therefore, some students do not have any idea about the concepts.

The four concepts considered in this study, fall into two subtopics: the structure and function of human excretory system, and diseases and disorders of the human excretory system. Figure 3 shows student conceptions across the two subtopics.

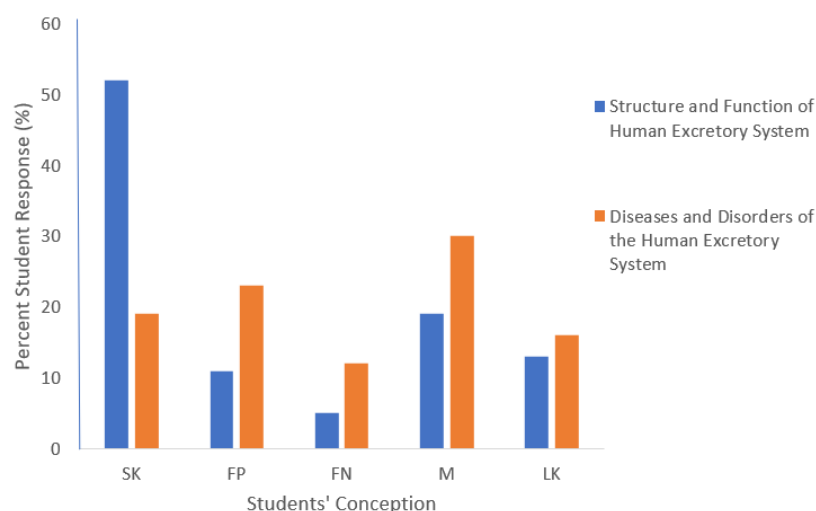


Figure 3. The Average Percentages of Students' Conceptions about Human Excretion from each Subtopic investigated

It is clear that SK is much higher for structure and functions of human excretory compared with the subtopic diseases and disorders. FP and FN are again high in the diseases and disorders subtopic. This subtopic also is the most misunderstood subtopic by the students, indicated by the high average percentage of M (30%). The subtopic of diseases and disorders of the human excretory system included only two questions which may contribute to the differences observed.

Based on interviews with the science teachers, students' responses showed the most erroneous conceptions (i.e. FP, FN, M) in the disease and disorder subtopic because this concept is quite difficult and complex. Firstly, students should master the structure and function of the excretory system. In addition, students did not pay attention when the teacher explained the topic, a lack of scientific literacy and a consequent lack of critical thinking skills in students were issues. Finally, according to the teachers, the coverage of the topic in the textbook did not go very deep.

Moreover the teacher experiences difficulties when explained the concept in front of the class because of the conventional methods. The teacher also mentioned the needs of appropriate learning media because it is too difficult if the students' only imagine about the topic talked in front of the class. Currently at this time, learning activities emphasize skills, active learning and process, thus the role of learning media be increasingly important. In addition that there are weaknesses in learning that still make teachers the main source of learning, so there needs to be an effort to overcome these weaknesses. It is importance the use of learning media as a liaison in the delivery of information and solve problems in a series of learning activities, for that the teacher can develop interactive learning media (Maskur et al., 2020).

Misconceptions can greatly affect students. It is important to address misconceptions appropriately because misconceptions that are not corrected can result in assuming false or inaccurate information is correct. If students do not correct existing misconceptions, they may not be able to understand more complex concepts or build solid knowledge in specific fields of study (Resbiantoro et al., 2022). Learning difficulties experienced by

students are one of the impacts of misconceptions that occur in students which can result in low learning achievement (Suwanto, 2013).

After highlighting the misconceptions in each subtopic above, the researcher analyzed the misconception level on each question. The results can be seen in Figure 4.

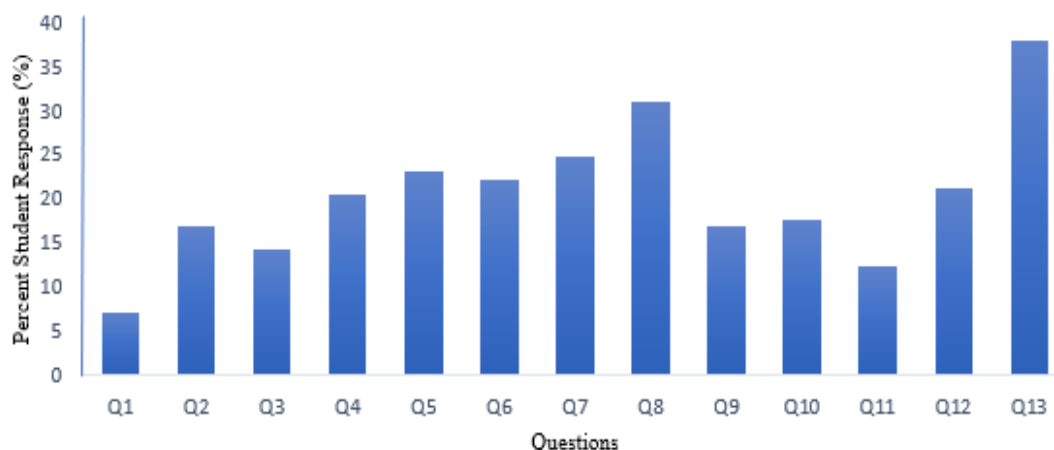


Figure 4. The Percentages of Students' Misconceptions about Human Excretion according to each Question

Misconceptions occurred in all questions presented, but the highest percentage (>20%) of misconceptions were found with Q5, Q6, Q7, Q8, Q12 and Q13. As mentioned the 13 test item consist of two subtopics in human excretory system. Questions 5, 6, 7, and 8 fall under the subtopic of "structure and function of human excretory system", while questions 12 and 13 are part of the "diseases and disorders of the human excretory system" subtopic.

Conclusion

The implementation of four-tier diagnostic test has provided useful insights into students' conceptions about human excretion. The most common misconception was in the disease and disorder subtopic. Interviews with teacher provided some essential insight about the factors that caused students' misconceptions, such as wrong ideas, the lack information in textbooks, lack of students' enthusiasm for learning and involvement in learning process, and also the lack of needed of learning media. In order to address these challenges, more interactive learning, case studies, and discussions to enhance students' comprehension should be used in middle school classrooms.

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References

- Aprilanti, H., Qurbaniah, M., & Muldayanti, N. D. 2016. Identifikasi miskonsepsi siswa pada materi sistem ekskresi manusia kelas XI MIA SMA Negeri 4 Pontianak. *Jurnal Bioeducation*, 3(2):63–77. <https://doi.org/10.29406/188>
- Caleon, I. & Subramaniam, R. 2010. Do students know what they know and what they don't know? Using a four-tier diagnostic test to assess the nature of students' alternative conceptions. *Research in Science Education*, 40(3):313–337. <https://doi.org/10.1007/s11165-009-9122-4>
- Dahlina, S., Sunandar, A., & Kurniawan, A.D. 2019. Analisis konsepsi siswa dengan three tier test pada materi sistem ekskresi di kelas VIII SMP Negeri 10 Pontianak. *Pena Kreatif: Jurnal Pendidikan*, 8(2):102-109. <https://doi.org/10.29406/jpk.v8i2.1783>
- Fraenkel, R.J., Wallen, E.N., & Hyun, H.H. 2011. How to design and evaluate research in education (8th ed.). *New York: McGraw Hill*.
- Gurel, D.K., Eryilmaz, A., & McDermott, L.C. 2015. A review and comparison of diagnostic instruments to identify students' misconceptions in science. *Eurasia Journal of Mathematics, Science and Technology Education*, 11(5):989–1008. <https://doi.org/10.12973/eurasia.2015.1369a>
- Hestenes, D. & Halloun, I. 1995. Interpreting the force concept inventory. *The Physics Teacher*, 33(8):504-506. <https://doi.org/10.1119/1.2344278>
- Istiyani, R., Muchyidin, A., & Raharjo, H. 2018. Analysis of student misconception on geometry concepts using three-tier diagnostic test. *Cakrawala Pendidikan: Jurnal Ilmiah Pendidikan*, 37(2):223-236. <http://dx.doi.org/10.21831/cp.v37i2.14493>
- Kaltakci-Gurel, D., Eryilmaz, A., & McDermott, L.C. 2017. Development and application of a four-tier test to assess pre-service physics teachers' misconceptions about geometrical optics. *Research in Science & Technological Education*, 35(2):238–260. <https://doi.org/10.1080/02635143.2017.1310094>
- Kaniawati, I., Fratiwi, N.J., Danawan, A., Suyana, I., Samsudin, A., & Suhendi, E. 2019. Analyzing students' misconceptions about Newton's laws through four-tier newtonian test (FTNT). *Journal of Turkish Science Education*, 16(1):110–122. <https://doi.org/10.12973/tused.10269a>
- Kiray, S.A. & Simsek, S. 2021. Determination and evaluation of the science teacher candidates' misconceptions about density by using four-tier diagnostic test. *International Journal of Science and Mathematics Education*, 19(5):935–955. <https://doi.org/10.1007/s10763-020-10087-5>
- Mardiani, R., Khoiri, N., & Norra, B.I. 2020. Inovasi modul pembelajaran biologi terintegrasi problem based learning dilengkapi dengan tes diagnostik multiple choice two tier pada materi sistem ekskresi manusia di SMP. *Bioeduca : Journal of Biology Education*, 2(2):50-58. <https://doi.org/10.21580/bioeduca.v2i2.6496>

- Maryanti, R., Hufad, A., Sunardi, S., & Nandiyanto, A.B.D. 2022. Teaching high school students with/without special needs and their misconception on corrosion. *Journal of Engineering Science and Technology*, 17(1):225–238. https://jestec.taylors.edu.my/Vol%2017%20Issue%201%20February%20%202022/17_1_17.pdf
- Maskur, R., Sumarno, Rahmawati, Y., Pradana, K., Syazali, M., Septian, A., & Palupi, E.K. 2020. The effectiveness of problem based learning and aptitude treatment interaction in improving mathematical creative thinking skills on curriculum 2013. *European Journal of Educational Research*, 9(1):375–383. <https://doi.org/10.12973/eu-er.9.1.375>
- Muryani, D.I., Jana, P., & Umasugi, S.M. 2022. The students' misconceptions in using three-tier multiple choice diagnostic test on the angle relationships. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, 12(1):25–34. <https://doi.org/10.30998/formatif.v12i1.9641>
- Resbiantoro, G., Setiani, R., & Dwikoranto. 2022. A review of misconception in physics: the diagnosis, causes, and remediation. *Journal of Turkish Science Education*, 19(2): 403–427. <https://doi.org/10.36681/tused.2022.128>
- Ritonga, N., Sakdiah Boru Gultom, H., & Fitriandika Sari, N. 2017. Miskonsepsi guru biologi pada materi sistem ekskresi di SMA Negeri se-Kabupaten Labuhanbatu. *Simbiosis*, 6(2):104–110. <https://www.journal.unrika.ac.id/index.php/simbiosajournal/article/viewFile/1157/912>
- Sreenivasulu, B., & Subramaniam, R. 2013. University students' understanding of chemical thermodynamics. *International Journal of Science Education*, 35(4):601–635. <https://doi.org/10.1080/09500693.2012.683460>
- Suwarto, D. 2013. *Pengembangan Tes Diagnostik Dalam Pembelajaran*. Yogyakarta: Pustaka Pelajar.
- Taslidere, E. 2016. Development and use of a three-tier diagnostic test to assess high school students' misconceptions about the photoelectric effect. *Research in Science and Technological Education*, 34(2):164–186. <https://doi.org/10.1080/02635143.2015.1124409>
- Wilantika, N., Khoiri, N., & Hidayat, S. 2018. Pengembangan penyusunan instrumen four-tier diagnostic test untuk mengungkap miskonsepsi materi sistem ekskresi di SMA Negeri 1 Mayong Jepara. *Phenomenon: Jurnal Pendidikan MIPA*, 8(2):200–214. <https://doi.org/10.21580/phen.2018.8.2.2699>
- Yan, Y.K. & Subramaniam, R. 2018. Using a multi-tier diagnostic test to explore the nature of students' alternative conceptions on reaction kinetics. *Chemistry Education Research and Practice*, 19(1):213–226. <https://doi.org/10.1039/C7RP00143F>